



# PIC16C7X

## 8-Bit CMOS Microcontrollers with A/D Converter

### Devices included in this data sheet:

- PIC16C710
- PIC16C71
- PIC16C711
- PIC16C72
- PIC16C73
- PIC16C73A
- PIC16C74
- PIC16C74A

### PIC16C7X Microcontroller Core Features:

- High-performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions (200 ns) except for program branches which are two cycle
- Operating speed: DC - 20 MHz clock input  
DC - 200 ns instruction cycle
- Interrupt capability
- Eight level deep hardware stack
- Direct, indirect, and relative addressing modes
- Power-on Reset (POR)
- Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code-protection
- Power saving SLEEP mode
- Selectable oscillator options
- 8-bit multichannel analog-to-digital converter

- Low-power, high-speed CMOS EPROM technology
- Fully static design
- Wide operating voltage range: 2.5V to 6.0V
- High Sink/Source Current 25/25 mA
- Commercial, Industrial and Automotive temperature ranges
- Low-power consumption:
  - < 2 mA @ 5V, 4 MHz
  - 15  $\mu$ A typical @ 3V, 32 kHz
  - < 1  $\mu$ A typical standby current

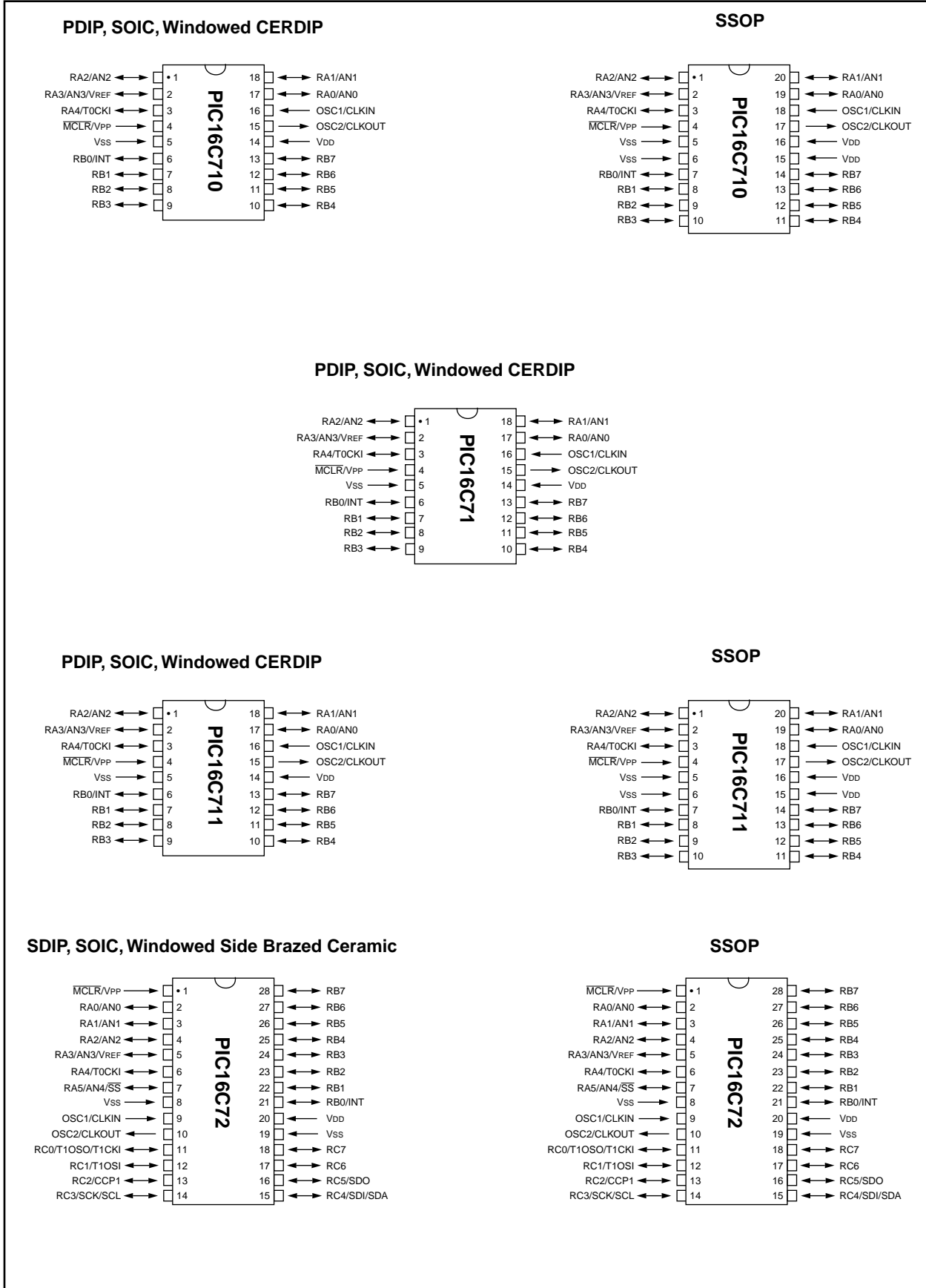
### PIC16C7X Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter. TMR1 can be incremented during sleep via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Capture, Compare, PWM module(s)
- Capture is 16-bit, max. resolution 12.5 ns, Compare is 16-bit, max. resolution 200 ns, max. PWM resolution is 10-bit
- Synchronous Serial Port (SSP) with SPI™ and I<sup>2</sup>C™
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI)
- Parallel Slave Port (PSP) 8-bits wide, with external  $\overline{RD}$ ,  $\overline{WR}$  and  $\overline{CS}$  controls
- Brown-out detection circuitry for Brown-out Reset (BOR)

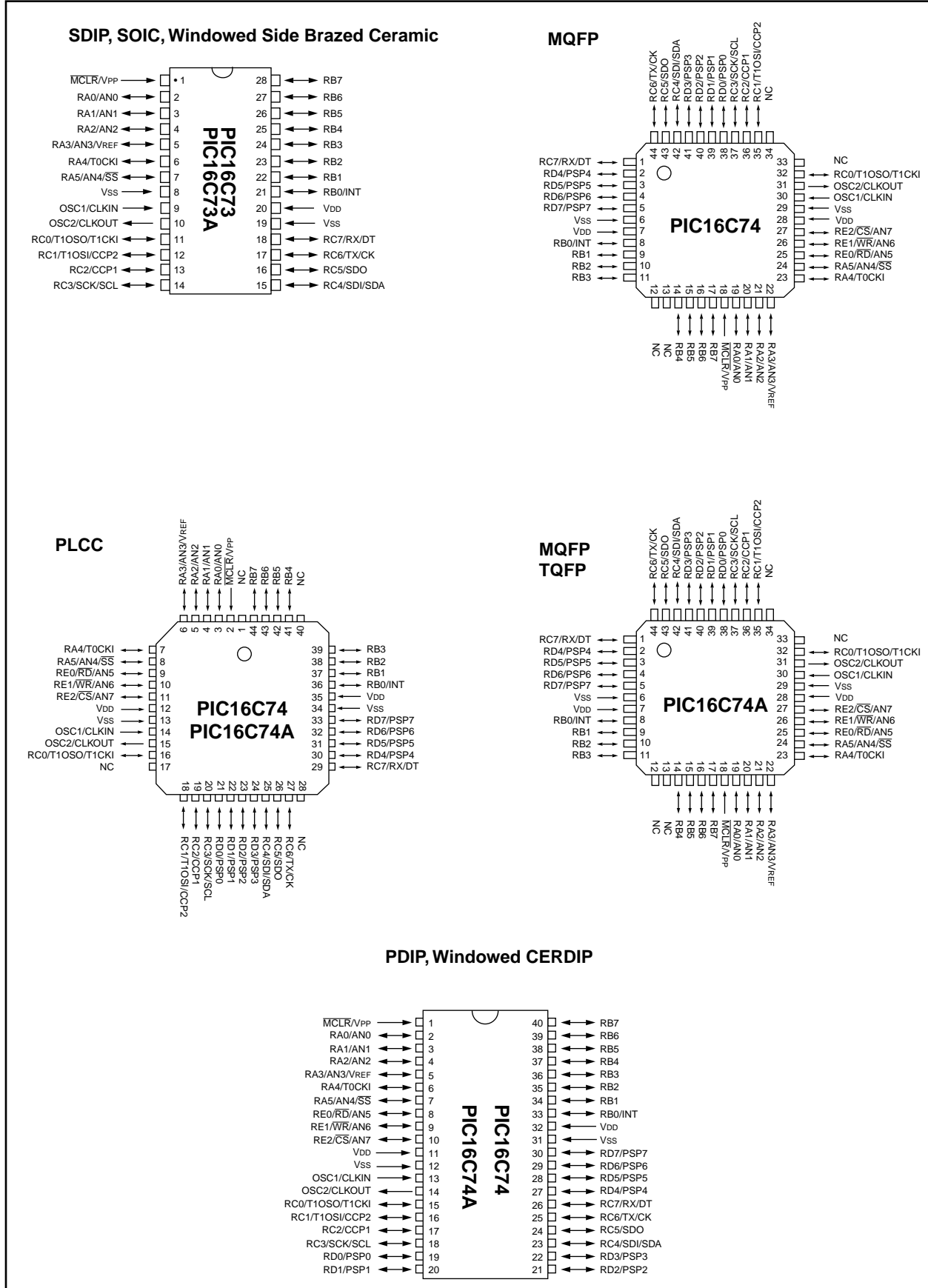
PIC16C7X Features	710	71	711	72	73	73A	74	74A
Program Memory (EPROM) x 14	512	1K	1K	2K	4K	4K	4K	4K
Data Memory (Bytes) x 8	36	36	68	128	192	192	192	192
I/O Pins	13	13	13	22	22	22	33	33
Parallel Slave Port	—	—	—	—	—	—	Yes	Yes
Capture/Compare/PWM Modules	—	—	—	1	2	2	2	2
Timer Modules	1	1	1	3	3	3	3	3
A/D Channels	4	4	4	5	5	5	8	8
Serial Communication	—	—	—	SPI/I <sup>2</sup> C	SPI/I <sup>2</sup> C, USART	SPI/I <sup>2</sup> C, USART	SPI/I <sup>2</sup> C, USART	SPI/I <sup>2</sup> C, USART
In-Circuit Serial Programming	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Brown-out Reset	Yes	—	Yes	Yes	—	Yes	—	Yes
Interrupt Sources	4	4	4	8	11	11	12	12

# PIC16C7X

## Pin Diagrams



## Pin Diagrams (Cont.'d)



# PIC16C7X

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For register and module descriptions in this data sheet, device legends show which devices apply to those sections. As an example, the legend below would mean that the following section applies only to the PIC16C711, PIC16C72, PIC16C73A and PIC16C74A devices.

Applicable Devices							
710	71	711	72	73	73A	74	74A

## To Our Valued Customers

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## 1.0 GENERAL DESCRIPTION

The PIC16C7X is a family of low-cost, high-performance, CMOS, fully-static, 8-bit microcontrollers with integrated analog-to-digital (A/D) converters, in the PIC16CXX mid-range family.

All PIC16/17 microcontrollers employ an advanced RISC architecture. The PIC16CXX microcontroller family has enhanced core features, eight-level deep stack, and multiple internal and external interrupt sources. The separate instruction and data buses of the Harvard architecture allow a 14-bit wide instruction word with the separate 8-bit wide data. The two stage instruction pipeline allows all instructions to execute in a single cycle, except for program branches which require two cycles. A total of 35 instructions (reduced instruction set) are available. Additionally, a large register set gives some of the architectural innovations used to achieve a very high performance.

PIC16CXX microcontrollers typically achieve a 2:1 code compression and a 4:1 speed improvement over other 8-bit microcontrollers in their class.

The **PIC16C710/71** devices have 36 bytes of RAM, and the **PIC16C711** has 68 bytes of RAM. The **PIC16C710/71/711** devices have 13 I/O pins. In addition a timer/counter is available. Also a 4-channel high-speed 8-bit A/D is provided. The 8-bit resolution is ideally suited for applications requiring low-cost analog interface, e.g. thermostat control, pressure sensing, etc.

The **PIC16C72** device has 128 bytes of RAM and 22 I/O pins. In addition several peripheral features are available including: three timer/counters, one Capture/Compare/PWM module and one serial port. The Synchronous Serial Port can be configured as either a 3-wire Serial Peripheral Interface (SPI) or the two-wire Inter-Integrated Circuit (I<sup>2</sup>C) bus. Also a 5-channel high-speed 8-bit A/D is provided. The 8-bit resolution is ideally suited for applications requiring low-cost analog interface, e.g. thermostat control, pressure sensing, etc.

The **PIC16C73/73A** devices have 192 bytes of RAM and 22 I/O pins. In addition, several peripheral features are available including: three timer/counters, two Capture/Compare/PWM modules and two serial ports. The Synchronous Serial Port can be configured as either a 3-wire Serial Peripheral Interface (SPI) or the two-wire Inter-Integrated Circuit (I<sup>2</sup>C) bus. The Universal Synchronous Asynchronous Receiver Transmitter (USART) is also known as the Serial Communications Interface or SCI. Also a 5-channel high-speed 8-bit A/D is provided. The 8-bit resolution is ideally suited for applications requiring low-cost analog interface, e.g. thermostat control, pressure sensing, etc.

The **PIC16C74/74A** devices have 192 bytes of RAM and 33 I/O pins. In addition several peripheral features are available including: three timer/counters, two Capture/Compare/PWM modules and two serial ports. The

Synchronous Serial Port can be configured as either a 3-wire Serial Peripheral Interface (SPI) or the two-wire Inter-Integrated Circuit (I<sup>2</sup>C) bus. The Universal Synchronous Asynchronous Receiver Transmitter (USART) is also known as the Serial Communications Interface or SCI. An 8-bit Parallel Slave Port is provided. Also an 8-channel high-speed 8-bit A/D is provided. The 8-bit resolution is ideally suited for applications requiring low-cost analog interface, e.g. thermostat control, pressure sensing, etc.

The PIC16C7X family has special features to reduce external components, thus reducing cost, enhancing system reliability and reducing power consumption. There are four oscillator options, of which the single pin RC oscillator provides a low-cost solution, the LP oscillator minimizes power consumption, XT is a standard crystal, and the HS is for High Speed crystals. The SLEEP (power-down) feature provides a power saving mode. The user can wake up the chip from SLEEP through several external and internal interrupts and resets.

A highly reliable Watchdog Timer with its own on-chip RC oscillator provides protection against software lock-up.

A UV erasable CERDIP packaged version is ideal for code development while the cost-effective One-Time-Programmable (OTP) version is suitable for production in any volume.

The PIC16C7X family fits perfectly in applications ranging from security and remote sensors to appliance control and automotive. The EPROM technology makes customization of application programs (transmitter codes, motor speeds, receiver frequencies, etc.) extremely fast and convenient. The small footprint packages make this microcontroller series perfect for all applications with space limitations. Low cost, low power, high performance, ease of use and I/O flexibility make the PIC16C7X very versatile even in areas where no microcontroller use has been considered before (e.g. timer functions, serial communication, capture and compare, PWM functions and coprocessor applications).

### 1.1 Family and Upward Compatibility

Users familiar with the PIC16C5X microcontroller family will realize that this is an enhanced version of the PIC16C5X architecture. Please refer to Appendix A for a detailed list of enhancements. Code written for the PIC16C5X can be easily ported to the PIC16CXX family of devices (Appendix B).

### 1.2 Development Support

The PIC16CXX family is supported by a full-featured macro assembler, a software simulator, an in-circuit emulator, a low-cost development programmer and a full-featured programmer. A "C" compiler and fuzzy logic support tools are also available. (Section 16.0)

# PIC16C7X

TABLE 1-1: PIC16C7X FAMILY OF DEVICES

Device	Clock			Memory			Peripherals					Features	
	Maximum Frequency of Operation (MHz)	EPROM Program Memory (K x 4 words)	Data Memory (bytes)	Timer Modules(s)	Serial Ports (SPI/I <sup>2</sup> C, USART)	Capture/Compare/PWM Modules(s)	AND Slave Port	Parallel Slave Port	Interrupt Sources	I/O Pins	Voltage Range (Volts)	In-Circuit Serial Programming	Brown-out Reset
PIC16C710	20	512	36	TMR0	—	—	4	4	13	3.0-6.0	Yes	Yes	18-pin DIP, SOIC; 20-pin SSOP
PIC16C71	20	1K	36	TMR0	—	—	4	4	13	3.0-6.0	Yes	—	18-pin DIP, SOIC
PIC16C711	20	1K	68	TMR0	—	—	4	4	13	3.0-6.0	Yes	Yes	18-pin DIP, SOIC; 20-pin SSOP
PIC16C72	20	2K	128	TMR0, TMR1, TMR2	1	SPI/I <sup>2</sup> C	5	8	22	2.5-6.0	Yes	Yes	28-pin SDIP, SOIC, SSOP
PIC16C73	20	4K	192	TMR0, TMR1, TMR2	2	SPI/I <sup>2</sup> C, USART	5	11	22	3.0-6.0	Yes	—	28-pin SDIP, SOIC
PIC16C73A <sup>(1)</sup>	20	4K	192	TMR0, TMR1, TMR2	2	SPI/I <sup>2</sup> C, USART	5	11	22	2.5-6.0	Yes	Yes	28-pin SDIP, SOIC
PIC16C74	20	4K	192	TMR0, TMR1, TMR2	2	SPI/I <sup>2</sup> C, USART	8	12	33	3.0-6.0	Yes	—	40-pin DIP; 44-pin PLCC, MQFP
PIC16C74A <sup>(1)</sup>	20	4K	192	TMR0, TMR1, TMR2	2	SPI/I <sup>2</sup> C, USART	8	12	33	2.5-6.0	Yes	Yes	40-pin DIP; 44-pin PLCC, MQFP, TQFP

All PIC16/17 Family devices have Power-on Reset, selectable Watchdog Timer, selectable code protect and high I/O current capability.

All PIC16C7X Family devices use serial programming with clock pin RB6 and data pin RB7.

Note 1: Please contact your local sales office for availability of these devices.

## 2.0 PIC16C7X DEVICE VARIETIES

A variety of frequency ranges and packaging options are available. Depending on application and production requirements, the proper device option can be selected using the information in the PIC16C7X Product Identification System section at the end of this data sheet. When placing orders, please use that page of the data sheet to specify the correct part number.

For the PIC16C7X family, there are two device "types" as indicated in the device number:

1. **C**, as in PIC16**C**74. These devices have EPROM type memory and operate over the standard voltage range.
2. **LC**, as in PIC16**LC**74. These devices have EPROM type memory and operate over an extended voltage range.

### 2.1 UV Erasable Devices

The UV erasable version, offered in Cerdip package, is optimal for prototype development and pilot programs.

The UV erasable version can be erased and reprogrammed to any of the configuration modes. Microchip's PICSTART<sup>®</sup> and PRO MATE<sup>®</sup> programmers both support the PIC16C7X. Third party programmers also are available; refer to the Microchip Third Party Guide for a list of sources.

### 2.2 One-Time-Programmable (OTP) Devices

The availability of OTP devices is especially useful for customers who need the flexibility for frequent code updates and small volume applications.

The OTP devices, packaged in plastic packages, permit the user to program them once. In addition to the program memory, the configuration bits must also be programmed.

### 2.3 Quick-Turnaround-Production (QTP) Devices

Microchip offers a QTP Programming Service for factory production orders. This service is made available for users who choose not to program a medium to high quantity of units and whose code patterns have stabilized. The devices are identical to the OTP devices but with all EPROM locations and configuration options already programmed by the factory. Certain code and prototype verification procedures apply before production shipments are available. Please contact your local Microchip Technology sales office for more details.

### 2.4 Serialized Quick-Turnaround Production (SQTP<sup>SM</sup>) Devices

Microchip offers a unique programming service where a few user-defined locations in each device are programmed with different serial numbers. The serial numbers may be random, pseudo-random, or sequential.

Serial programming allows each device to have a unique number which can serve as an entry-code, password, or ID number.

# PIC16C7X

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NOTES:



## 3.0 ARCHITECTURAL OVERVIEW

The high performance of the PIC16CXX family can be attributed to a number of architectural features commonly found in RISC microprocessors. To begin with, the PIC16CXX uses a Harvard architecture, in which, program and data are accessed from separate memories using separate buses. This improves bandwidth over traditional von Neumann architecture in which program and data are fetched from the same memory using the same bus. Separating program and data buses further allows instructions to be sized differently than the 8-bit wide data word. Instruction opcodes are 14-bits wide making it possible to have all single word instructions. A 14-bit wide program memory access bus fetches a 14-bit instruction in a single cycle. A two-stage pipeline overlaps fetch and execution of instructions (Example 3-1). Consequently, all instructions (35) execute in a single cycle (200 ns @ 20 MHz) except for program branches.

The table below lists program memory (EPROM) and data memory (RAM) for each PIC16C7X device.

Device	Program Memory	Data Memory
PIC16C710	512 x 14	36 x 8
PIC16C71	1K x 14	36 x 8
PIC16C711	1K x 14	68 x 8
PIC16C72	2K x 14	128 x 8
PIC16C73	4K x 14	192 x 8
PIC16C73A	4K x 14	192 x 8
PIC16C74	4K x 14	192 x 8
PIC16C74A	4K x 14	192 x 8

The PIC16CXX can directly or indirectly address its register files or data memory. All special function registers, including the program counter, are mapped in the data memory. The PIC16CXX has an orthogonal (symmetrical) instruction set that makes it possible to carry out any operation on any register using any addressing mode. This symmetrical nature and lack of 'special optimal situations' make programming with the PIC16CXX simple yet efficient. In addition, the learning curve is reduced significantly.

PIC16CXX devices contain an 8-bit ALU and working register. The ALU is a general purpose arithmetic unit. It performs arithmetic and Boolean functions between the data in the working register and any register file.

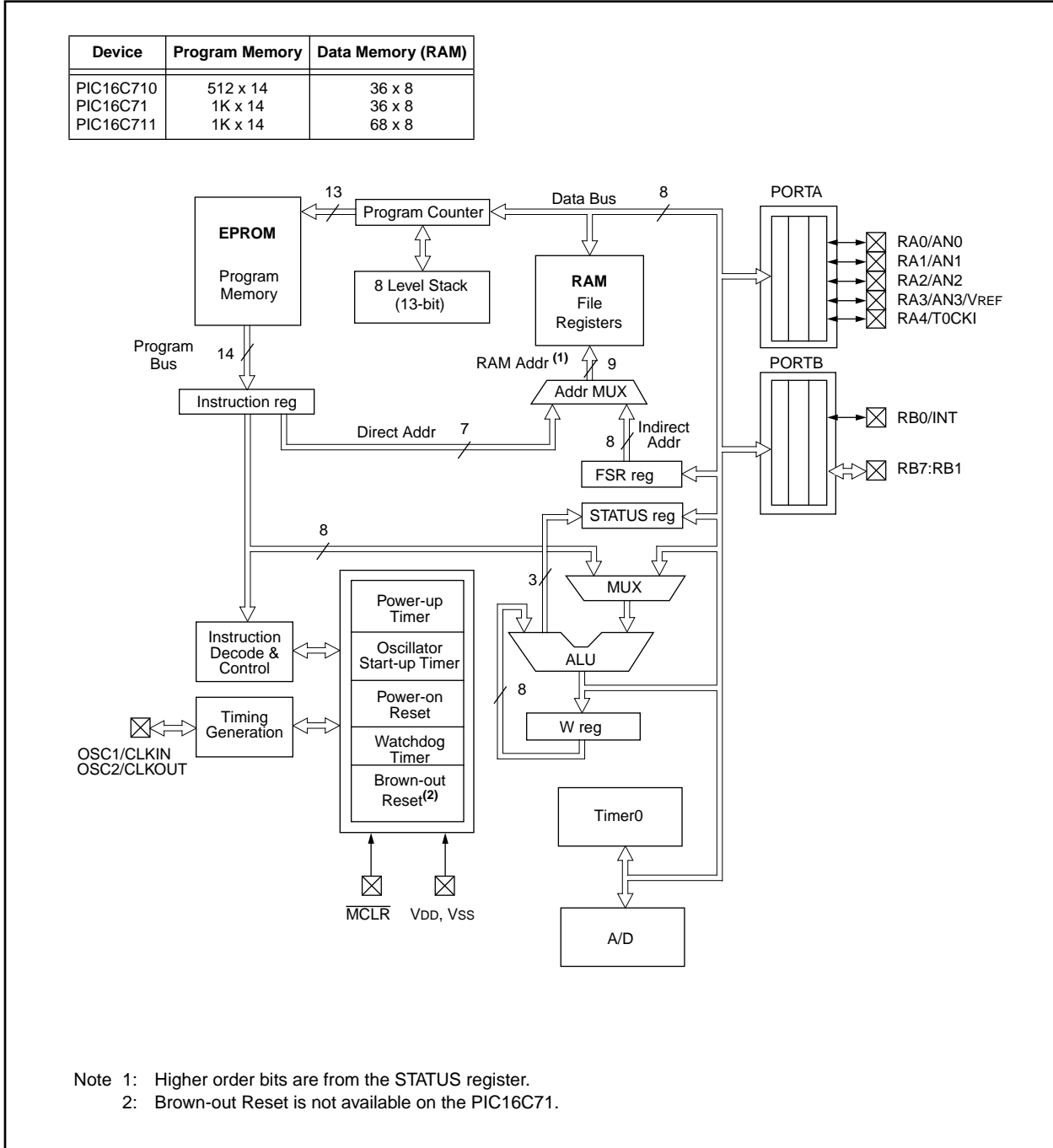
The ALU is 8-bits wide and capable of addition, subtraction, shift and logical operations. Unless otherwise mentioned, arithmetic operations are two's complement in nature. In two-operand instructions, typically one operand is the working register (W register). The other operand is a file register or an immediate constant. In single operand instructions, the operand is either the W register or a file register.

The W register is an 8-bit working register used for ALU operations. It is not an addressable register.

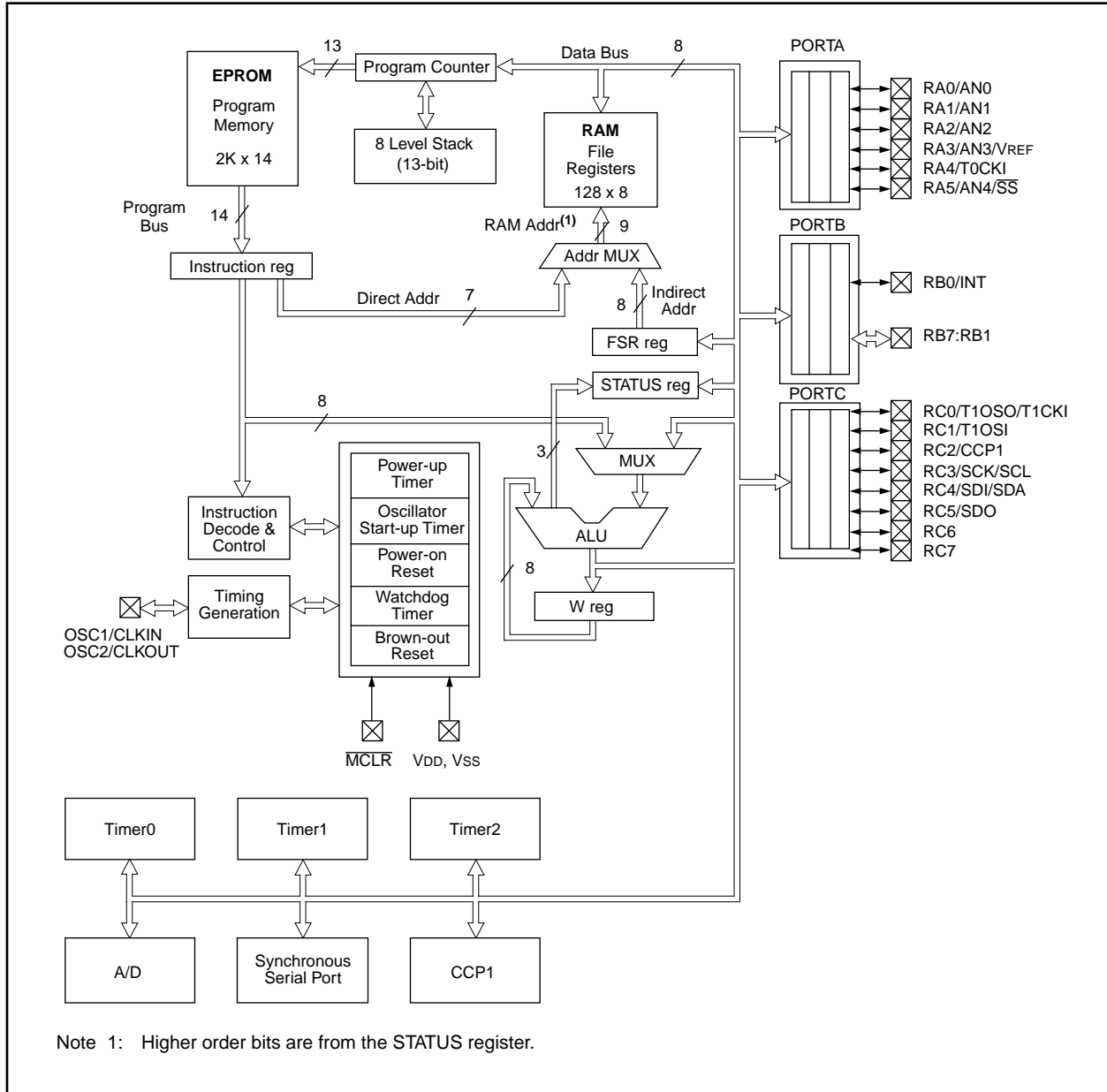
Depending on the instruction executed, the ALU may affect the values of the Carry (C), Digit Carry (DC), and Zero (Z) bits in the STATUS register. The C and DC bits operate as a borrow bit and a digit borrow out bit, respectively, in subtraction. See the `SUBLW` and `SUBWF` instructions for examples.

# PIC16C7X

**FIGURE 3-1: PIC16C710/711/711 BLOCK DIAGRAM**

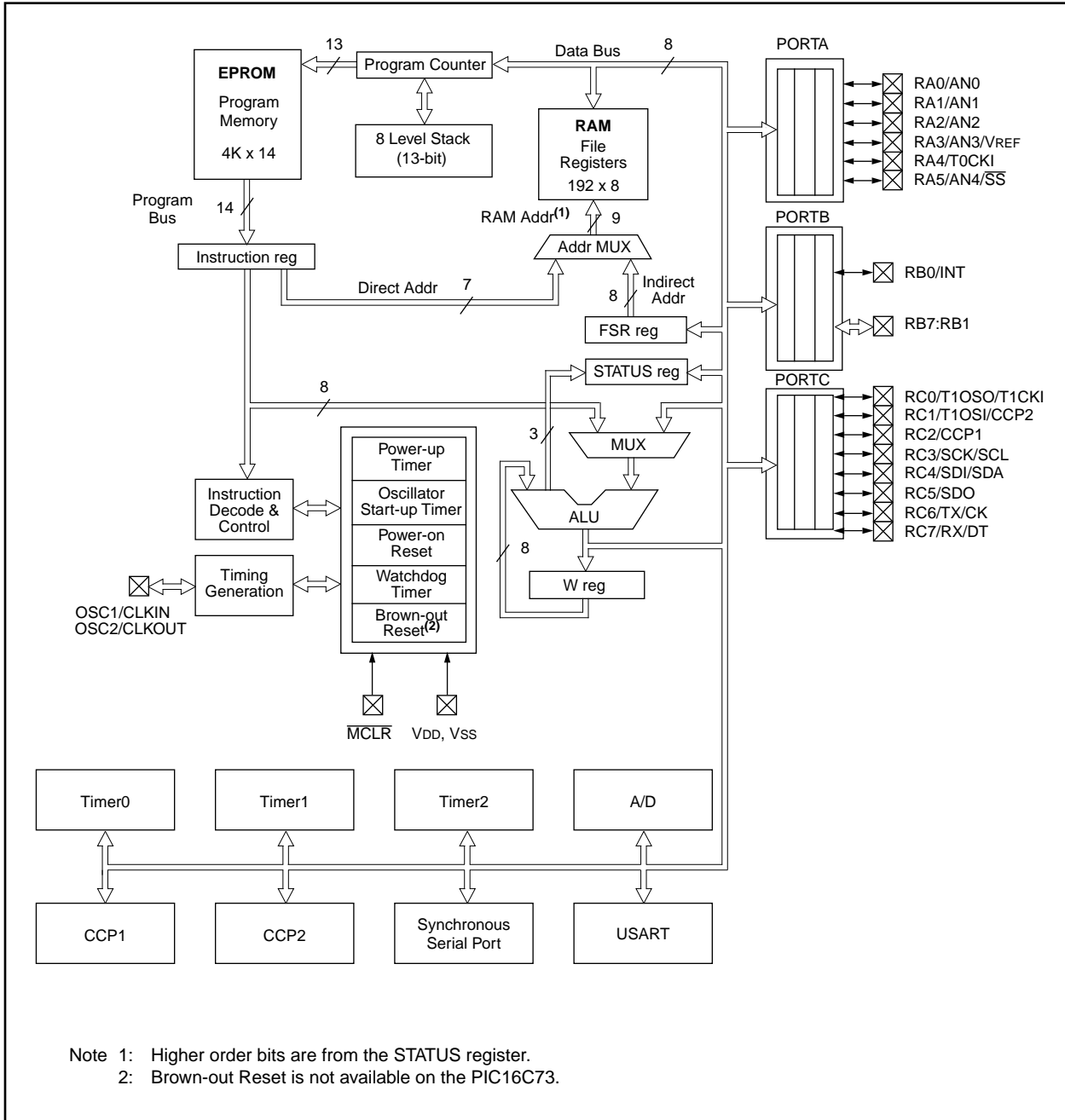


**FIGURE 3-2: PIC16C72 BLOCK DIAGRAM**

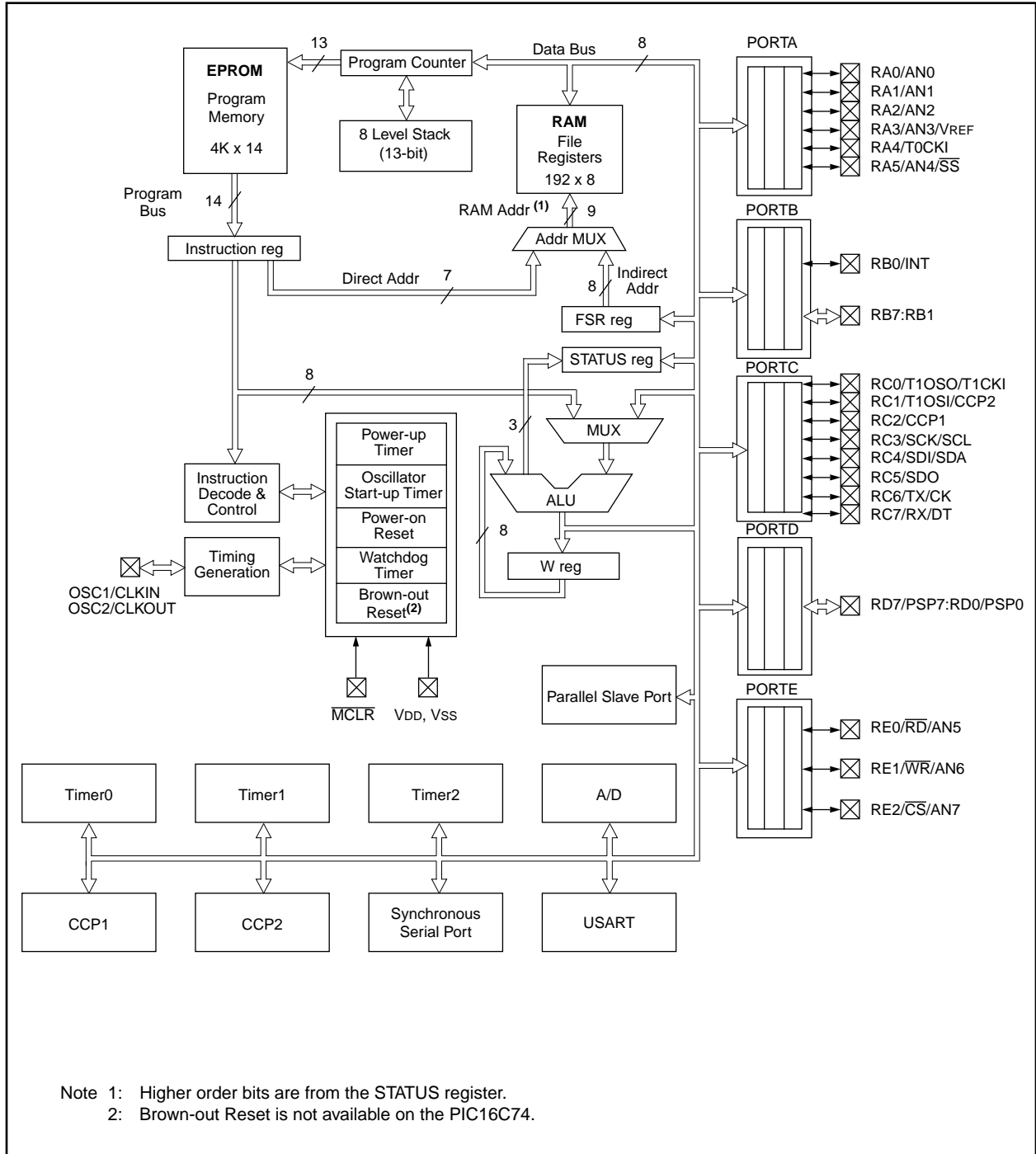


# PIC16C7X

FIGURE 3-3: PIC16C73/73A BLOCK DIAGRAM



**FIGURE 3-4: PIC16C74/74A BLOCK DIAGRAM**



# PIC16C7X

**TABLE 3-1: PIC16C710/711 PINOUT DESCRIPTION**

Pin Name	DIP Pin#	SSOP Pin#	SOIC Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKIN	16	18	16	I	ST/CMOS <sup>(3)</sup>	Oscillator crystal input/external clock source input.
OSC2/CLKOUT	15	17	15	O	—	Oscillator crystal output. Connects to crystal or resonator in crystal oscillator mode. In RC mode, OSC2 pin outputs CLKOUT which has 1/4 the frequency of OSC1, and denotes the instruction cycle rate.
MCLR/VPP	4	4	4	I/P	ST	Master clear (reset) input/programming voltage input. This pin is an active low reset to the device.
RA0/AN0	17	19	17	I/O	TTL	PORTA is a bi-directional I/O port. Analog input0 Analog input1 Analog input2 Analog input3/VREF Can also be selected to be the clock input to the Timer0 module. Output is open drain type.
RA1/AN1	18	20	18	I/O	TTL	
RA2/AN2	1	1	1	I/O	TTL	
RA3/AN3/VREF	2	2	2	I/O	TTL	
RA4/T0CKI	3	3	3	I/O	ST	
RB0/INT	6	7	6	I/O	TTL/ST <sup>(1)</sup>	PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs. RB0/INT can also be selected as an external interrupt pin.  Interrupt on change pin. Interrupt on change pin. Interrupt on change pin. Serial programming clock. Interrupt on change pin. Serial programming data.
RB1	7	8	7	I/O	TTL	
RB2	8	9	8	I/O	TTL	
RB3	9	10	9	I/O	TTL	
RB4	10	11	10	I/O	TTL	
RB5	11	12	11	I/O	TTL	
RB6	12	13	12	I/O	TTL/ST <sup>(2)</sup>	
RB7	13	14	13	I/O	TTL/ST <sup>(2)</sup>	
VSS	5	4, 6	5	P	—	Ground reference for logic and I/O pins.
VDD	14	15, 16	14	P	—	Positive supply for logic and I/O pins.

Legend: I = input      O = output      I/O = input/output      P = power  
                          — = Not used      TTL = TTL input      ST = Schmitt Trigger input

- Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.  
 Note 2: This buffer is a Schmitt Trigger input when used in serial programming mode.  
 Note 3: This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.

**TABLE 3-2: PIC16C71 PINOUT DESCRIPTION**

Pin Name	DIP Pin#	SOIC Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKIN	16	16	I	ST/CMOS <sup>(3)</sup>	Oscillator crystal input/external clock source input.
OSC2/CLKOUT	15	15	O	—	Oscillator crystal output. Connects to crystal or resonator in crystal oscillator mode. In RC mode, OSC2 pin outputs CLKOUT which has 1/4 the frequency of OSC1, and denotes the instruction cycle rate.
MCLR/VPP	4	4	I/P	ST	Master clear (reset) input/programming voltage input. This pin is an active low reset to the device.
RA0/AN0	17	17	I/O	TTL	PORTA is a bi-directional I/O port. Analog input0 Analog input1 Analog input2 Analog input3/VREF Can also be selected to be the clock input to the Timer0 module. Output is open drain type.
RA1/AN1	18	18	I/O	TTL	
RA2/AN2	1	1	I/O	TTL	
RA3/AN3/VREF	2	2	I/O	TTL	
RA4/T0CKI	3	3	I/O	ST	
RB0/INT	6	6	I/O	TTL/ST <sup>(1)</sup>	PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs. RB0/INT can also be selected as an external interrupt pin.  Interrupt on change pin. Interrupt on change pin. Interrupt on change pin. Serial programming clock. Interrupt on change pin. Serial programming data.
RB1	7	7	I/O	TTL	
RB2	8	8	I/O	TTL	
RB3	9	9	I/O	TTL	
RB4	10	10	I/O	TTL	
RB5	11	11	I/O	TTL	
RB6	12	12	I/O	TTL/ST <sup>(2)</sup>	
RB7	13	13	I/O	TTL/ST <sup>(2)</sup>	
VSS	5	5	P	—	Ground reference for logic and I/O pins.
VDD	14	14	P	—	Positive supply for logic and I/O pins.

Legend: I = input    O = output    I/O = input/output    P = power  
 — = Not used    TTL = TTL input    ST = Schmitt Trigger input

- Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.  
 Note 2: This buffer is a Schmitt Trigger input when used in serial programming mode.  
 Note 3: This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.

# PIC16C7X

**TABLE 3-3: PIC16C72 PINOUT DESCRIPTION**

Pin Name	DIP Pin#	SSOP Pin#	SOIC Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKIN	9	9	9	I	ST/CMOS <sup>(3)</sup>	Oscillator crystal input/external clock source input.
OSC2/CLKOUT	10	10	10	O	—	Oscillator crystal output. Connects to crystal or resonator in crystal oscillator mode. In RC mode, the OSC2 pin outputs CLKOUT which has 1/4 the frequency of OSC1, and denotes the instruction cycle rate.
MCLR/VPP	1	1	1	I/P	ST	Master clear (reset) input/programming voltage input. This pin is an active low reset to the device.
RA0/AN0	2	2	2	I/O	TTL	PORTA is a bi-directional I/O port. Analog input0 Analog input1 Analog input2 Analog input3/V <sub>REF</sub> Can also be selected to be the clock input to the Timer0 module. Output is open drain type. Analog input4 can also be the slave select for the synchronous serial port.
RA1/AN1	3	3	3	I/O	TTL	
RA2/AN2	4	4	4	I/O	TTL	
RA3/AN3/V <sub>REF</sub>	5	5	5	I/O	TTL	
RA4/TOCKI	6	6	6	I/O	ST	
RA5/AN4/ $\overline{SS}$	7	7	7	I/O	TTL	
RB0/INT	21	21	21	I/O	TTL/ST <sup>(1)</sup>	PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs. RB0/INT can also be selected as an external interrupt pin.  Interrupt on change pin. Interrupt on change pin. Interrupt on change pin. Serial programming clock. Interrupt on change pin. Serial programming data.
RB1	22	22	22	I/O	TTL	
RB2	23	23	23	I/O	TTL	
RB3	24	24	24	I/O	TTL	
RB4	25	25	25	I/O	TTL	
RB5	26	26	26	I/O	TTL	
RB6	27	27	27	I/O	TTL/ST <sup>(2)</sup>	
RB7	28	28	28	I/O	TTL/ST <sup>(2)</sup>	
RC0/T1OSO/T1CKI	11	11	11	I/O	ST	PORTC is a bi-directional I/O port. RC0/T1OSO/T1CKI can also be selected as a Timer1 oscillator output/Timer1 clock input. RC1/T1OSI can also be selected as a Timer1 oscillator input. RC2/CCP1 can also be selected as a Capture1 input/Compare1 output/PWM1 output. RC3/SCK/SCL can also be selected as the synchronous serial clock input/output for both SPI and I <sup>2</sup> C modes. RC4/SDI/SDA can also be selected as the SPI Data In (SPI mode) or data I/O (I <sup>2</sup> C mode). RC5/SDO can also be selected as the SPI Data Out (SPI mode).
RC1/T1OSI	12	12	12	I/O	ST	
RC2/CCP1	13	13	13	I/O	ST	
RC3/SCK/SCL	14	14	14	I/O	ST	
RC4/SDI/SDA	15	15	15	I/O	ST	
RC5/SDO	16	16	16	I/O	ST	
RC6	17	17	17	I/O	ST	
RC7	18	18	18	I/O	ST	
Vss	8, 19	8, 19	8, 19	P	—	Ground reference for logic and I/O pins.
VDD	20	20	20	P	—	Positive supply for logic and I/O pins.

Legend: I = input      O = output      I/O = input/output      P = power  
 — = Not used      TTL = TTL input      ST = Schmitt Trigger input

- Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.  
 2: This buffer is a Schmitt Trigger input when used in serial programming mode.  
 3: This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.



**TABLE 3-4: PIC16C73/73A PINOUT DESCRIPTION**

Pin Name	DIP Pin#	SOIC Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKIN	9	9	I	ST/CMOS <sup>(3)</sup>	Oscillator crystal input/external clock source input.
OSC2/CLKOUT	10	10	O	—	Oscillator crystal output. Connects to crystal or resonator in crystal oscillator mode. In RC mode, the OSC2 pin outputs CLKOUT which has 1/4 the frequency of OSC1, and denotes the instruction cycle rate.
MCLR/VPP	1	1	I/P	ST	Master clear (reset) input/programming voltage input. This pin is an active low reset to the device.
RA0/AN0	2	2	I/O	TTL	PORTA is a bi-directional I/O port. Analog input0 Analog input1 Analog input2 Analog input3/VREF Can also be selected to be the clock input to the Timer0 module. Output is open drain type. Analog input4 can also be the slave select for the synchronous serial port.
RA1/AN1	3	3	I/O	TTL	
RA2/AN2	4	4	I/O	TTL	
RA3/AN3/VREF	5	5	I/O	TTL	
RA4/T0CKI	6	6	I/O	ST	
RA5/AN4/ $\overline{SS}$	7	7	I/O	TTL	
RB0/INT	21	21	I/O	TTL/ST <sup>(1)</sup>	PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs. RB0/INT can also be selected as an external interrupt pin.  Interrupt on change pin. Interrupt on change pin. Interrupt on change pin. Serial programming clock. Interrupt on change pin. Serial programming data.
RB1	22	22	I/O	TTL	
RB2	23	23	I/O	TTL	
RB3	24	24	I/O	TTL	
RB4	25	25	I/O	TTL	
RB5	26	26	I/O	TTL	
RB6	27	27	I/O	TTL/ST <sup>(2)</sup>	
RB7	28	28	I/O	TTL/ST <sup>(2)</sup>	
RC0/T1OSO/T1CKI	11	11	I/O	ST	PORTC is a bi-directional I/O port. RC0/T1OSO/T1CKI can also be selected as a Timer1 oscillator output/Timer1 clock input. RC1/T1OSI/CCP2 can also be selected as a Timer1 oscillator input or Capture2 input/Compare2 output/PWM2 output. RC2/CCP1 can also be selected as a Capture1 input/Compare1 output/PWM1 output. RC3/SCK/SCL can also be selected as the synchronous serial clock input/output for both SPI and I <sup>2</sup> C modes. RC4/SDI/SDA can also be selected as the SPI Data In (SPI mode) or data I/O (I <sup>2</sup> C mode). RC5/SDO can also be selected as the SPI Data Out (SPI mode). RC6/TX/CK can also be selected as Asynchronous Transmit or USART Synchronous Clock. RC7/RX/DT can also be selected as the Asynchronous Receive or USART Synchronous Data.
RC1/T1OSI/CCP2	12	12	I/O	ST	
RC2/CCP1	13	13	I/O	ST	
RC3/SCK/SCL	14	14	I/O	ST	
RC4/SDI/SDA	15	15	I/O	ST	
RC5/SDO	16	16	I/O	ST	
RC6/TX/CK	17	17	I/O	ST	
RC7/RX/DT	18	18	I/O	ST	
Vss	8, 19	8, 19	P	—	Ground reference for logic and I/O pins.
VDD	20	20	P	—	Positive supply for logic and I/O pins.

Legend: I = input    O = output    I/O = input/output    P = power  
 — = Not used    TTL = TTL input    ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.  
 2: This buffer is a Schmitt Trigger input when used in serial programming mode.  
 3: This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.

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**TABLE 3-5: PIC16C74/74A PINOUT DESCRIPTION**

Pin Name	DIP Pin#	PLCC Pin#	QFP Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKIN	13	14	30	I	ST/CMOS <sup>(4)</sup>	Oscillator crystal input/external clock source input.
OSC2/CLKOUT	14	15	31	O	—	Oscillator crystal output. Connects to crystal or resonator in crystal oscillator mode. In RC mode, OSC2 pin outputs CLKOUT which has 1/4 the frequency of OSC1, and denotes the instruction cycle rate.
MCLR/VPP	1	2	18	I/P	ST	Master clear (reset) input/programming voltage input. This pin is an active low reset to the device.
RA0/AN0	2	3	19	I/O	TTL	PORTA is a bi-directional I/O port. Analog input0 Analog input1 Analog input2 Analog input3/VREF Can also be selected to be the clock input to the Timer0 timer/counter. Output is open drain type. Analog input4 can also be the slave select for the synchronous serial port.
RA1/AN1	3	4	20	I/O	TTL	
RA2/AN2	4	5	21	I/O	TTL	
RA3/AN3/VREF	5	6	22	I/O	TTL	
RA4/T0CKI	6	7	23	I/O	ST	
RA5/AN4/ $\overline{SS}$	7	8	24	I/O	TTL	
RB0/INT	33	36	8	I/O	TTL/ST <sup>(1)</sup>	PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs. RB0/INT can also be selected as an external interrupt pin.  Interrupt on change pin. Interrupt on change pin. Interrupt on change pin. Serial programming clock. Interrupt on change pin. Serial programming data.
RB1	34	37	9	I/O	TTL	
RB2	35	38	10	I/O	TTL	
RB3	36	39	11	I/O	TTL	
RB4	37	41	14	I/O	TTL	
RB5	38	42	15	I/O	TTL	
RB6	39	43	16	I/O	TTL/ST <sup>(2)</sup>	
RB7	40	44	17	I/O	TTL/ST <sup>(2)</sup>	

Legend: I = input    O = output    I/O = input/output    P = power  
 — = Not used    TTL = TTL input    ST = Schmitt Trigger input

- Note 1: This buffer is a Schmitt Trigger input when configured as an external interrupt.  
 Note 2: This buffer is a Schmitt Trigger input when used in serial programming mode.  
 Note 3: This buffer is a Schmitt Trigger input when configured as general purpose I/O and a TTL input when used in the Parallel Slave Port mode (for interfacing to a microprocessor bus).  
 Note 4: This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.

**TABLE 3-5: PIC16C74/74A PINOUT DESCRIPTION (Cont'd)**

Pin Name	DIP Pin#	PLCC Pin#	QFP Pin#	I/O/P Type	Buffer Type	Description
RC0/T1OSO/T1CKI	15	16	32	I/O	ST	<p>PORTC is a bi-directional I/O port.</p> <p>RC0/T1OSO/T1CKI can also be selected as a Timer1 oscillator output or a Timer1 clock input.</p> <p>RC1/T1OSI/CCP2 can also be selected as a Timer1 oscillator input or Capture2 input/Compare2 output/PWM2 output.</p> <p>RC2/CCP1 can also be selected as a Capture1 input/Compare1 output/PWM1 output.</p> <p>RC3/SCK/SCL can also be selected as the synchronous serial clock input/output for both SPI and I<sup>2</sup>C modes.</p> <p>RC4/SDI/SDA can also be selected as the SPI Data In (SPI mode) or data I/O (I<sup>2</sup>C mode).</p> <p>RC5/SDO can also be selected as the SPI Data Out (SPI mode).</p> <p>RC6/TX/CK can also be selected as Asynchronous Transmit or USART Synchronous Clock.</p> <p>RC7/RX/DT can also be selected as the Asynchronous Receive or USART Synchronous Data.</p>
RC1/T1OSI/CCP2	16	18	35	I/O	ST	
RC2/CCP1	17	19	36	I/O	ST	
RC3/SCK/SCL	18	20	37	I/O	ST	
RC4/SDI/SDA	23	25	42	I/O	ST	
RC5/SDO	24	26	43	I/O	ST	
RC6/TX/CK	25	27	44	I/O	ST	
RC7/RX/DT	26	29	1	I/O	ST	
RD0/PSP0	19	21	38	I/O	ST/TTL <sup>(3)</sup>	<p>PORTD is a bi-directional I/O port or parallel slave port when interfacing to a microprocessor bus.</p>
RD1/PSP1	20	22	39	I/O	ST/TTL <sup>(3)</sup>	
RD2/PSP2	21	23	40	I/O	ST/TTL <sup>(3)</sup>	
RD3/PSP3	22	24	41	I/O	ST/TTL <sup>(3)</sup>	
RD4/PSP4	27	30	2	I/O	ST/TTL <sup>(3)</sup>	
RD5/PSP5	28	31	3	I/O	ST/TTL <sup>(3)</sup>	
RD6/PSP6	29	32	4	I/O	ST/TTL <sup>(3)</sup>	
RD7/PSP7	30	33	5	I/O	ST/TTL <sup>(3)</sup>	
RE0/RD/AN5	8	9	25	I/O	ST/TTL <sup>(3)</sup>	<p>PORTE is a bi-directional I/O port.</p> <p>RE0/RD/AN5 read control for parallel slave port, or analog input5.</p> <p>RE1/WR/AN6 write control for parallel slave port, or analog input6.</p> <p>RE2/CS/AN7 select control for parallel slave port, or analog input7.</p>
RE1/WR/AN6	9	10	26	I/O	ST/TTL <sup>(3)</sup>	
RE2/CS/AN7	10	11	27	I/O	ST/TTL <sup>(3)</sup>	
Vss	12,31	13,34	6,29	P	—	Ground reference for logic and I/O pins.
VDD	11,32	12,35	7,28	P	—	Positive supply for logic and I/O pins.
NC	—	1,17,28,40	12,13,33,34		—	These pins are not internally connected. These pins should be left unconnected.

Legend: I = input    O = output    I/O = input/output    P = power  
 — = Not used    TTL = TTL input    ST = Schmitt Trigger input

- Note 1: This buffer is a Schmitt Trigger input when configured as an external interrupt.  
 2: This buffer is a Schmitt Trigger input when used in serial programming mode.  
 3: This buffer is a Schmitt Trigger input when configured as general purpose I/O and a TTL input when used in the Parallel Slave Port mode (for interfacing to a microprocessor bus).  
 4: This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.

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## 3.1 Clocking Scheme/Instruction Cycle

The clock input (from OSC1) is internally divided by four to generate four non-overlapping quadrature clocks namely Q1, Q2, Q3 and Q4. Internally, the program counter (PC) is incremented every Q1, the instruction is fetched from the program memory and latched into the instruction register in Q4. The instruction is decoded and executed during the following Q1 through Q4. The clocks and instruction execution flow is shown in Figure 3-5.

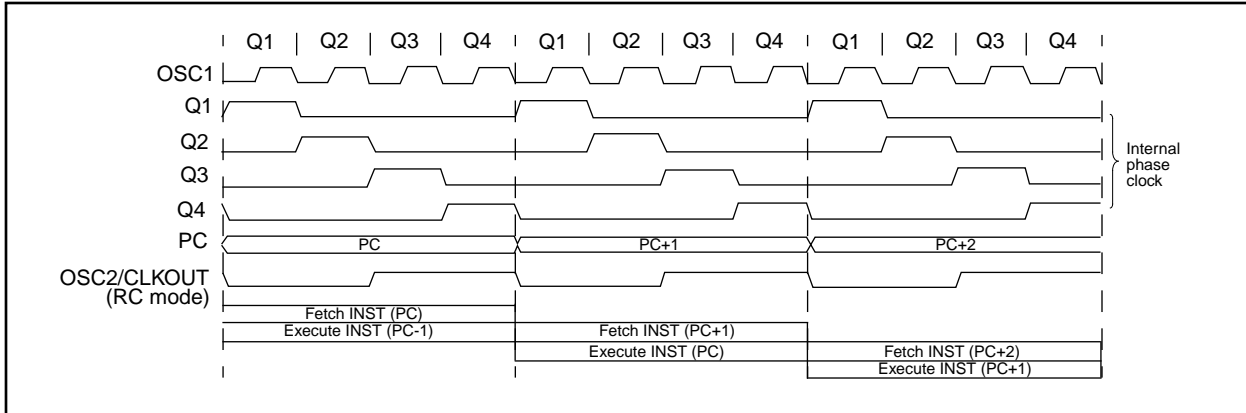
## 3.2 Instruction Flow/Pipelining

An "Instruction Cycle" consists of four Q cycles (Q1, Q2, Q3 and Q4). The instruction fetch and execute are pipelined such that fetch takes one instruction cycle while decode and execute takes another instruction cycle. However, due to the pipelining, each instruction effectively executes in one cycle. If an instruction causes the program counter to change (e.g. GOTO) then two cycles are required to complete the instruction (Example 3-1).

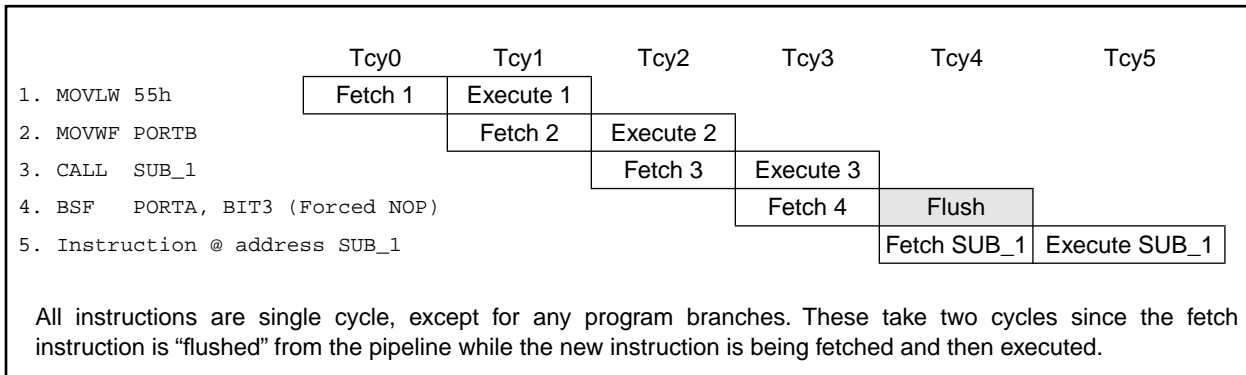
A fetch cycle begins with the program counter (PC) incrementing in Q1.

In the execution cycle, the fetched instruction is latched into the "Instruction Register" (IR) in cycle Q1. This instruction is then decoded and executed during the Q2, Q3, and Q4 cycles. Data memory is read during Q2 (operand read) and written during Q4 (destination write).

**FIGURE 3-5: CLOCK/INSTRUCTION CYCLE**



**EXAMPLE 3-1: INSTRUCTION PIPELINE FLOW**



## 4.0 MEMORY ORGANIZATION

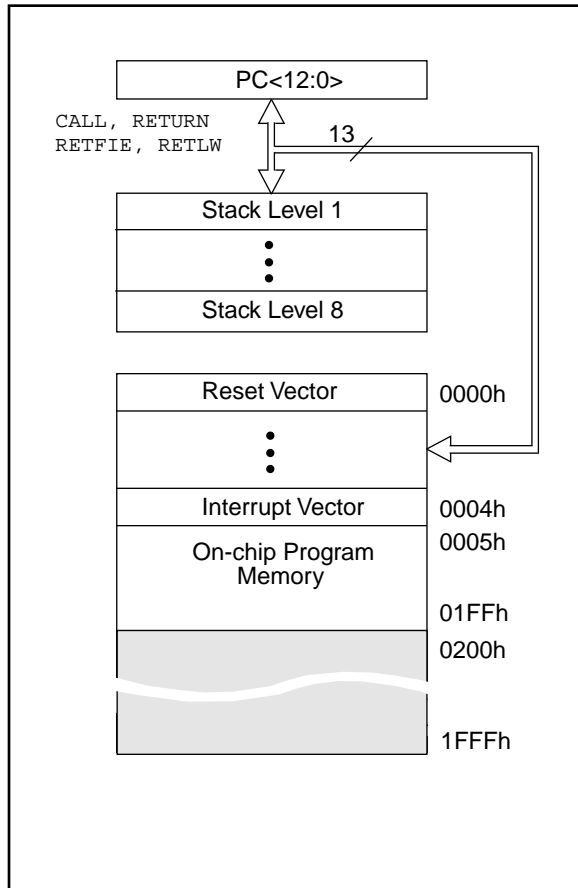
Applicable Devices							
710	71	711	72	73	73A	74	74A

### 4.1 Program Memory Organization

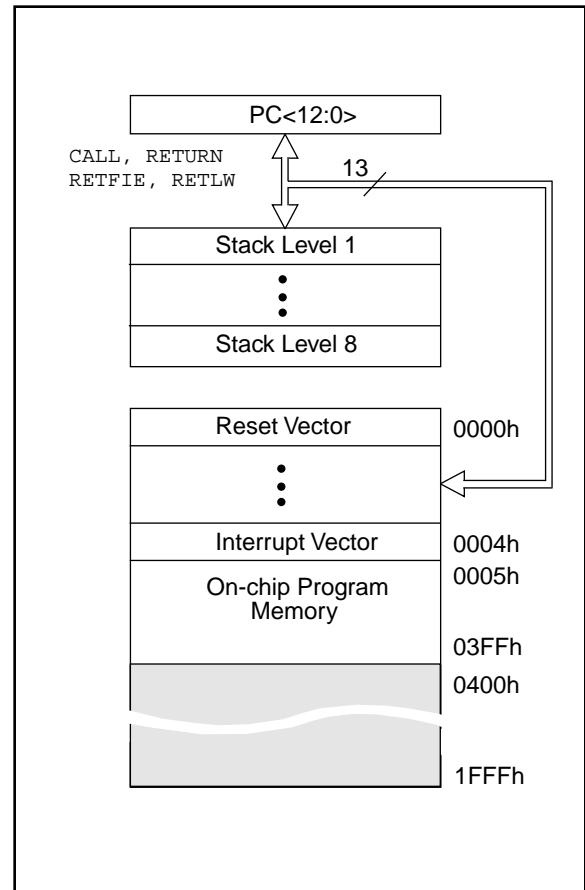
The PIC16C7X family has a 13-bit program counter capable of addressing an 8K x 14 program memory space.

For the PIC16C710, only the first 512 x 14 (0000h-01FFh) is physically implemented. For the PIC16C71/711 only the first 1K x 14 (0000h-03FFh) is implemented. For the PIC16C72, only the first 2K x 14 (0000h-07FFh) is implemented. For the PIC16C73, PIC16C73A, PIC16C74, and PIC16C74A, only the first 4K x 14 (0000h-0FFFh) is physically implemented. Accessing a location above the physically implemented address will cause a wraparound. The reset vector is at 0000h and the interrupt vector is at 0004h.

**FIGURE 4-1: PIC16C710 PROGRAM MEMORY MAP AND STACK**

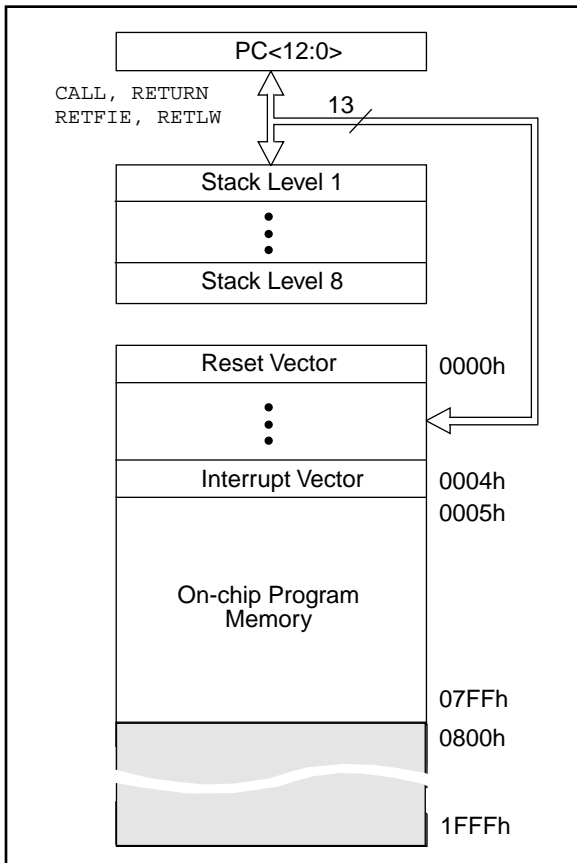


**FIGURE 4-2: PIC16C71/711 PROGRAM MEMORY MAP AND STACK**

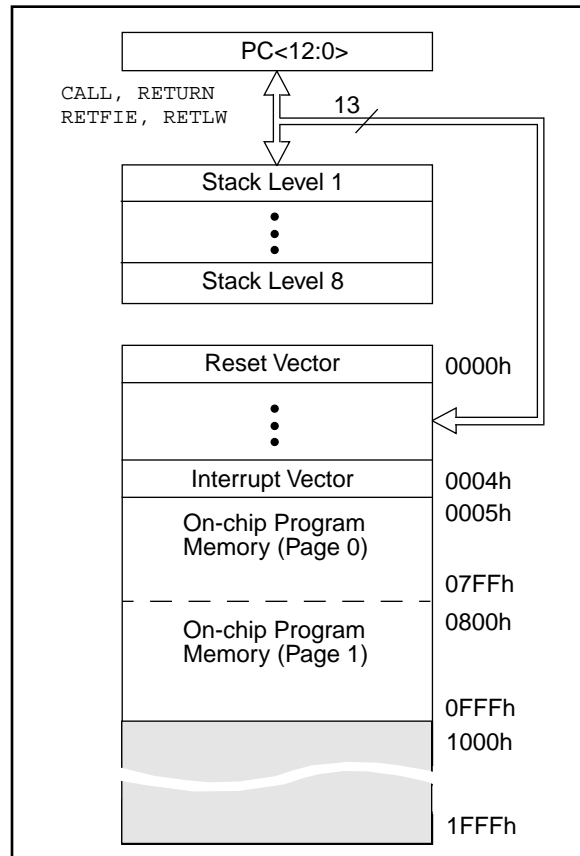


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**FIGURE 4-3: PIC16C72 PROGRAM MEMORY MAP AND STACK**



**FIGURE 4-4: PIC16C73/73A/74/74A PROGRAM MEMORY MAP AND STACK**



## 4.2 Data Memory Organization

Applicable Devices							
710	711	711	72	73	73A	74	74A

The data memory is partitioned into two Banks which contain the General Purpose Registers and the Special Function Registers. Bit RP0 is the bank select bit.

RP0 (STATUS<5>) = 1 → Bank 1

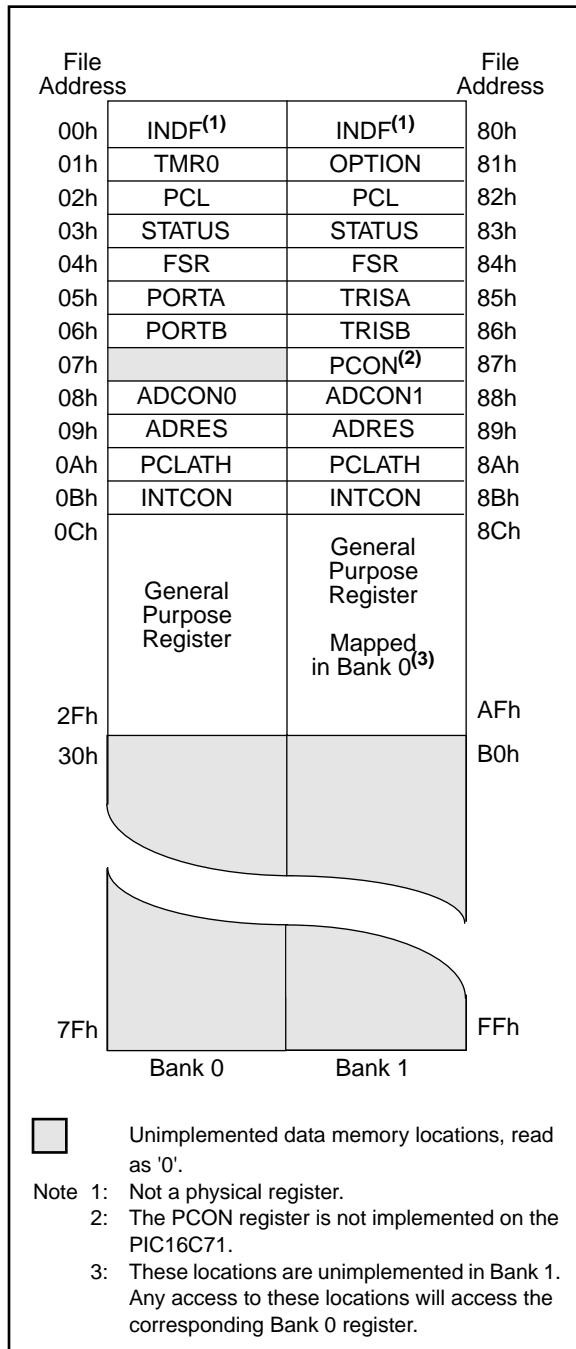
RP0 (STATUS<5>) = 0 → Bank 0

Each Bank extends up to 7Fh (128 bytes). The lower locations of each Bank are reserved for the Special Function Registers. Above the Special Function Registers are General Purpose Registers implemented as static RAM. Both Bank 0 and Bank 1 contain special function registers. Some "high use" special function registers from Bank 0 are mirrored in Bank 1 for code reduction and quicker access.

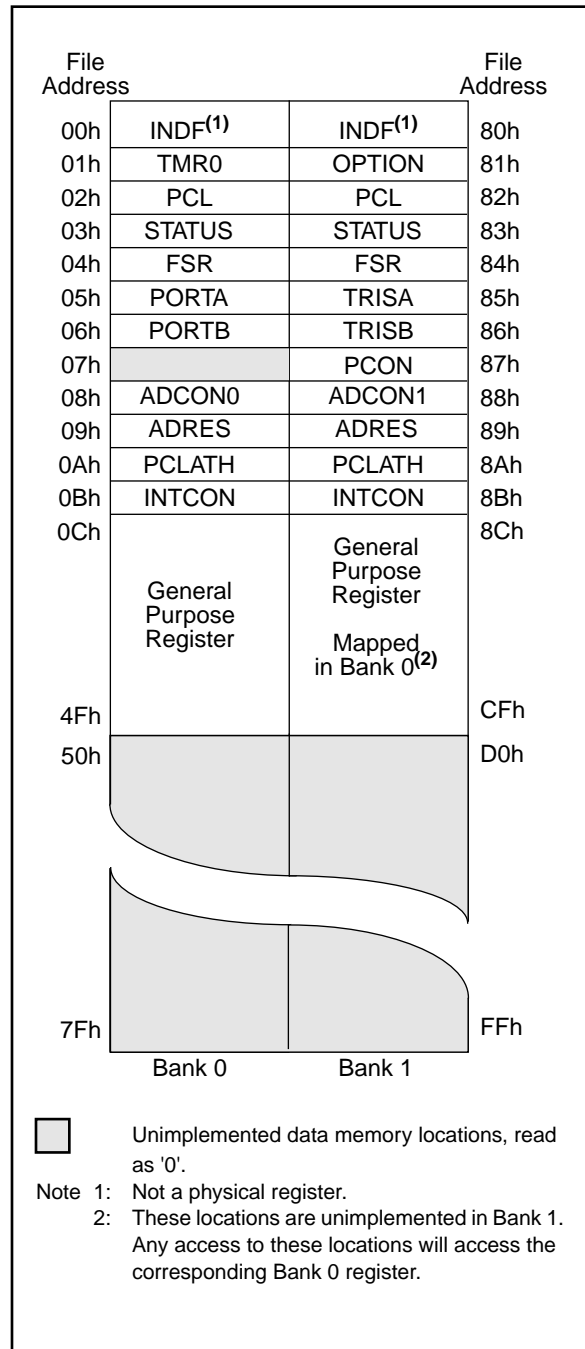
### 4.2.1 GENERAL PURPOSE REGISTER FILE

The register file can be accessed either directly, or indirectly through the File Select Register FSR (Section 4.5).

**FIGURE 4-5: PIC16C710/71 REGISTER FILE MAP**



**FIGURE 4-6: PIC16C711 REGISTER FILE MAP**







## 4.2.2 SPECIAL FUNCTION REGISTERS

The Special Function Registers are registers used by the CPU and Peripheral Modules for controlling the desired operation of the device. These registers are implemented as static RAM.

The special function registers can be classified into two sets (core and peripheral). Those registers associated with the “core” functions are described in this section, and those related to the operation of the peripheral features are described in the section of that peripheral feature.

**TABLE 4-1: PIC16C710/71/711 SPECIAL FUNCTION REGISTER SUMMARY**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets (1)
<b>Bank 0</b>											
00h <sup>(3)</sup>	INDF	Addressing this location uses contents of FSR to address data memory (not a physical register)								0000 0000	0000 0000
01h	TMR0	Timer0 module's register								xxxx xxxx	uuuu uuuu
02h <sup>(3)</sup>	PCL	Program Counter's (PC) Least Significant Byte								0000 0000	0000 0000
03h <sup>(3)</sup>	STATUS	IRP <sup>(5)</sup>	RP1 <sup>(5)</sup>	RP0	$\overline{TO}$	$\overline{PD}$	Z	DC	C	0001 1xxx	000q quuu
04h <sup>(3)</sup>	FSR	Indirect data memory address pointer								xxxx xxxx	uuuu uuuu
05h	PORTA	—	—	—	PORTA Data Latch when written: PORTA pins when read					---x 0000	---u 0000
06h	PORTB	PORTB Data Latch when written: PORTB pins when read								xxxx xxxx	uuuu uuuu
07h	—	Unimplemented								—	—
08h	ADCON0	ADCS1	ADCS0	(6)	CHS1	CHS0	GO/ $\overline{DONE}$	ADIF	ADON	00-0 0000	00-0 0000
09h <sup>(3)</sup>	ADRES	A/D Result Register								xxxx xxxx	uuuu uuuu
0Ah <sup>(2,3)</sup>	PCLATH	—	—	—	Write Buffer for the upper 5 bits of the Program Counter					---0 0000	---0 0000
0Bh <sup>(3)</sup>	INTCON	GIE	ADIE	TOIE	INTE	RBIE	TOIF	INTF	RBIF	0000 000x	0000 000u
<b>Bank 1</b>											
80h <sup>(3)</sup>	INDF	Addressing this location uses contents of FSR to address data memory (not a physical register)								0000 0000	0000 0000
81h	OPTION	$\overline{RBPU}$	INTEDG	TOCS	TOSE	PSA	PS2	PS1	PS0	1111 1111	1111 1111
82h <sup>(3)</sup>	PCL	Program Counter's (PC) Least Significant Byte								0000 0000	0000 0000
83h <sup>(3)</sup>	STATUS	IRP <sup>(5)</sup>	RP1 <sup>(5)</sup>	RP0	$\overline{TO}$	$\overline{PD}$	Z	DC	C	0001 1xxx	000q quuu
84h <sup>(3)</sup>	FSR	Indirect data memory address pointer								xxxx xxxx	uuuu uuuu
85h	TRISA	—	—	—	PORTA Data Direction Register					---1 1111	---1 1111
86h	TRISB	PORTB Data Direction Control Register								1111 1111	1111 1111
87h <sup>(4)</sup>	PCON	—	—	—	—	—	—	$\overline{POR}$	$\overline{BOR}$	---- --qq	---- --uu
88h	ADCON1	—	—	—	—	—	—	PCFG1	PCFG0	---- --00	---- --00
89h <sup>(3)</sup>	ADRES	A/D Result Register								xxxx xxxx	uuuu uuuu
8Ah <sup>(2,3)</sup>	PCLATH	—	—	—	Write Buffer for the upper 5 bits of the Program Counter					---0 0000	---0 0000
8Bh <sup>(3)</sup>	INTCON	GIE	ADIE	TOIE	INTE	RBIE	TOIF	INTF	RBIF	0000 000x	0000 000u

Legend: x = unknown, u = unchanged, q = value depends on condition, - = unimplemented read as '0'.  
Shaded locations are unimplemented, read as '0'.

Note 1: Other (non power-up) resets include external reset through  $\overline{MCLR}$  and Watchdog Timer Reset.

2: The upper byte of the program counter is not directly accessible. PCLATH is a holding register for the PC<12:8> whose contents are transferred to the upper byte of the program counter.

3: These registers can be addressed from either bank.

4: The PCON register is not physically implemented in the PIC16C71, read as '0'.

5: The IRP and RP1 bits are reserved on the PIC16C7X, always maintain these bits clear.

6: Bit5 of ADCON0 is a General Purpose R/W bit for the PIC16C71 only. For the PIC16C710/711, this bit is unimplemented, read as '0'.

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**TABLE 4-2: PIC16C72 SPECIAL FUNCTION REGISTER SUMMARY**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets (3)	
<b>Bank 0</b>												
00h <sup>(1)</sup>	INDF	Addressing this location uses contents of FSR to address data memory (not a physical register)								0000 0000	0000 0000	
01h	TMR0	Timer0 module's register								xxxx xxxx	uuuu uuuu	
02h <sup>(1)</sup>	PCL	Program Counter's (PC) Least Significant Byte								0000 0000	0000 0000	
03h <sup>(1)</sup>	STATUS	IRP <sup>(4)</sup>	RP1 <sup>(4)</sup>	RP0	T0	PD	Z	DC	C	0001 1xxx	000q quuu	
04h <sup>(1)</sup>	FSR	Indirect data memory address pointer								xxxx xxxx	uuuu uuuu	
05h	PORTA	—	—	PORTA Data Latch when written: PORTA pins when read						--0x 0000	--0u 0000	
06h	PORTB	PORTB Data Latch when written: PORTB pins when read								xxxx xxxx	uuuu uuuu	
07h	PORTC	PORTC Data Latch when written: PORTC pins when read								xxxx xxxx	uuuu uuuu	
08h	—	Unimplemented								—	—	
09h	—	Unimplemented								—	—	
0Ah <sup>(1,2)</sup>	PCLATH	—	—	—	Write Buffer for the upper 5 bits of the Program Counter						---0 0000	---0 0000
0Bh <sup>(1)</sup>	INTCON	GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	0000 000x	0000 000u	
0Ch	PIR1	—	ADIF	—	—	SSPIF	CCP1IF	TMR2IF	TMR1IF	-0-- 0000	-0-- 0000	
0Dh	—	Unimplemented								—	—	
0Eh	TMR1L	Holding register for the Least Significant Byte of the 16-bit TMR1 register								xxxx xxxx	uuuu uuuu	
0Fh	TMR1H	Holding register for the Most Significant Byte of the 16-bit TMR1 register								xxxx xxxx	uuuu uuuu	
10h	T1CON	—	—	T1CKPS1	T1CKPS0	T1OSCEN	T1SYNC	TMR1CS	TMR1ON	--00 0000	--uu uuuu	
11h	TMR2	Timer2 module's register								0000 0000	0000 0000	
12h	T2CON	—	TOUTPS3	TOUTPS2	TOUTPS1	TOUTPS0	TMR2ON	T2CKPS1	T2CKPS0	-000 0000	-000 0000	
13h	SSPBUF	Synchronous Serial Port Receive Buffer/Transmit Register								xxxx xxxx	uuuu uuuu	
14h	SSPCON	WCOL	SSPOV	SSPEN	CKP	SSPM3	SSPM2	SSPM1	SSPM0	0000 0000	0000 0000	
15h	CCPR1L	Capture/Compare/PWM Register (LSB)								xxxx xxxx	uuuu uuuu	
16h	CCPR1H	Capture/Compare/PWM Register (MSB)								xxxx xxxx	uuuu uuuu	
17h	CCP1CON	—	—	CCP1X	CCP1Y	CCP1M3	CCP1M2	CCP1M1	CCP1M0	--00 0000	--00 0000	
18h	—	Unimplemented								—	—	
19h	—	Unimplemented								—	—	
1Ah	—	Unimplemented								—	—	
1Bh	—	Unimplemented								—	—	
1Ch	—	Unimplemented								—	—	
1Dh	—	Unimplemented								—	—	
1Eh	ADRES	A/D Result Register								xxxx xxxx	uuuu uuuu	
1Fh	ADCON0	ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/DONE	—	ADON	0000 00-0	0000 00-0	

Legend: x = unknown, u = unchanged, q = value depends on condition, - = unimplemented read as '0'.  
Shaded locations are unimplemented, read as '0'.

- Note 1: These registers can be addressed from either bank.  
 2: The upper byte of the program counter is not directly accessible. PCLATH is a holding register for the PC<12:8> whose contents are transferred to the upper byte of the program counter.  
 3: Other (non power-up) resets include external reset through MCLR and Watchdog Timer Reset.  
 4: The IRP and RP1 bits are reserved on the PIC16C7X, always maintain these bits clear.

**TABLE 4-2: PIC16C72 SPECIAL FUNCTION REGISTER SUMMARY (Cont.'d)**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets (3)
<b>Bank 1</b>											
80h <sup>(1)</sup>	INDF	Addressing this location uses contents of FSR to address data memory (not a physical register)								0000 0000	0000 0000
81h	OPTION	RBP $\bar{U}$	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0	1111 1111	1111 1111
82h <sup>(1)</sup>	PCL	Program Counter's (PC) Least Significant Byte								0000 0000	0000 0000
83h <sup>(1)</sup>	STATUS	IRP <sup>(4)</sup>	RP1 <sup>(4)</sup>	RP0	$\bar{T}O$	$\bar{P}D$	Z	DC	C	0001 1xxx	000q quuu
84h <sup>(1)</sup>	FSR	Indirect data memory address pointer								xxxx xxxx	uuuu uuuu
85h	TRISA	—	—	PORTA Data Direction Register						--11 1111	--11 1111
86h	TRISB	PORTB Data Direction Register								1111 1111	1111 1111
87h	TRISC	PORTC Data Direction Register								1111 1111	1111 1111
88h	—	Unimplemented								—	—
89h	—	Unimplemented								—	—
8Ah <sup>(1,2)</sup>	PCLATH	—	—	—	Write Buffer for the upper 5 bits of the PC					---0 0000	---0 0000
8Bh <sup>(1)</sup>	INTCON	GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBF	0000 000x	0000 000u
8Ch	PIE1	—	ADIE	—	—	SSPIE	CCP1IE	TMR2IE	TMR1IE	-0-- 0000	-0-- 0000
8Dh	—	Unimplemented								—	—
8Eh	PCON	—	—	—	—	—	—	POR	$\bar{B}OR$	---- -gq	---- -uu
8Fh	—	Unimplemented								—	—
90h	—	Unimplemented								—	—
91h	—	Unimplemented								—	—
92h	PR2	Timer2 Period Register								1111 1111	1111 1111
93h	SSPADD	Synchronous Serial Port (I <sup>2</sup> C mode) Address Register								0000 0000	0000 0000
94h	SSPSTAT	—	—	D/ $\bar{A}$	P	S	R/ $\bar{W}$	UA	BF	--00 0000	--00 0000
95h	—	Unimplemented								—	—
96h	—	Unimplemented								—	—
97h	—	Unimplemented								—	—
98h	—	Unimplemented								—	—
99h	—	Unimplemented								—	—
9Ah	—	Unimplemented								—	—
9Bh	—	Unimplemented								—	—
9Ch	—	Unimplemented								—	—
9Dh	—	Unimplemented								—	—
9Eh	—	Unimplemented								—	—
9Fh	ADCON1	—	—	—	—	—	PCFG2	PCFG1	PCFG0	---- -000	---- -000

Legend: x = unknown, u = unchanged, q = value depends on condition, - = unimplemented read as '0'.

Shaded locations are unimplemented, read as '0'.

Note 1: These registers can be addressed from either bank.

2: The upper byte of the program counter is not directly accessible. PCLATH is a holding register for the PC<12:8> whose contents are transferred to the upper byte of the program counter.

3: Other (non power-up) resets include external reset through  $\bar{M}CLR$  and Watchdog Timer Reset.

4: The IRP and RP1 bits are reserved on the PIC16C7X, always maintain these bits clear.

# PIC16C7X

**TABLE 4-3: PIC16C73/73A/74/74A SPECIAL FUNCTION REGISTER SUMMARY**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets (2)
<b>Bank 0</b>											
00h <sup>(4)</sup>	INDF	Addressing this location uses contents of FSR to address data memory (not a physical register)								0000 0000	0000 0000
01h	TMR0	Timer0 module's register								xxxx xxxx	uuuu uuuu
02h <sup>(4)</sup>	PCL	Program Counter's (PC) Least Significant Byte								0000 0000	0000 0000
03h <sup>(4)</sup>	STATUS	IRP <sup>(7)</sup>	RP1 <sup>(7)</sup>	RP0	TO	PD	Z	DC	C	0001 1xxx	000q quuu
04h <sup>(4)</sup>	FSR	Indirect data memory address pointer								xxxx xxxx	uuuu uuuu
05h	PORTA	—	—	PORTA Data Latch when written: PORTA pins when read						--0x 0000	--0u 0000
06h	PORTB	PORTB Data Latch when written: PORTB pins when read								xxxx xxxx	uuuu uuuu
07h	PORTC	PORTC Data Latch when written: PORTC pins when read								xxxx xxxx	uuuu uuuu
08h <sup>(5)</sup>	PORTD	PORTD Data Latch when written: PORTD pins when read								xxxx xxxx	uuuu uuuu
09h <sup>(5)</sup>	PORTE	—	—	—	—	—	RE2	RE1	RE0	---- -xxx	---- -uuu
0Ah <sup>(1,4)</sup>	PCLATH	—	—	—	Write Buffer for the upper 5 bits of the Program Counter					---0 0000	---0 0000
0Bh <sup>(4)</sup>	INTCON	GIE	PEIE	TOIE	INTE	RBIE	T0IF	INTF	RBIF	0000 000x	0000 000u
0Ch	PIR1	PSPIF <sup>(3)</sup>	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
0Dh	PIR2	—	—	—	—	—	—	—	CCP2IF	---- --0	---- --0
0Eh	TMR1L	Holding register for the Least Significant Byte of the 16-bit TMR1 register								xxxx xxxx	uuuu uuuu
0Fh	TMR1H	Holding register for the Most Significant Byte of the 16-bit TMR1 register								xxxx xxxx	uuuu uuuu
10h	T1CON	—	—	T1CKPS1	T1CKPS0	T1OSCEN	T1SYNCR	TMR1CS	TMR1ON	--00 0000	--uu uuuu
11h	TMR2	Timer2 module's register								0000 0000	0000 0000
12h	T2CON	—	TOUTPS3	TOUTPS2	TOUTPS1	TOUTPS0	TMR2ON	T2CKPS1	T2CKPS0	-000 0000	-000 0000
13h	SSPBUF	Synchronous Serial Port Receive Buffer/Transmit Register								xxxx xxxx	uuuu uuuu
14h	SSPCON	WCOL	SSPOV	SSPEN	CKP	SSPM3	SSPM2	SSPM1	SSPM0	0000 0000	0000 0000
15h	CCPR1L	Capture/Compare/PWM Register1 (LSB)								xxxx xxxx	uuuu uuuu
16h	CCPR1H	Capture/Compare/PWM Register1 (MSB)								xxxx xxxx	uuuu uuuu
17h	CCP1CON	—	—	CCP1X	CCP1Y	CCP1M3	CCP1M2	CCP1M1	CCP1M0	--00 0000	--00 0000
18h	RCSTA	SPEN	RX9	SREN	CREN	—	FERR	OERR	RX9D	0000 -00x	0000 -00x
19h	TXREG	USART Transmit Data Register								0000 0000	0000 0000
1Ah	RCREG	USART Receive Data Register								0000 0000	0000 0000
1Bh	CCPR2L	Capture/Compare/PWM Register2 (LSB)								xxxx xxxx	uuuu uuuu
1Ch	CCPR2H	Capture/Compare/PWM Register2 (MSB)								xxxx xxxx	uuuu uuuu
1Dh	CCP2CON	—	—	CCP2X	CCP2Y	CCP2M3	CCP2M2	CCP2M1	CCP2M0	--00 0000	--00 0000
1Eh	ADRES	A/D Result Register								xxxx xxxx	uuuu uuuu
1Fh	ADCON0	ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/DONE	—	ADON	0000 00-0	0000 00-0

Legend: x = unknown, u = unchanged, q = value depends on condition, - = unimplemented read as '0'.  
Shaded locations are unimplemented, read as '0'.

- Note 1: The upper byte of the program counter is not directly accessible. PCLATH is a holding register for the PC<12:8> whose contents are transferred to the upper byte of the program counter.
- 2: Other (non power-up) resets include external reset through MCLR and Watchdog Timer Reset.
- 3: Bits PSPIE and PSPIF are reserved on the PIC16C73/73A, always maintain these bits clear.
- 4: These registers can be addressed from either bank.
- 5: PORTD and PORTE are not physically implemented on the PIC16C73/73A, read as '0'.
- 6: Brown-out Reset is not implemented on the PIC16C73 or the PIC16C74, read as '0'.
- 7: The IRP and RP1 bits are reserved on the PIC16C7X, always maintain these bits clear.

**TABLE 4-3: PIC16C73/73A/74/74A SPECIAL FUNCTION REGISTER SUMMARY (Cont.'d)**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets (2)
<b>Bank 1</b>											
80h <sup>(4)</sup>	INDF	Addressing this location uses contents of FSR to address data memory (not a physical register)								0000 0000	0000 0000
81h	OPTION	RBP $\bar{U}$	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0	1111 1111	1111 1111
82h <sup>(4)</sup>	PCL	Program Counter's (PC) Least Significant Byte								0000 0000	0000 0000
83h <sup>(4)</sup>	STATUS	IRP <sup>(7)</sup>	RP1 <sup>(7)</sup>	RP0	$\bar{T}O$	$\bar{P}D$	Z	DC	C	0001 1xxx	000q quuu
84h <sup>(4)</sup>	FSR	Indirect data memory address pointer								xxxx xxxx	uuuu uuuu
85h	TRISA	—	—	PORTA Data Direction Register						--11 1111	--11 1111
86h	TRISB	PORTB Data Direction Register								1111 1111	1111 1111
87h	TRISC	PORTC Data Direction Register								1111 1111	1111 1111
88h <sup>(5)</sup>	TRISD	PORTD Data Direction Register								1111 1111	1111 1111
89h <sup>(5)</sup>	TRISE	IBF	OBF	IBOV	PSPMODE	—	TRISE2	TRISE1	TRISE0	0000 -111	0000 -111
8Ah <sup>(1,4)</sup>	PCLATH	—	—	—	Write Buffer for the upper 5 bits of the Program Counter					---0 0000	---0 0000
8Bh <sup>(4)</sup>	INTCON	GIE	PEIE	TOIE	INTE	RBIE	T0IF	INTF	RBIF	0000 000x	0000 000u
8Ch	PIE1	PSPIE <sup>(3)</sup>	ADIE	RCIE	TXIE	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
8Dh	PIE2	—	—	—	—	—	—	—	CCP2IE	---- --0	---- --0
8Eh	PCON	—	—	—	—	—	—	POR	$\bar{B}OR$ <sup>(6)</sup>	---- --qg	---- --uu
8Fh	—	Unimplemented								—	—
90h	—	Unimplemented								—	—
91h	—	Unimplemented								—	—
92h	PR2	Timer2 Period Register								1111 1111	1111 1111
93h	SSPADD	Synchronous Serial Port (I <sup>2</sup> C mode) Address Register								0000 0000	0000 0000
94h	SSPSTAT	—	—	D/ $\bar{A}$	P	S	R/ $\bar{W}$	UA	BF	--00 0000	--00 0000
95h	—	Unimplemented								—	—
96h	—	Unimplemented								—	—
97h	—	Unimplemented								—	—
98h	TXSTA	CSRC	TX9	TXEN	SYNC	—	BRGH	TRMT	TX9D	0000 -010	0000 -010
99h	SPBRG	Baud Rate Generator Register								0000 0000	0000 0000
9Ah	—	Unimplemented								—	—
9Bh	—	Unimplemented								—	—
9Ch	—	Unimplemented								—	—
9Dh	—	Unimplemented								—	—
9Eh	—	Unimplemented								—	—
9Fh	ADCON1	—	—	—	—	—	PCFG2	PCFG1	PCFG0	---- -000	---- -000

Legend: x = unknown, u = unchanged, q = value depends on condition, - = unimplemented read as '0'.

Shaded locations are unimplemented, read as '0'.

Note 1: The upper byte of the program counter is not directly accessible. PCLATH is a holding register for the PC<12:8> whose contents are transferred to the upper byte of the program counter.

2: Other (non power-up) resets include external reset through  $\bar{M}CLR$  and Watchdog Timer Reset.

3: Bits PSPIE and PSPIF are reserved on the PIC16C73/73A, always maintain these bits clear.

4: These registers can be addressed from either bank.

5: PORTD and PORTE are not physically implemented on the PIC16C73/73A, read as '0'.

6: Brown-out Reset is not implemented on the PIC16C73 or the PIC16C74, read as '0'.

7: The IRP and RP1 bits are reserved on the PIC16C7X, always maintain these bits clear.

# PIC16C7X

## 4.2.2.1 STATUS REGISTER

Applicable Devices							
710	711	712	713	73A	74	74A	

The STATUS register, shown in Figure 4-9, contains the arithmetic status of the ALU, the RESET status and the bank select bits for data memory.

The STATUS register can be the destination for any instruction, as with any other register. If the STATUS register is the destination for an instruction that affects the Z, DC or C bits, then the write to these three bits is disabled. These bits are set or cleared according to the device logic. Furthermore, the TO and PD bits are not writable. Therefore, the result of an instruction with the STATUS register as destination may be different than intended.

For example, CLRF STATUS will clear the upper-three bits and set the Z bit. This leaves the STATUS register as 000u u1uu (where u = unchanged).

It is recommended, therefore, that only BCF, BSF, SWAPF and MOVWF instructions are used to alter the STATUS register because these instructions do not affect the Z, C or DC bits from the STATUS register. For other instructions, not affecting any status bits, see the "Instruction Set Summary."

**Note 1:** Bits IRP and RP1 (STATUS<7:6>) are not used by the PIC16C7X and should be maintained clear. Use of these bits as general purpose R/W bits is NOT recommended, since this may affect upward compatibility with future products.

**Note 2:** The C and DC bits operate as a borrow and digit borrow bit, respectively, in subtraction. See the SUBLW and SUBWF instructions for examples.

**FIGURE 4-9: STATUS REGISTER (ADDRESS 03h, 83h)**

R/W-0	R/W-0	R/W-0	R-1	R-1	R/W-x	R/W-x	R/W-x	
IRP	RP1	RP0	TO	PD	Z	DC	C	
bit7								bit0
<p><b>R = Readable bit</b>  <b>W = Writable bit</b>  <b>U = Unimplemented bit, read as '0'</b>  <b>- n = Value at POR reset</b></p>								
<p>bit 7: <b>IRP:</b> Register Bank Select bit (used for indirect addressing)            1 = Bank 2, 3 (100h - 1FFh)            0 = Bank 0, 1 (00h - FFh)            The IRP bit is reserved on the PIC16C7X, always maintain this bit clear.</p>								
<p>bit 6-5: <b>RP1:RP0:</b> Register Bank Select bits (used for direct addressing)            11 = Bank 3 (180h - 1FFh)            10 = Bank 2 (100h - 17Fh)            01 = Bank 1 (80h - FFh)            00 = Bank 0 (00h - 7Fh)            Each bank is 128 bytes. The RP1 bit is reserved on the PIC16C7X, always maintain this bit clear.</p>								
<p>bit 4: <b>TO:</b> Time-out bit            1 = After power-up, CLRWDT instruction, or SLEEP instruction            0 = A WDT time-out occurred</p>								
<p>bit 3: <b>PD:</b> Power-down bit            1 = After power-up or by the CLRWDT instruction            0 = By execution of the SLEEP instruction</p>								
<p>bit 2: <b>Z:</b> Zero bit            1 = The result of an arithmetic or logic operation is zero            0 = The result of an arithmetic or logic operation is not zero</p>								
<p>bit 1: <b>DC:</b> Digit carry/borrow bit (ADDWF, ADDLW, SUBLW, SUBWF instructions)(for borrow the polarity is reversed)            1 = A carry-out from the 4th low order bit of the result occurred            0 = No carry-out from the 4th low order bit of the result</p>								
<p>bit 0: <b>C:</b> Carry/borrow bit (ADDWF, ADDLW, SUBLW, SUBWF instructions)            1 = A carry-out from the most significant bit of the result occurred            0 = No carry-out from the most significant bit of the result occurred            Note: For borrow the polarity is reversed. A subtraction is executed by adding the two's complement of the second operand. For rotate (RRF, RLF) instructions, this bit is loaded with either the high or low order bit of the source register.</p>								

## 4.2.2.2 OPTION REGISTER

Applicable Devices							
710	711	721	731	73A	741	74A	

The OPTION register is a readable and writable register which contains various control bits to configure the TMR0/WDT prescaler, the External INT Interrupt, TMR0, and the weak pull-ups on PORTB.

**Note:** To achieve a 1:1 prescaler assignment for the TMR0 register, assign the prescaler to the Watchdog Timer by setting bit PSA (OPTION<3>).

**FIGURE 4-10: OPTION REGISTER (ADDRESS 81h)**

R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1
$\overline{\text{RBP}}\overline{\text{U}}$	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0
bit7							bit0

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

bit 7:  **$\overline{\text{RBP}}\overline{\text{U}}$** : PORTB Pull-up Enable bit  
1 = PORTB pull-ups are disabled  
0 = PORTB pull-ups are enabled by individual port latch values

bit 6: **INTEDG**: Interrupt Edge Select bit  
1 = Interrupt on rising edge of RB0/INT pin  
0 = Interrupt on falling edge of RB0/INT pin

bit 5: **T0CS**: TMR0 Clock Source Select bit  
1 = Transition on RA4/T0CKI pin  
0 = Internal instruction cycle clock (CLKOUT)

bit 4: **T0SE**: TMR0 Source Edge Select bit  
1 = Increment on high-to-low transition on RA4/T0CKI pin  
0 = Increment on low-to-high transition on RA4/T0CKI pin

bit 3: **PSA**: Prescaler Assignment bit  
1 = Prescaler is assigned to the WDT  
0 = Prescaler is assigned to the Timer0 module

bit 2-0: **PS2:PS0**: Prescaler Rate Select bits

Bit Value	TMR0 Rate	WDT Rate
000	1 : 2	1 : 1
001	1 : 4	1 : 2
010	1 : 8	1 : 4
011	1 : 16	1 : 8
100	1 : 32	1 : 16
101	1 : 64	1 : 32
110	1 : 128	1 : 64
111	1 : 256	1 : 128

# PIC16C7X

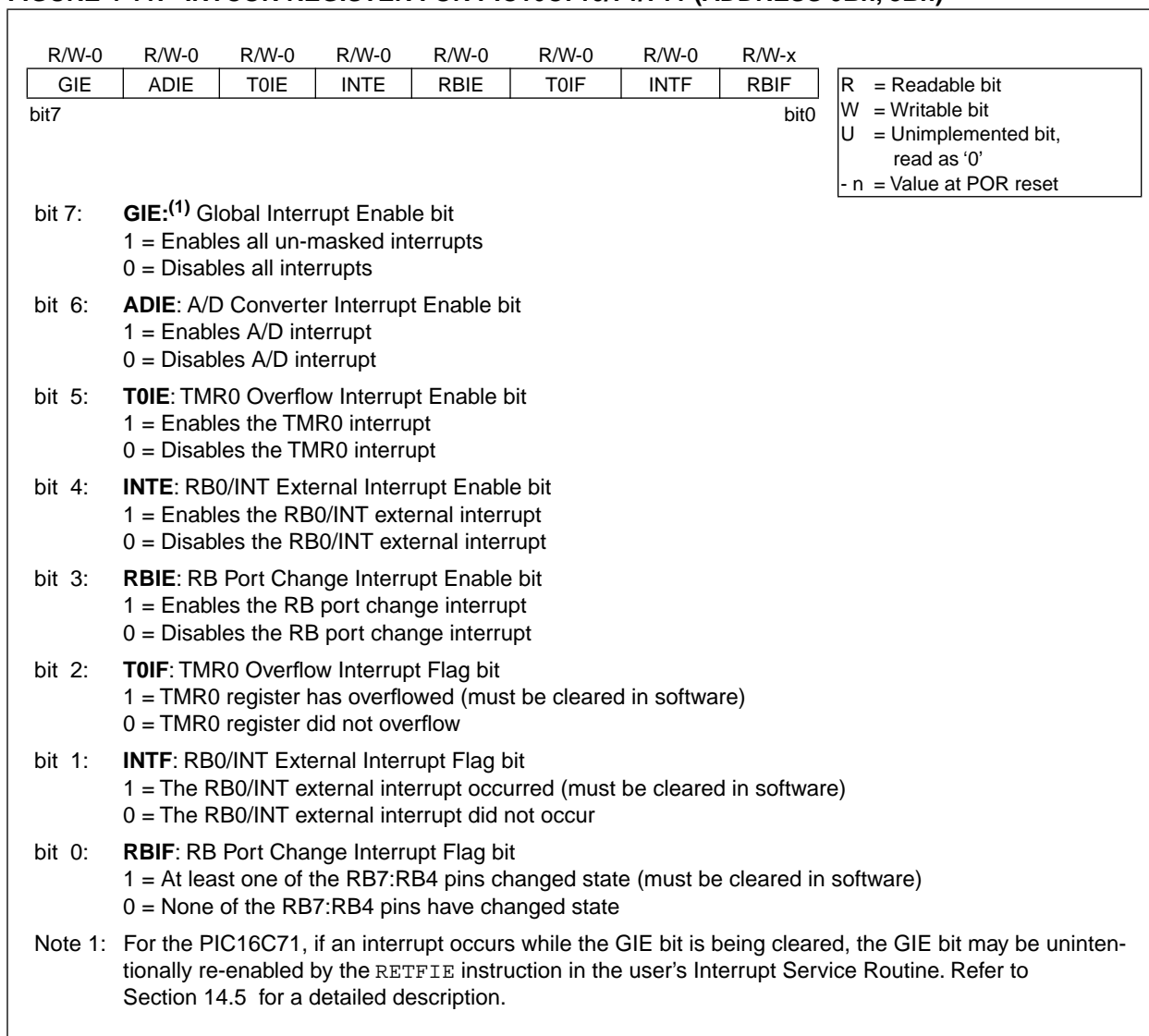
## 4.2.2.3 INTCON REGISTER

Applicable Devices							
710	711	72	73	73A	74	74A	

The INTCON Register is a readable and writable register which contains various enable and flag bits for the TMR0 register overflow, RB Port change and External RB0/INT Pin interrupts.

**Note:** Interrupt flag bits get set when an interrupt condition occurs regardless of the state of its corresponding enable bit or the global enable bit, GIE (INTCON<7>).

**FIGURE 4-11: INTCON REGISTER FOR PIC16C710/711/711 (ADDRESS 0Bh, 8Bh)**





**FIGURE 4-12: INTCON REGISTER FOR PIC16C72/73/73A/74/74A (ADDRESS 0Bh, 8Bh)**

	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-x
	GIE	PEIE	TOIE	INTE	RBIE	TOIF	INTF	RBIF
bit7								bit0
<div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p>R = Readable bit  W = Writable bit  U = Unimplemented bit, read as '0'  -n = Value at POR reset</p> </div>								
bit 7:	<p><b>GIE:</b><sup>(1)</sup> Global Interrupt Enable bit  1 = Enables all un-masked interrupts  0 = Disables all interrupts</p>							
bit 6:	<p><b>PEIE:</b> Peripheral Interrupt Enable bit  1 = Enables all un-masked peripheral interrupts  0 = Disables all peripheral interrupts</p>							
bit 5:	<p><b>TOIE:</b> TMR0 Overflow Interrupt Enable bit  1 = Enables the TMR0 interrupt  0 = Disables the TMR0 interrupt</p>							
bit 4:	<p><b>INTE:</b> RB0/INT External Interrupt Enable bit  1 = Enables the RB0/INT external interrupt  0 = Disables the RB0/INT external interrupt</p>							
bit 3:	<p><b>RBIE:</b> RB Port Change Interrupt Enable bit  1 = Enables the RB port change interrupt  0 = Disables the RB port change interrupt</p>							
bit 2:	<p><b>TOIF:</b> TMR0 Overflow Interrupt Flag bit  1 = TMR0 register has overflowed (must be cleared in software)  0 = TMR0 register did not overflow</p>							
bit 1:	<p><b>INTF:</b> RB0/INT External Interrupt Flag bit  1 = The RB0/INT external interrupt occurred (must be cleared in software)  0 = The RB0/INT external interrupt did not occur</p>							
bit 0:	<p><b>RBIF:</b> RB Port Change Interrupt Flag bit  1 = At least one of the RB7:RB4 pins changed state (must be cleared in software)  0 = None of the RB7:RB4 pins have changed state</p>							
<p>Note 1: For the PIC16C73 and PIC16C74, if an interrupt occurs while the GIE bit is being cleared, the GIE bit may be unintentionally re-enabled by the <code>RETFIE</code> instruction in the user's Interrupt Service Routine. Refer to Section 14.5 for a detailed description.</p>								

# PIC16C7X

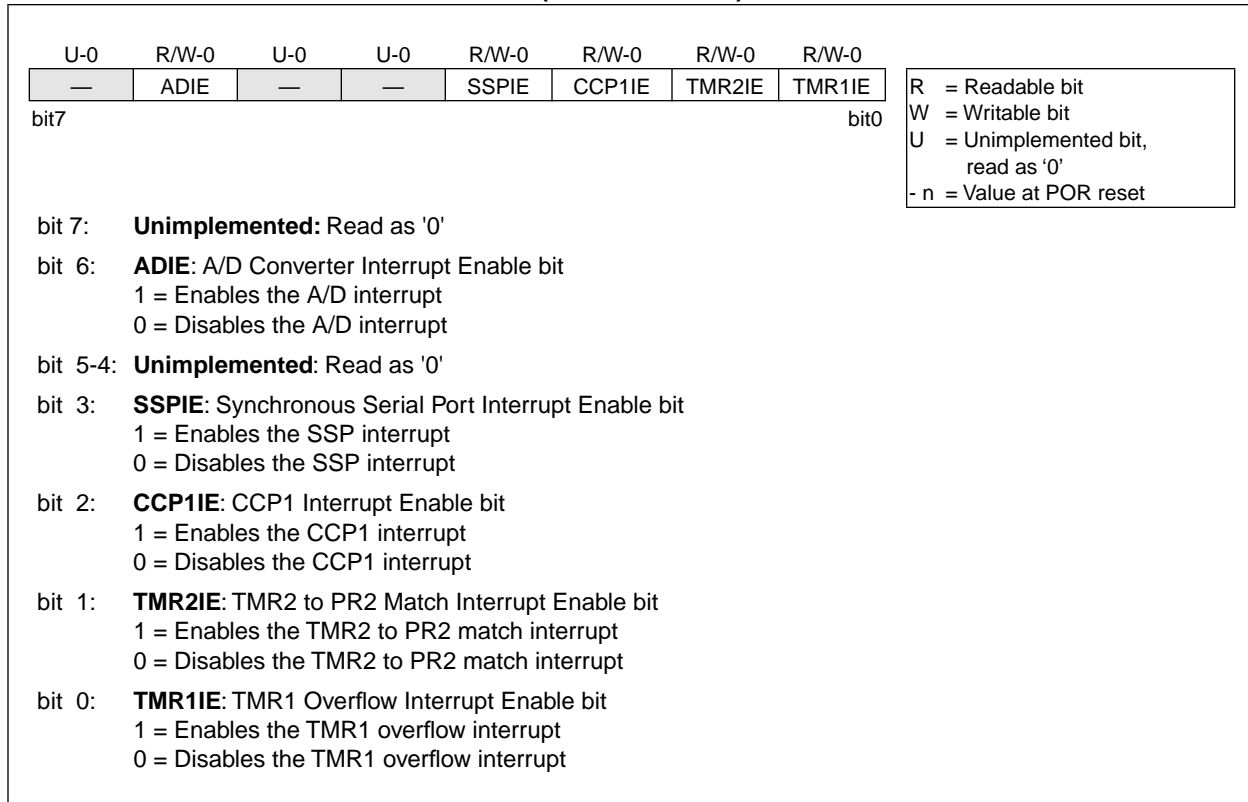
## 4.2.2.4 PIE1 REGISTER

Applicable Devices							
710	711	72	73	73A	74	74A	

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

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

**FIGURE 4-13: PIE1 REGISTER PIC16C72 (ADDRESS 8Ch)**



**FIGURE 4-14: PIE1 REGISTER PIC16C73/73A/74/74A (ADDRESS 8Ch)**

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	
PSPIE <sup>(1)</sup>	ADIE	RCIE	TXIE	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: **PSPIE<sup>(1)</sup>**: Parallel Slave Port Read/Write Interrupt Enable bit  
1 = Enables the PSP read/write interrupt  
0 = Disables the PSP read/write interrupt

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

bit 5: **RCIE**: USART Receive Interrupt Enable bit  
1 = Enables the USART receive interrupt  
0 = Disables the USART receive interrupt

bit 4: **TXIE**: USART Transmit Interrupt Enable bit  
1 = Enables the USART transmit interrupt  
0 = Disables the USART transmit interrupt

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: PIC16C73 and PIC16C73A devices do not have a Parallel Slave Port implemented, this bit location is reserved on these two devices, always maintain this bit clear.

# PIC16C7X

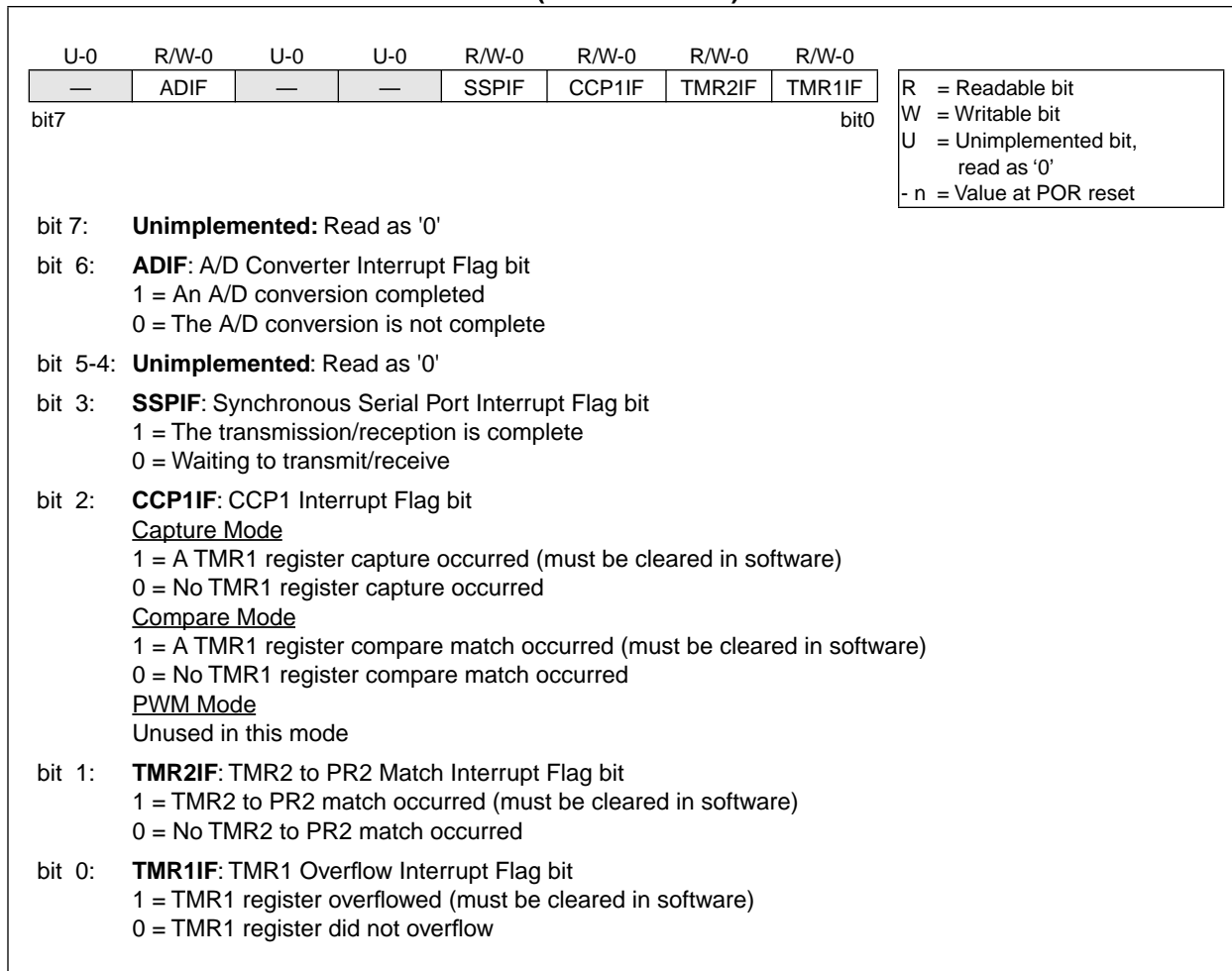
## 4.2.2.5 PIR1 REGISTER

Applicable Devices							
710	711	711	72	73	73A	74	74A

This register contains the individual flag bits for the Peripheral interrupts.

**Note:** Interrupt flag bits get set when an interrupt condition occurs regardless of the state of its corresponding enable bit or the global enable bit, GIE (INTCON<7>). User software should ensure the appropriate interrupt flag bits are clear prior to enabling an interrupt.

**FIGURE 4-15: PIR1 REGISTER PIC16C72 (ADDRESS 0Ch)**



**FIGURE 4-16: PIR1 REGISTER PIC16C73/73A/74/74A (ADDRESS 0Ch)**

R/W-0	R/W-0	R-0	R-0	R/W-0	R/W-0	R/W-0	R/W-0
PSPIF <sup>(1)</sup>	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF
bit7							bit0

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

bit 7: **PSPIF<sup>(1)</sup>**: Parallel Slave Port Read/Write Interrupt Flag bit  
1 = A read or a write operation has taken place (must be cleared in software)  
0 = No read or write has occurred

bit 6: **ADIF**: A/D Converter Interrupt Flag bit  
1 = An A/D conversion completed  
0 = The A/D conversion is not complete

bit 5: **RCIF**: USART Receive Interrupt Flag bit  
1 = The USART receive buffer is full  
0 = The USART receive buffer is empty

bit 4: **TXIF**: USART Transmit Interrupt Flag bit  
1 = The USART transmit buffer is empty  
0 = The USART transmit buffer is full

bit 3: **SSPIF**: Synchronous Serial Port Interrupt Flag bit  
1 = The transmission/reception is complete  
0 = Waiting to transmit/receive

bit 2: **CCP1IF**: CCP1 Interrupt Flag bit  
Capture Mode  
1 = A TMR1 register capture occurred (must be cleared in software)  
0 = No TMR1 register capture occurred  
Compare Mode  
1 = A TMR1 register compare match occurred (must be cleared in software)  
0 = No TMR1 register compare match occurred  
PWM Mode  
Unused in this mode

bit 1: **TMR2IF**: TMR2 to PR2 Match Interrupt Flag bit  
1 = TMR2 to PR2 match occurred (must be cleared in software)  
0 = No TMR2 to PR2 match occurred

bit 0: **TMR1IF**: TMR1 Overflow Interrupt Flag bit  
1 = TMR1 register overflowed (must be cleared in software)  
0 = TMR1 register did not overflow

Note 1: PIC16C73 and PIC16C73A devices do not have a Parallel Slave Port implemented, this bit location is reserved on these two devices, always maintain this bit clear.

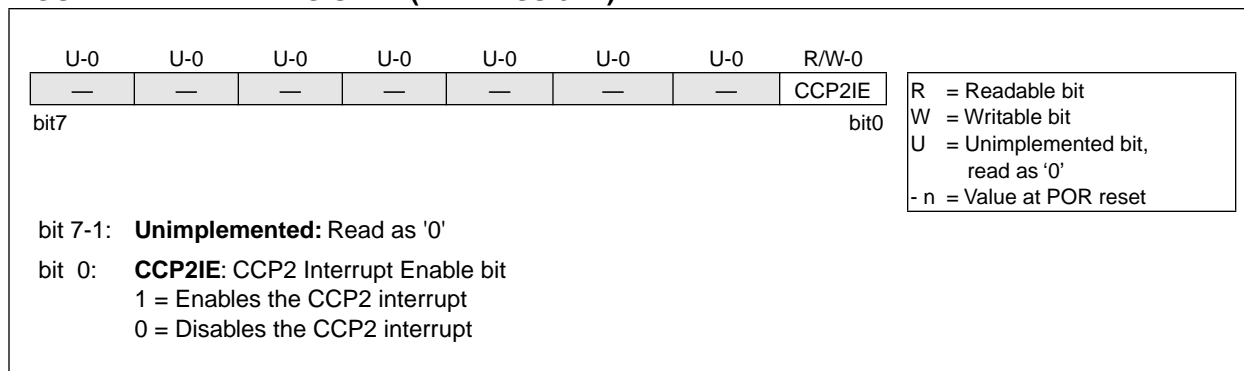
# PIC16C7X

## 4.2.2.6 PIE2 REGISTER

Applicable Devices							
710	711	711	72	73	73A	74	74A

This register contains the individual enable bit for the CCP2 peripheral interrupt.

**FIGURE 4-17: PIE2 REGISTER (ADDRESS 8Dh)**



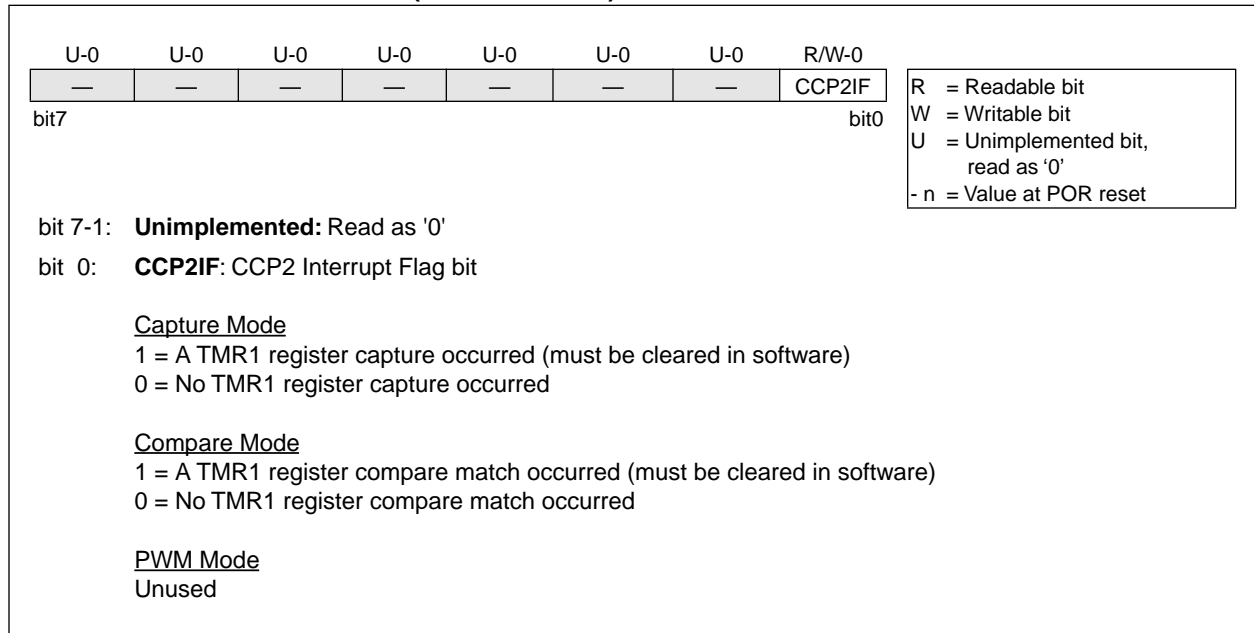
## 4.2.2.7 PIR2 REGISTER

Applicable Devices							
710	711	72	73	73A	74	74A	

This register contains the CCP2 interrupt flag bit.

**Note:** Interrupt flag bits get set when an interrupt condition occurs regardless of the state of its corresponding enable bit or the global enable bit, GIE (INTCON<7>). User software should ensure the appropriate interrupt flag bits are clear prior to enabling an interrupt.

**FIGURE 4-18: PIR2 REGISTER (ADDRESS 0Dh)**



# PIC16C7X

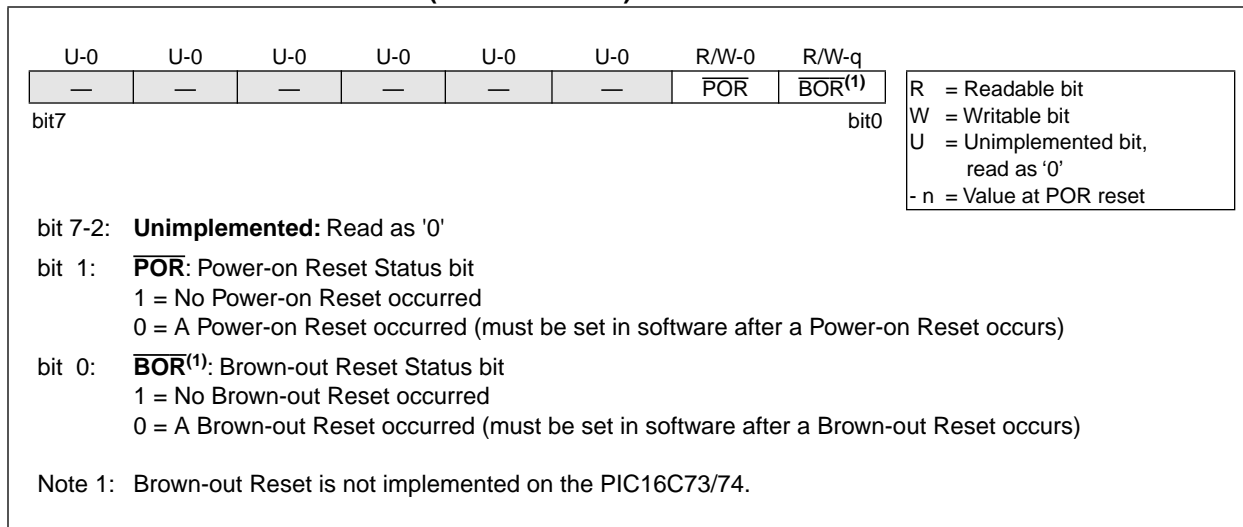
## 4.2.2.8 PCON REGISTER

Applicable Devices							
710	711	711	72	73	73A	74	74A

The Power Control (PCON) register contains a flag bit to allow differentiation between a Power-on Reset (POR) to an external  $\overline{\text{MCLR}}$  Reset or WDT Reset. It also contains a status bit to determine if a Brown-out Reset (BOR) occurred.

**Note:**  $\overline{\text{BOR}}$  is unknown on Power-on Reset. It must then be set by the user and checked on subsequent resets to see if  $\overline{\text{BOR}}$  is clear, indicating a brown-out has occurred. The  $\overline{\text{BOR}}$  status bit is a don't care and is not necessarily predictable if the brown-out circuit is disabled (by clearing the BODEN bit in the Configuration word).

**FIGURE 4-19: PCON REGISTER (ADDRESS 8Eh)**



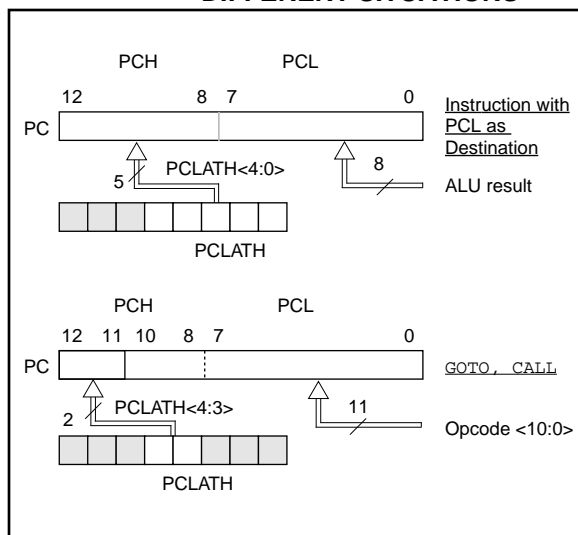


## 4.3 PCL and PCLATH

Applicable Devices							
710	71	711	72	73	73A	74	74A

The program counter (PC) is 13-bits wide. The low byte comes from the PCL register, which is a readable and writable register. The high byte (PC<12:8>) is not directly readable or writable and comes from PCLATH. On any reset, the PC is cleared. Figure 4-20 shows the two situations for the loading of the PC. The upper example in the figure shows how the PC is loaded on a write to PCL (PCLATH<4:0> → PCH). The lower example in the figure shows how the PC is loaded during a CALL or GOTO instruction (PCLATH<4:3> → PCH).

**FIGURE 4-20: LOADING OF PC IN DIFFERENT SITUATIONS**



### 4.3.1 COMPUTED GOTO

A computed GOTO is accomplished by adding an offset to the program counter (`ADDWF PCL`). When doing a table read using a computed GOTO method, care should be exercised if the table location crosses a PCL memory boundary (each 256 byte block). Refer to the application note "Implementing a Table Read" (AN556).

### 4.3.2 STACK

The PIC16CXX family has an 8 level deep x 13-bit wide hardware stack. The stack space is not part of either program or data space and the stack pointer is not readable or writable. 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 RETFIE instruction execution. PCLATH is not affected by a PUSH or POP operation.

The stack operates as a circular buffer. This means that 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).

**Note 1:** There are no status bits to indicate stack overflow or stack underflow conditions.

**Note 2:** There are no instructions/mnemonics called PUSH or POP. These are actions that occur from the execution of the CALL, RETURN, RETLW, and RETFIE instructions, or the vectoring to an interrupt address.

## 4.4 Program Memory Paging

Applicable Devices							
710	71	711	72	73	73A	74	74A

The PIC16C73/73A and the PIC16C74/74A have 4K of program memory, but the CALL and GOTO instructions only have a 11-bit address range. This 11-bit address range allows a branch within a 2K program memory page size. To allow CALL and GOTO instructions to address the entire 4K program memory address range, there must be another bit to specify the program memory page. This paging bit comes from the PCLATH<3> bit (Figure 4-20). When doing a CALL or GOTO instruction, the user must ensure that this page bit (PCLATH<3>) is programmed so that the desired program memory page is addressed. If a return from a CALL instruction (or interrupt) is executed, the entire 13-bit PC is PUSHed onto the stack. Therefore, manipulation of the PCLATH<3> is not required for the return instructions (which POPs the address from the stack).

**Note 1:** The PIC16C710/711/711/72 ignore both paging bits (PCLATH<4:3>), which are used to access program memory when more than one page is available. The use of PCLATH<4:3> as general purpose read/write bits for the PIC16C7X is not recommended since this may affect upward compatibility with future products.

The PIC16C73/73A/74/74A ignores paging bit (PCLATH<4>), which is used to access program memory pages 2 and 3 (1000h - 1FFFh). The use of PCLATH<4> as a general purpose read/write bit is not recommended since this may affect upward compatibility with future products.

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Example 4-1 shows the calling of a subroutine in page 1 of the program memory. This example assumes that PCLATH is saved and restored by the interrupt service routine (if interrupts are used).

## EXAMPLE 4-1: CALL OF A SUBROUTINE IN PAGE 1 FROM PAGE 0

```

ORG 0x500
BSF    PCLATH,3    ;Select page 1 (800h-FFFh)
CALL   SUB1_P1     ;Call subroutine in
      :           ;page 1 (800h-FFFh)
      :
      :
ORG 0x900
SUB1_P1:          ;called subroutine
      :           ;page 1 (800h-FFFh)
      :
RETURN          ;return to Call subroutine
              ;in page 0 (000h-7FFh)
    
```

## 4.5 Indirect Addressing, INDF and FSR Registers

Applicable Devices							
710	711	72	73	73A	74	74A	

The INDF register is not a physical register. Addressing the INDF register will cause indirect addressing.

Indirect addressing is possible by using the INDF register. Any instruction using the INDF register actually accesses the register pointed to by the File Select Register, FSR. Reading the INDF register itself indirectly (FSR = '0') will read 00h. Writing to the INDF register indirectly results in a no-operation (although status bits may be affected). An effective 9-bit address is obtained by concatenating the 8-bit FSR register and the IRP bit (STATUS<7>), as shown in Figure 4-21. However, IRP is not used in the PIC16C7X.

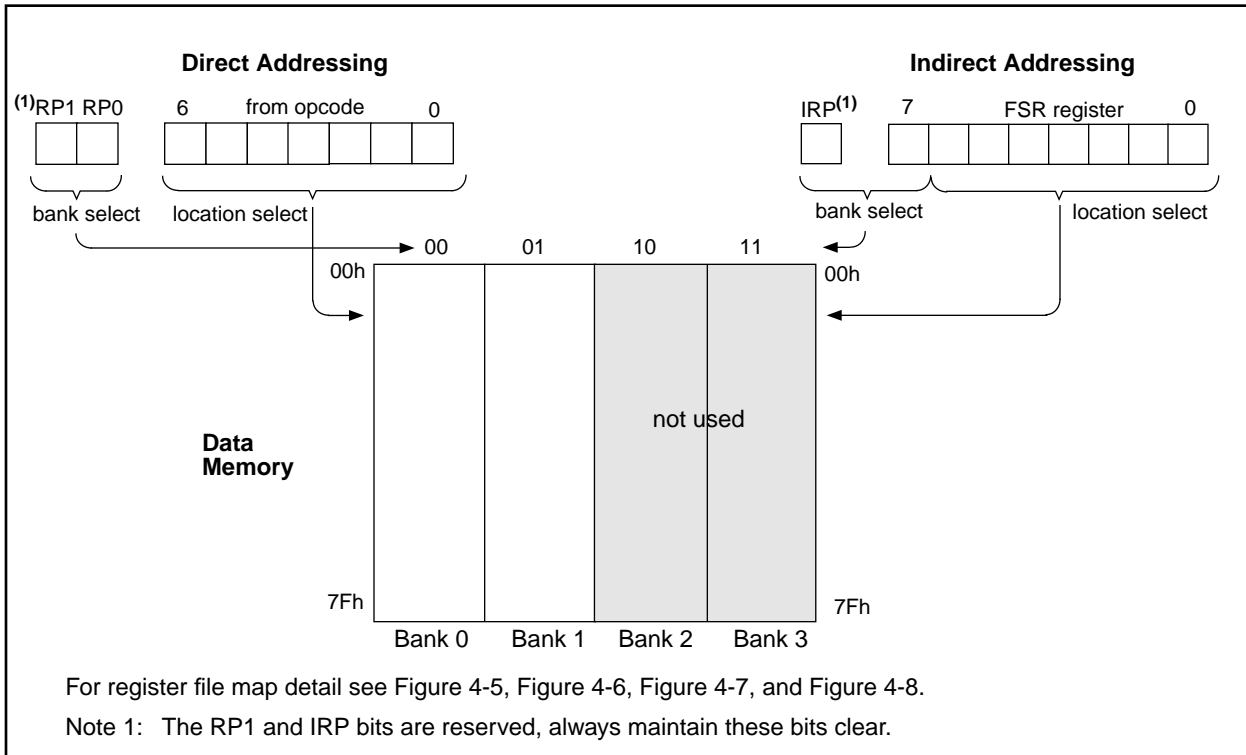
A simple program to clear RAM locations 20h-2Fh using indirect addressing is shown in Example 4-2.

## EXAMPLE 4-2: INDIRECT ADDRESSING

```

      movlw 0x20    ;initialize pointer
      movwf FSR    ;to RAM
NEXT   clrf  INDF  ;clear INDF register
      incf  FSR,F  ;inc pointer
      btfss FSR,4  ;all done?
      goto  NEXT  ;no clear next
CONTINUE
      :           ;yes continue
    
```

FIGURE 4-21: DIRECT/INDIRECT ADDRESSING



## 5.0 I/O PORTS

Applicable Devices							
710	71	711	72	73	73A	74	74A

Some pins for these I/O ports are multiplexed with an alternate function for the peripheral features on the device. In general, when a peripheral is enabled, that pin may not be used as a general purpose I/O pin.

### 5.1 PORTA and TRISA Registers

Applicable Devices							
710	71	711	72	73	73A	74	74A

PORTA is a 5-bit latch for PIC16C710/71/711.

PORTA is a 6-bit latch for PIC16C72/73/73A/74/74A.

The RA4/T0CKI pin is a Schmitt Trigger input and an open drain output. All other RA port pins have TTL input levels and full CMOS output drivers. All pins have data direction bits (TRIS registers) which can configure these pins as output or input.

Setting a TRISA register bit puts the corresponding output driver in a hi-impedance mode. Clearing a bit in the TRISA register puts the contents of the output latch on the selected pin(s).

Reading the PORTA register reads the status of the pins whereas writing to it will write to the port latch. All write operations are read-modify-write operations.

Therefore a write to a port implies that the port pins are read, this value is modified, and then written to the port data latch.

Pin RA4 is multiplexed with the Timer0 module clock input to become the RA4/T0CKI pin.

Other PORTA pins are multiplexed with analog inputs and analog VREF input. The operation of each pin is selected by clearing/setting the control bits in the ADCON1 register (A/D Control Register1).

**Note:** On a Power-on Reset, these pins are configured as analog inputs and read as '0'.

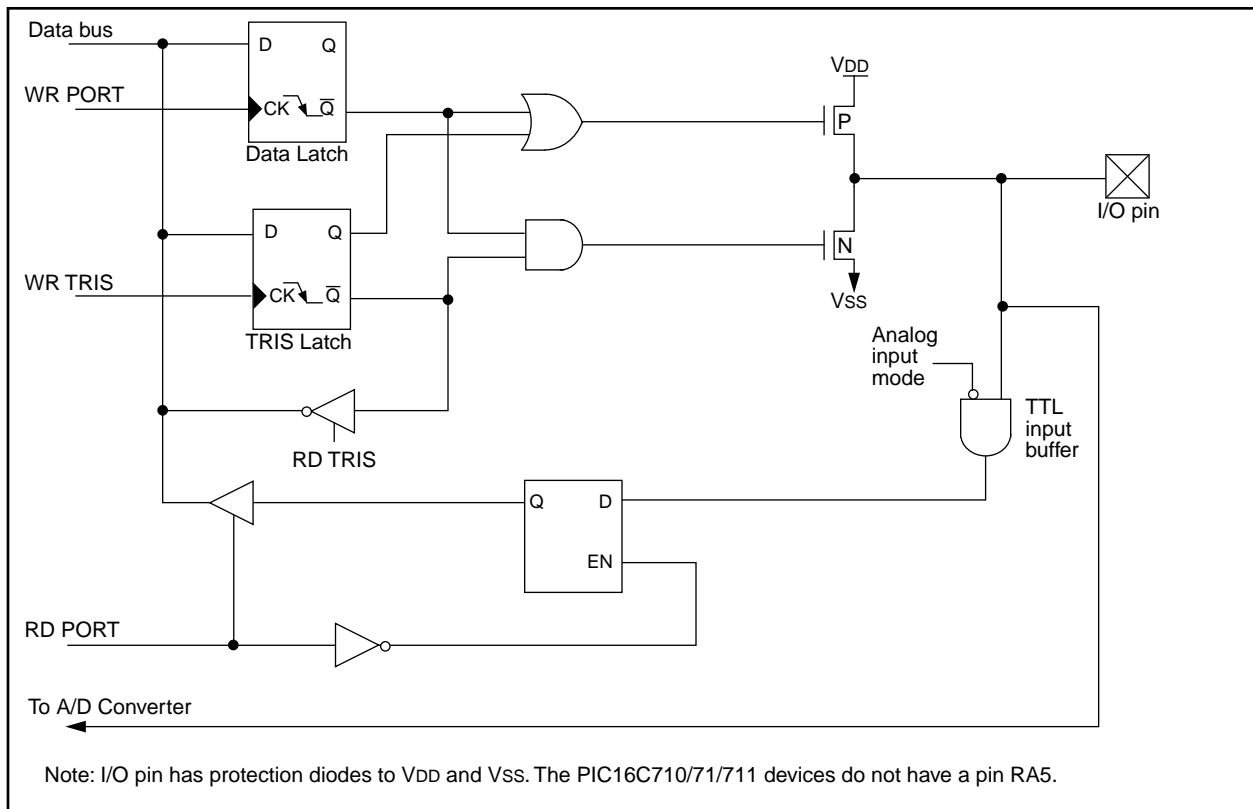
The TRISA register controls the direction of the RA pins, even when they are being used as analog inputs. The user must ensure the bits in the TRISA register are maintained set when using them as analog inputs.

#### EXAMPLE 5-1: INITIALIZING PORTA

```

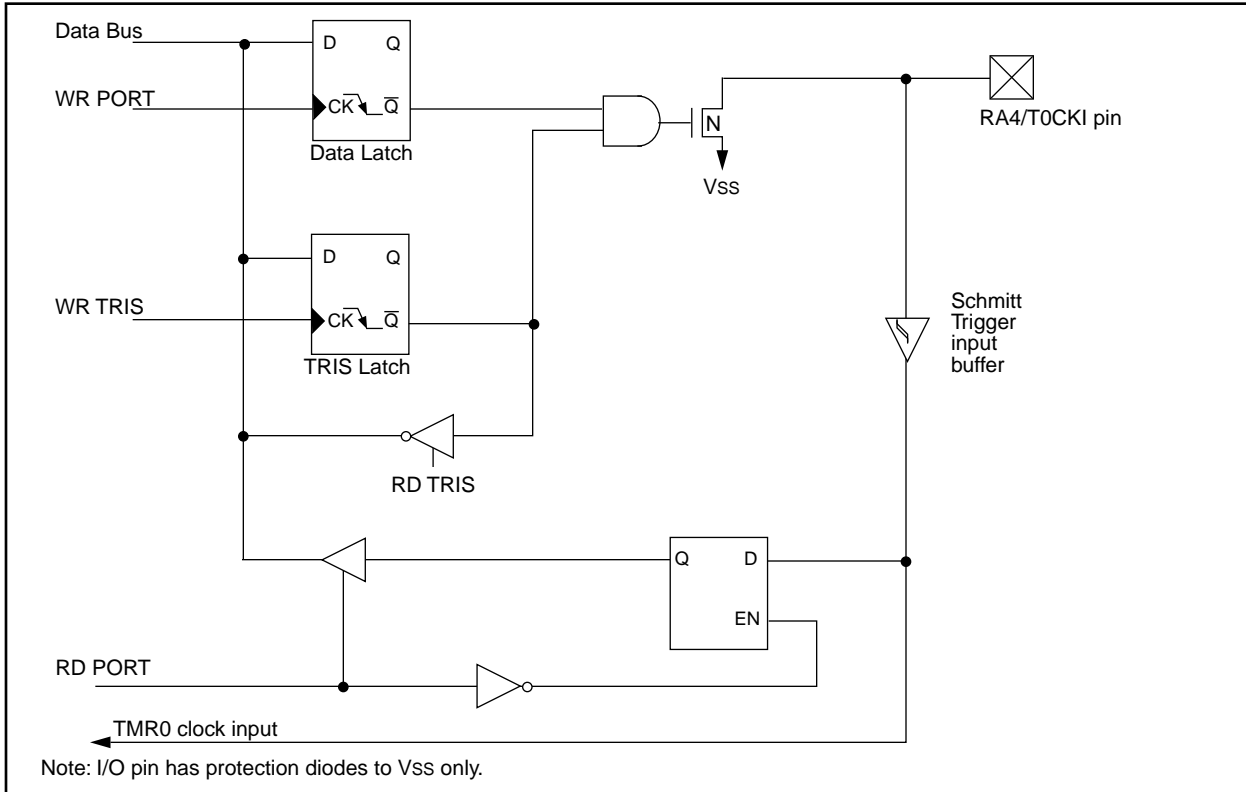
CLRF   PORTA           ; Initialize PORTA by
                        ; clearing output
                        ; data latches
BSF    STATUS, RP0     ; Select Bank 1
MOVLW  0xCF            ; Value used to
                        ; initialize data
                        ; direction
MOVWF  TRISA           ; Set RA<3:0> as inputs
                        ; RA<5:4> as outputs
                        ; TRISA<7:6> are always
                        ; read as '0'.
    
```

**FIGURE 5-1: BLOCK DIAGRAM OF RA3:RA0 AND RA5 PINS**



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**FIGURE 5-2: BLOCK DIAGRAM OF RA4/T0CKI PIN**



**TABLE 5-1: PORTA FUNCTIONS**

Name	Bit#	Buffer	Function
RA0/AN0	bit0	TTL	Input/output or analog input
RA1/AN1	bit1	TTL	Input/output or analog input
RA2/AN2	bit2	TTL	Input/output or analog input
RA3/AN3/VREF	bit3	TTL	Input/output or analog input/VREF
RA4/T0CKI	bit4	ST	Input/output or external clock input for Timer0 Output is open drain type
RA5/AN4/ $\overline{SS}^{(1)}$	bit5	TTL	Input/output or slave select input for synchronous serial port or analog input

Legend: TTL = TTL input, ST = Schmitt Trigger input

Note 1: The PIC16C710/71/711 does not have PORTA<5> or TRISA<5>, read as '0'.

**TABLE 5-2: SUMMARY OF REGISTERS ASSOCIATED WITH PORTA**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets
05h	PORTA	—	—	RA5 <sup>(1)</sup>	RA4	RA3	RA2	RA1	RA0	--0x 0000	--0u 0000
85h	TRISA	—	—	TRISA5 <sup>(1)</sup>	TRISA4	TRISA3	TRISA2	TRISA1	TRISA0	--11 1111	--11 1111
9Fh	ADCON1	—	—	—	—	—	PCFG2 <sup>(2)</sup>	PCFG1	PCFG0	---- -000	---- -000

Legend: x = unknown, u = unchanged, - = unimplemented locations read as '0'. Shaded cells are not used by PORTA.

Note 1: PORTA<5> and TRISA<5> are not implemented on the PIC16C710/71/711.

2: Bit PCFG2 is not implemented on the PIC16C710/71/711.

## 5.2 PORTB and TRISB Registers

Applicable Devices							
710	711	711	72	73	73A	74	74A

PORTB is an 8-bit wide bi-directional port. The corresponding data direction register is TRISB. Setting a bit in the TRISB register puts the corresponding output driver in a hi-impedance input mode. Clearing a bit in the TRISB register puts the contents of the output latch on the selected pin(s).

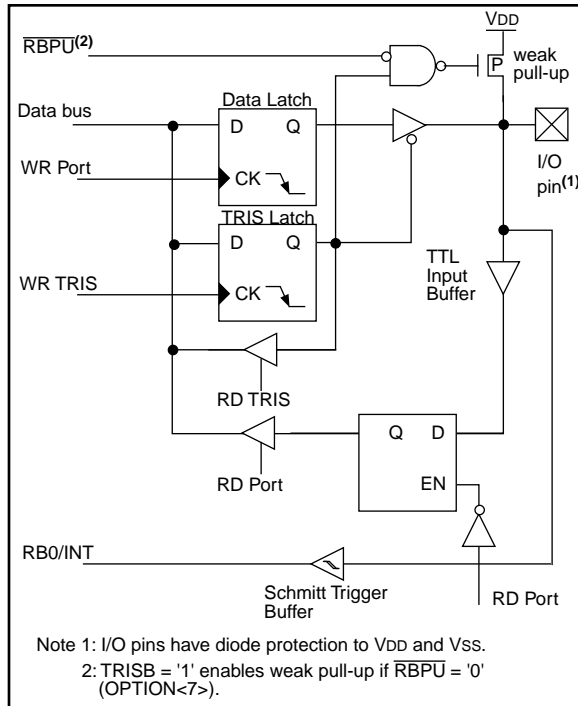
### EXAMPLE 5-2: INITIALIZING PORTB

```

CLRF   PORTB           ; Initialize PORTB by
                        ; clearing output
                        ; data latches
BSF    STATUS, RP0     ; Select Bank 1
MOVLW  0xCF            ; Value used to
                        ; initialize data
                        ; direction
MOVWF  TRISB           ; Set RB<3:0> as inputs
                        ; RB<5:4> as outputs
                        ; RB<7:6> as inputs
    
```

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  $\overline{RBP\bar{U}}$  (OPTION<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 5-3: BLOCK DIAGRAM OF RB3:RB0 PINS**



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:

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

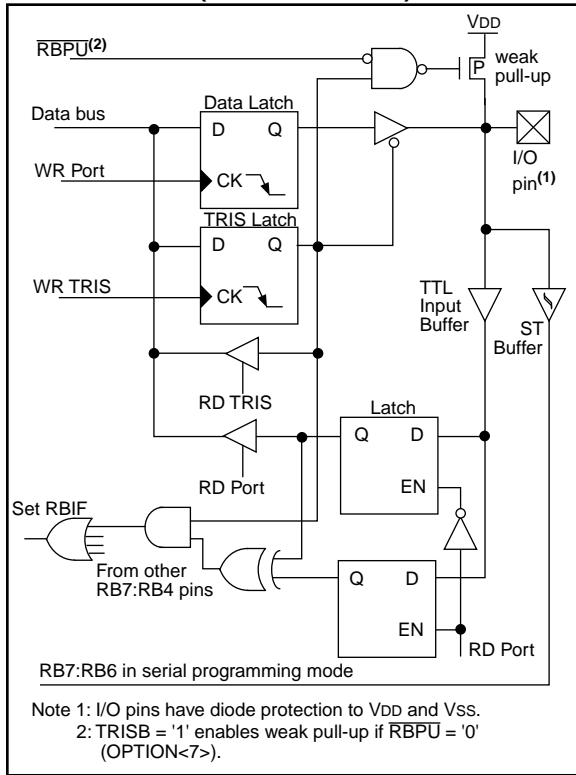
This interrupt on mismatch feature, together with software configurable pull-ups on these four pins allow easy interface to a keypad and make it possible for wake-up on key-depression. Refer to the Embedded Control Handbook, "Implementing Wake-Up on Key Stroke" (AN552).

**Note:** For the PIC16C71/73/74 if a change on the I/O pin should occur when the read operation is being executed (start of the Q2 cycle), then interrupt flag bit RBIF may not get set.

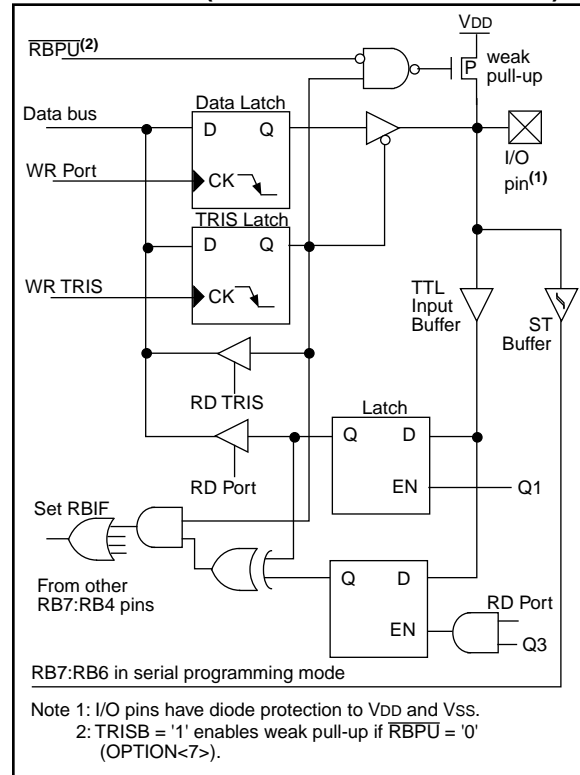
The interrupt on change feature is recommended for wake-up on key depression operation and operations where PORTB is only used for the interrupt on change feature. Polling of PORTB is not recommended while using the interrupt on change feature.

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**FIGURE 5-4: BLOCK DIAGRAM OF RB7:RB4 PINS (PIC16C71/73/74)**



**FIGURE 5-5: BLOCK DIAGRAM OF RB7:RB4 PINS (PIC16C710/711/72/73A/74A)**



**TABLE 5-3: PORTB FUNCTIONS**

Name	Bit#	Buffer	Function
RB0/INT	bit0	TTL/ST <sup>(1)</sup>	Input/output pin or external interrupt input. Internal software programmable weak pull-up.
RB1	bit1	TTL	Input/output pin. Internal software programmable weak pull-up.
RB2	bit2	TTL	Input/output pin. Internal software programmable weak pull-up.
RB3	bit3	TTL	Input/output pin. Internal software programmable weak pull-up.
RB4	bit4	TTL	Input/output pin (with interrupt on change). Internal software programmable weak pull-up.
RB5	bit5	TTL	Input/output pin (with interrupt on change). Internal software programmable weak pull-up.
RB6	bit6	TTL/ST <sup>(2)</sup>	Input/output pin (with interrupt on change). Internal software programmable weak pull-up. Serial programming clock.
RB7	bit7	TTL/ST <sup>(2)</sup>	Input/output pin (with interrupt on change). Internal software programmable weak pull-up. Serial programming data.

Legend: TTL = TTL input, ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.

2: This buffer is a Schmitt Trigger input when used in serial programming mode.

**TABLE 5-4: SUMMARY OF REGISTERS ASSOCIATED WITH PORTB**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets
06h	PORTB	RB7	RB6	RB5	RB4	RB3	RB2	RB1	RB0	xxxx xxxx	uuuu uuuu
86h	TRISB	TRISB7	TRISB6	TRISB5	TRISB4	TRISB3	TRISB2	TRISB1	TRISB0	1111 1111	1111 1111
81h	OPTION	$\overline{\text{RBPU}}$	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0	1111 1111	1111 1111

Legend: x = unknown, u = unchanged. Shaded cells are not used by PORTB.

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## 5.3 PORTC and TRISC Registers

Applicable Devices							
710	711	712	713	73A	74	74A	

PORTC is an 8-bit bi-directional port. Each pin is individually configurable as an input or output through the TRISC register. PORTC is multiplexed with several peripheral functions (Table 5-5). PORTC pins have Schmitt Trigger input buffers.

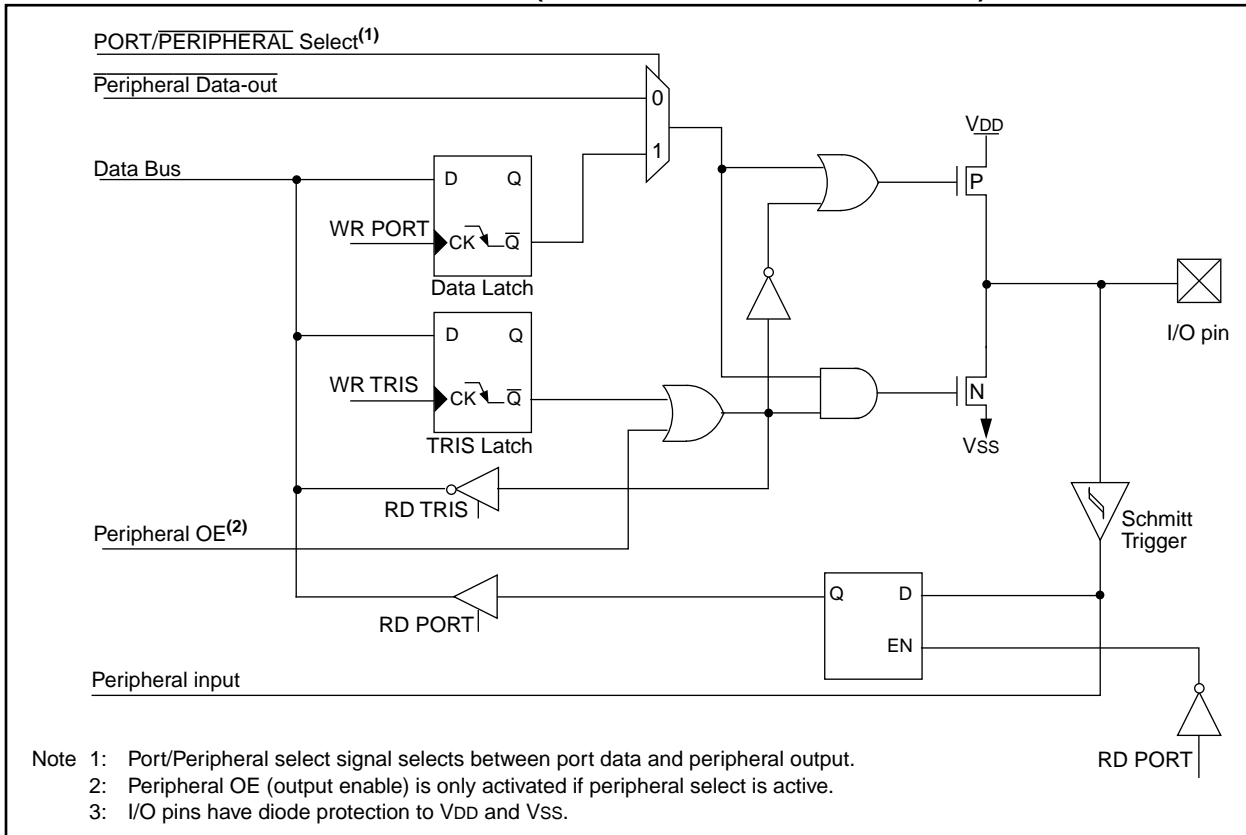
When enabling peripheral functions, care should be taken in defining TRIS bits for each PORTC pin. Some peripherals override the TRIS bit to make a pin an output, while other peripherals override the TRIS bit to make a pin an input. Since the TRIS bit override is in effect while the peripheral is enabled, read-modify-write instructions (*BSF*, *BCF*, *XORWF*) with TRISC as destination should be avoided. The user should refer to the corresponding peripheral section for the correct TRIS bit settings.

### EXAMPLE 5-3: INITIALIZING PORTC

```

CLRWF  PORTC      ; Initialize PORTC by
                  ; clearing output
                  ; data latches
BSF     STATUS, RP0 ; Select Bank 1
MOVLW  0xCF       ; Value used to
                  ; initialize data
                  ; direction
MOVWF  TRISC      ; Set RC<3:0> as inputs
                  ; RC<5:4> as outputs
                  ; RC<7:6> as inputs
    
```

**FIGURE 5-6: PORTC BLOCK DIAGRAM (PERIPHERAL OUTPUT OVERRIDE)**





**TABLE 5-5: PORTC FUNCTIONS**

Name	Bit#	Buffer Type	Function
RC0/T1OSO/T1CKI	bit0	ST	Input/output port pin or Timer1 oscillator output/Timer1 clock input
RC1/T1OSI/CCP2 <sup>(1)</sup>	bit1	ST	Input/output port pin or Timer1 oscillator input or Capture2 input/Compare2 output/PWM2 output
RC2/CCP1	bit2	ST	Input/output port pin or Capture1 input/Compare1 output/PWM1 output
RC3/SCK/SCL	bit3	ST	RC3/SCK/SCL can also be selected as the synchronous serial clock for both SPI and I <sup>2</sup> C modes.
RC4/SDI/SDA	bit4	ST	RC4/SDI/SDA can also be selected as the SPI Data In (SPI mode) or data I/O (I <sup>2</sup> C mode).
RC5/SDO	bit5	ST	Input/output port pin or Synchronous Serial Port data output
RC6/TX/CK <sup>(2)</sup>	bit6	ST	Input/output port pin or USART Asynchronous Transmit, or USART Synchronous Clock
RC7/RX/DT <sup>(2)</sup>	bit7	ST	Input/output port pin or USART Asynchronous Receive, or USART Synchronous Data

Legend: ST = Schmitt Trigger input

Note 1: The CCP2 multiplexed function is not enabled on the PIC16C72.

2: The TX/CK and RX/DT multiplexed functions are not enabled on the PIC16C72.

**TABLE 5-6: SUMMARY OF REGISTERS ASSOCIATED WITH PORTC**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets
07h	PORTC	RC7	RC6	RC5	RC4	RC3	RC2	RC1	RC0	xxxx xxxx	uuuu uuuu
87h	TRISC	TRISC7	TRISC6	TRISC5	TRISC4	TRISC3	TRISC2	TRISC1	TRISC0	1111 1111	1111 1111

Legend: x = unknown, u = unchanged.

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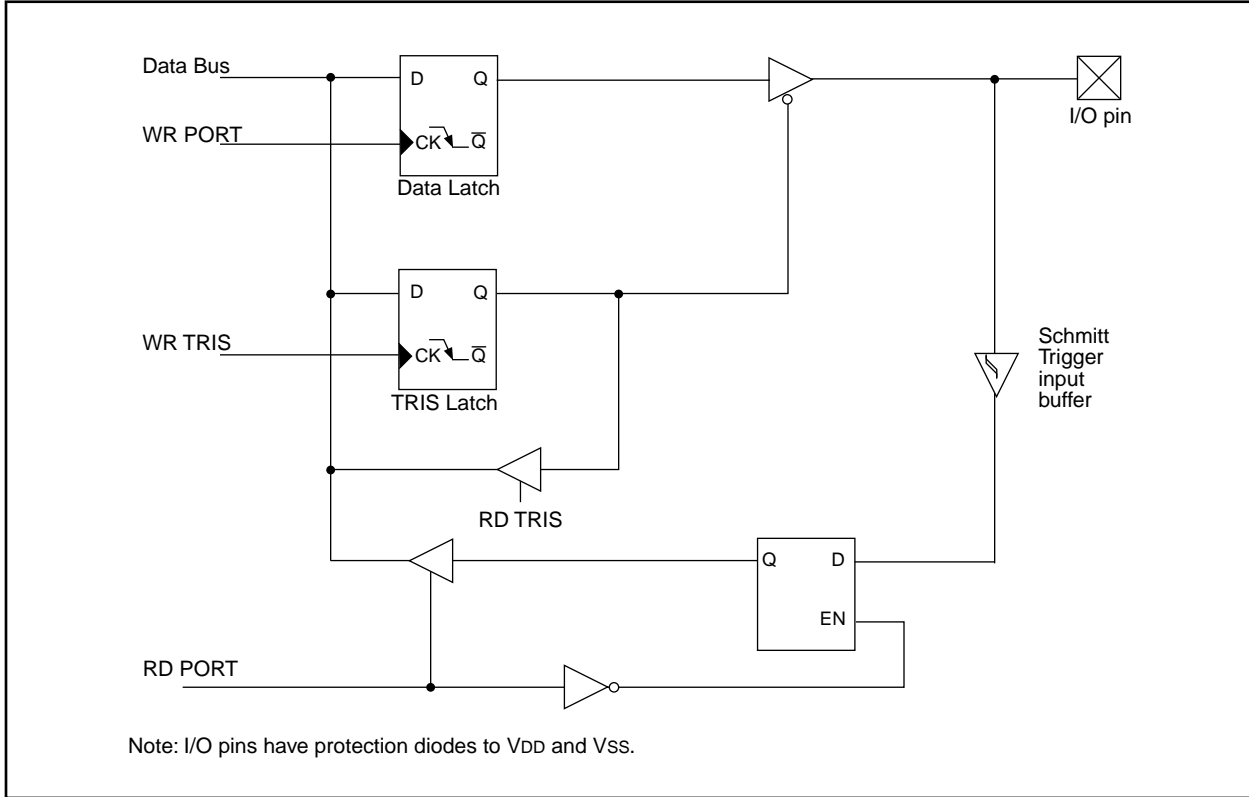
## 5.4 PORTD and TRISD Registers

Applicable Devices							
710	711	712	713	73A	74	74A	

PORTD is an 8-bit port with Schmitt Trigger input buffers. Each pin is individually configurable as an input or output.

PORTD can be configured as an 8-bit wide microprocessor port (parallel slave port) by setting control bit PSMODE (TRISE<4>). In this mode, the input buffers are TTL.

**FIGURE 5-7: PORTD BLOCK DIAGRAM (IN I/O PORT MODE)**



**TABLE 5-7: PORTD FUNCTIONS**

Name	Bit#	Buffer Type	Function
RD0/PSP0	bit0	ST/TTL <sup>(1)</sup>	Input/output port pin or parallel slave port bit0
RD1/PSP1	bit1	ST/TTL <sup>(1)</sup>	Input/output port pin or parallel slave port bit1
RD2/PSP2	bit2	ST/TTL <sup>(1)</sup>	Input/output port pin or parallel slave port bit2
RD3/PSP3	bit3	ST/TTL <sup>(1)</sup>	Input/output port pin or parallel slave port bit3
RD4/PSP4	bit4	ST/TTL <sup>(1)</sup>	Input/output port pin or parallel slave port bit4
RD5/PSP5	bit5	ST/TTL <sup>(1)</sup>	Input/output port pin or parallel slave port bit5
RD6/PSP6	bit6	ST/TTL <sup>(1)</sup>	Input/output port pin or parallel slave port bit6
RD7/PSP7	bit7	ST/TTL <sup>(1)</sup>	Input/output port pin or parallel slave port bit7

Legend: ST = Schmitt Trigger input TTL = TTL input

Note 1: Input buffers are Schmitt Triggers when in I/O mode and TTL buffer when in Parallel Slave Port Mode.

**TABLE 5-8: SUMMARY OF REGISTERS ASSOCIATED WITH PORTD**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets
08h	PORTD	RD7	RD6	RD5	RD4	RD3	RD2	RD1	RD0	xxxx xxxx	uuuu uuuu
88h	TRISD	TRISD7	TRISD6	TRISD5	TRISD4	TRISD3	TRISD2	TRISD1	TRISD0	1111 1111	1111 1111
89h	TRISE	IBF	OBF	IBOV	PSPMODE	—	TRISE2	TRISE1	TRISE0	0000 -111	0000 -111

Legend: x = unknown, u = unchanged, - = unimplemented read as '0'. Shaded cells are not used by PORTD.

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## 5.5 PORTE and TRISE Register

Applicable Devices							
710	711	711	72	73	73A	74	74A

PORTE has three pins RE0/ $\overline{RD}$ /AN5, RE1/ $\overline{WR}$ /AN6 and RE2/ $\overline{CS}$ /AN7, which are individually configurable as inputs or outputs. These pins have Schmitt Trigger input buffers.

I/O PORTE becomes control inputs for the microprocessor port when bit PSPMODE (TRISE<4>) is set. In this mode, the user must make sure that the TRISE<2:0> bits are set (pins are configured as digital inputs) and that register ADCON1 is configured for digital I/O. In this mode the input buffers are TTL.

Figure 5-8 shows the TRISE register, which also controls the parallel slave port operation.

PORTE pins are multiplexed with analog inputs. The operation of these pins is selected by control bits in the ADCON1 register. When selected as an analog input, these pins will read as '0's.

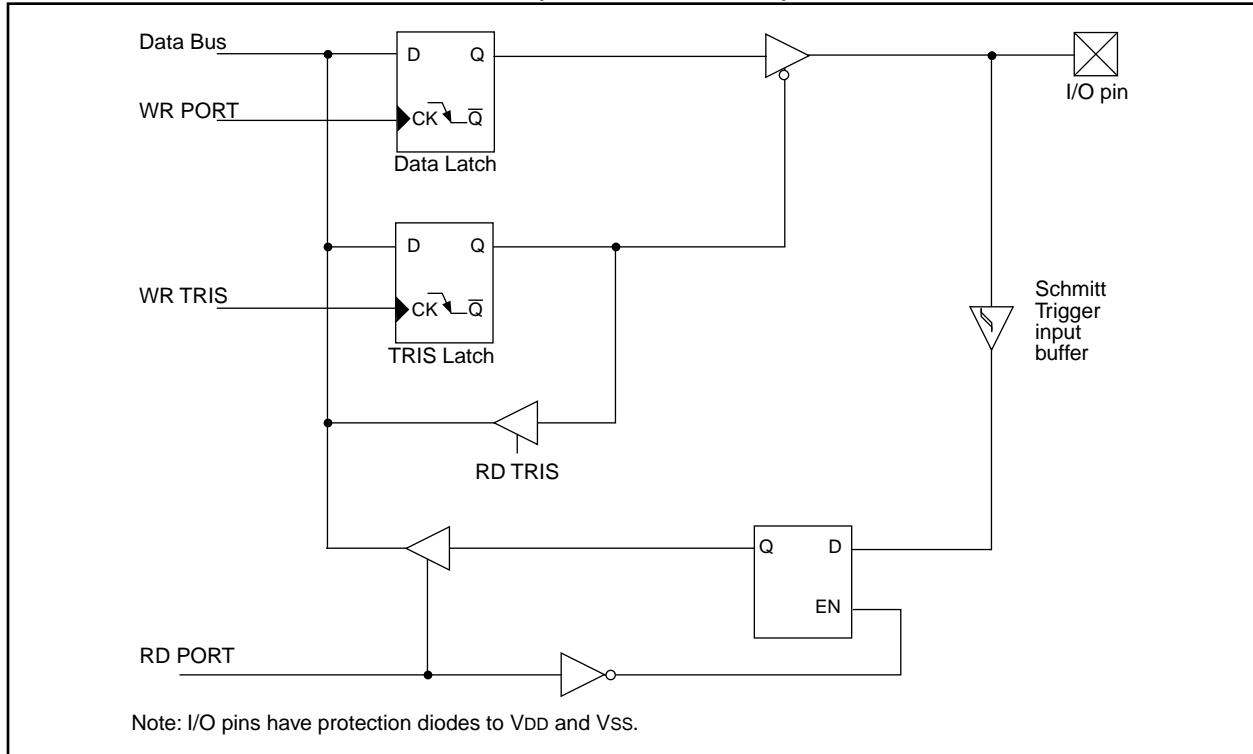
TRISE controls the direction of the RE pins, even when they are being used as analog inputs. The user must make sure to keep the pins configured as inputs when using them as analog inputs.

**Note:** On a Power-on Reset these pins are configured as analog inputs.

**FIGURE 5-8: TRISE REGISTER (ADDRESS 89h)**

	R-0	R-0	R/W-0	R/W-0	U-0	R/W-1	R/W-1	R/W-1	
	IBF	OBF	IBOV	PSPMODE	—	TRISE2	TRISE1	TRISE0	
bit7									bit0
									R = Readable bit W = Writable bit U = Unimplemented bit, read as '0' - n = Value at POR reset
bit 7:	<b>IBF:</b> Input Buffer Full Status bit 1 = A word has been received and waiting to be read by the CPU 0 = No word has been received								
bit 6:	<b>OBF:</b> Output Buffer Full Status bit 1 = The output buffer still holds a previously written word 0 = The output buffer has been read								
bit 5:	<b>IBOV:</b> Input Buffer Overflow Detect bit (in microprocessor mode) 1 = A write occurred when a previously input word has not been read (must be cleared in software) 0 = No overflow occurred								
bit 4:	<b>PSPMODE:</b> Parallel Slave Port Mode Select bit 1 = Parallel slave port mode 0 = General purpose I/O mode								
bit 3:	<b>Unimplemented:</b> Read as '0'								
bit 2:	<b>TRISE2:</b> Direction control bit for pin RE2/ $\overline{CS}$ /AN7 1 = Input 0 = Output								
bit 1:	<b>TRISE1:</b> Direction control bit for pin RE1/ $\overline{WR}$ /AN6 1 = Input 0 = Output								
bit 0:	<b>TRISE0:</b> Direction control bit for pin RE0/ $\overline{RD}$ /AN5 1 = Input 0 = Output								

**FIGURE 5-9: PORTE BLOCK DIAGRAM (IN I/O PORT MODE)**



**TABLE 5-9: PORTE FUNCTIONS**

Name	Bit#	Buffer Type	Function
RE0/ $\overline{RD}$ /AN5	bit0	ST/TTL <sup>(1)</sup>	Input/output port pin or read control input in parallel slave port mode or analog input: RD 1 = Not a read operation 0 = Read operation. Reads PORTD register (if chip selected)
RE1/ $\overline{WR}$ /AN6	bit1	ST/TTL <sup>(1)</sup>	Input/output port pin or write control input in parallel slave port mode or analog input: WR 1 = Not a write operation 0 = Write operation. Writes PORTD register (if chip selected)
RE2/ $\overline{CS}$ /AN7	bit2	ST/TTL <sup>(1)</sup>	Input/output port pin or chip select control input in parallel slave port mode or analog input: $\overline{CS}$ 1 = Device is not selected 0 = Device is selected

Legend: ST = Schmitt Trigger input TTL = TTL input

Note 1: Input buffers are Schmitt Triggers when in I/O mode and TTL buffers when in Parallel Slave Port Mode.

**TABLE 5-10: SUMMARY OF REGISTERS ASSOCIATED WITH PORTE**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets
09h	PORTE	—	—	—	—	—	RE2	RE1	RE0	---- -xxx	---- -uuu
89h	TRISE	IBF	OBF	IBOV	PSPMODE	—	TRISE2	TRISE1	TRISE0	0000 -111	0000 -111
9Fh	ADCON1	—	—	—	—	—	PCFG2	PCFG1	PCFG0	---- -000	---- -000

Legend: x = unknown, u = unchanged, - = unimplemented read as '0'. Shaded cells are not used by PORTE.

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## 5.6 I/O Programming Considerations

Applicable Devices							
710	711	711	72	73	73A	74	74A

### 5.6.1 BI-DIRECTIONAL I/O PORTS

Any instruction which writes, operates internally as a read followed by a write operation. The BCF and BSF instructions, for example, read the register into the CPU, execute the bit operation and write the result back to the register. Caution must be used when these instructions are applied to a port with both inputs and outputs defined. For example, a BSF operation on bit5 of PORTB will cause all eight bits of PORTB to be read into the CPU. Then the BSF operation takes place on bit5 and PORTB is written to the output latches. If another bit of PORTB is used as a bi-directional I/O pin (e.g., bit0) and it is defined as an input at this time, the input signal present on the pin itself would be read into the CPU and rewritten to the data latch of this particular pin, overwriting the previous content. As long as the pin stays in the input mode, no problem occurs. However, if bit0 is switched to an output, the content of the data latch may now be unknown.

Reading the port register, reads the values of the port pins. Writing to the port register writes the value to the port latch. When using read-modify-write instructions (ex. BCF, BSF, etc.) on a port, the value of the port pins is read, the desired operation is done to this value, and this value is then written to the port latch.

Example 5-4 shows the effect of two sequential read-modify-write instructions on an I/O port.

### EXAMPLE 5-4: READ-MODIFY-WRITE INSTRUCTIONS ON AN I/O PORT

```

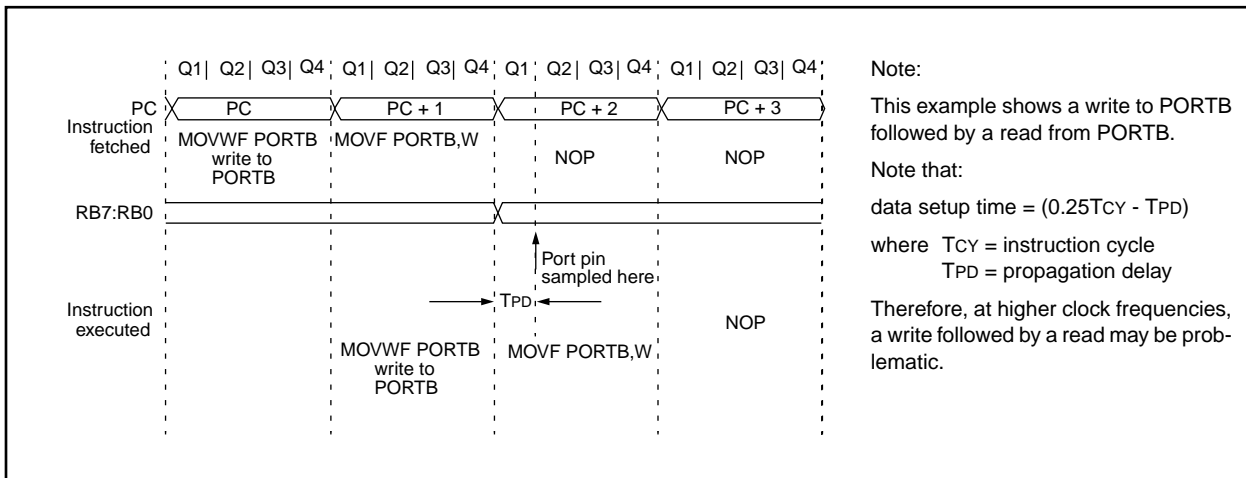
;Initial PORT settings: PORTB<7:4> Inputs
;                          PORTB<3:0> Outputs
;PORTB<7:6> have external pull-ups and are
;not connected to other circuitry
;
;
;          PORT latch  PORT pins
;          -----  -----
BCF PORTB, 7      ; 01pp pppp   11pp pppp
BCF PORTB, 6      ; 10pp pppp   11pp pppp
BSF STATUS, RP0   ;
BCF TRISB, 7      ; 10pp pppp   11pp pppp
BCF TRISB, 6      ; 10pp pppp   10pp pppp
;
;Note that the user may have expected the
;pin values to be 00pp ppp. The 2nd BCF
;caused RB7 to be latched as the pin value
;(high).
    
```

A pin actively outputting a Low or High should not be driven from external devices at the same time in order to change the level on this pin (“wired-or”, “wired-and”). The resulting high output currents may damage the chip.

### 5.6.2 SUCCESSIVE OPERATIONS ON I/O PORTS

The actual write to an I/O port happens at the end of an instruction cycle, whereas for reading, the data must be valid at the beginning of the instruction cycle (Figure 5-10). Therefore, care must be exercised if a write followed by a read operation is carried out on the same I/O port. The sequence of instructions should be such to allow the pin voltage to stabilize (load dependent) before the next instruction which causes that file to be read into the CPU is executed. Otherwise, the previous state of that pin may be read into the CPU rather than the new state. When in doubt, it is better to separate these instructions with a NOP or another instruction not accessing this I/O port.

FIGURE 5-10: SUCCESSIVE I/O OPERATION





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**TABLE 5-11: REGISTERS ASSOCIATED WITH PARALLEL SLAVE PORT**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets
08h	PORTD	PSP7	PSP6	PSP5	PSP4	PSP3	PSP2	PSP1	PSP0	xxxxx xxxxx	uuuu uuuu
09h	PORTE	—	—	—	—	—	RE2	RE1	RE0	---- -xxx	---- -uuu
89h	TRISE	IBF	OBF	IBOV	PSPMODE	—	TRISE2	TRISE1	TRISE0	0000 -111	0000 -111
0Ch	PIR1	PSPIF	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
8Ch	PIE1	PSPIE	ADIE	RCIE	TXIE	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
9Fh	ADCON1	—	—	—	—	—	PCFG2	PCFG1	PCFG0	---- -000	---- -000

Legend: x = unknown, u = unchanged, - = unimplemented read as '0'. Shaded cells are not used by the Parallel Slave Port.



## 6.0 OVERVIEW OF TIMER MODULES

Applicable Devices							
710	71	711	72	73	73A	74	74A

The PIC16C710 and PIC16C71/711 have one timer module.

The PIC16C72, PIC16C73/73A and PIC16C74/74A each have three timer modules.

Each module can generate an interrupt to indicate that an event has occurred (i.e. timer overflow). Each of these modules is explained in full detail in the following sections. The timer modules are:

- Timer0 Module (Section 7.0)
- Timer1 Module (Section 8.0)
- Timer2 Module (Section 9.0)

### 6.1 Timer0 Overview

Applicable Devices							
710	71	711	72	73	73A	74	74A

The Timer0 module (previously known as RTCC) is a simple 8-bit overflow counter. The clock source can be either the internal system clock ( $F_{osc}/4$ ) or an external clock. When the clock source is an external clock, the Timer0 module can be selected to increment on either the rising or falling edge.

The Timer0 module also has a programmable prescaler option. This prescaler can be assigned to either the Timer0 module or the Watchdog Timer. Bit PSA (OPTION<3>) assigns the prescaler, and bits PS2:PS0 (OPTION<2:0>) determine the prescaler value. Timer0 can increment at the following rates: 1:1 (when prescaler assigned to Watchdog timer), 1:2, 1:4, 1:8, 1:16, 1:32, 1:64, 1:128, and 1:256 (Timer0 only).

Synchronization of the external clock occurs after the prescaler. When the prescaler is used, the external clock frequency may be higher than the device's frequency. The maximum frequency is 50 MHz, given the high and low time requirements of the clock.

### 6.2 Timer1 Overview

Applicable Devices							
710	71	711	72	73	73A	74	74A

Timer1 is a 16-bit timer/counter. The clock source can be either the internal system clock ( $F_{osc}/4$ ), an external clock, or an external crystal. Timer1 can operate as either a timer or a counter. When operating as a counter (external clock source), the counter can either operate synchronized to the device or asynchronously to the device. Asynchronous operation allows Timer1 to operate during sleep, which is useful for applications that require a real-time clock as well as the power savings of SLEEP mode.

Timer1 also has a prescaler option which allows Timer1 to increment at the following rates: 1:1, 1:2, 1:4, and 1:8. Timer1 can be used in conjunction with the Cap-

ture/Compare/PWM module. When used with a CCP module, Timer1 is the time-base for 16-bit Capture or the 16-bit Compare and must be synchronized to the device.

### 6.3 Timer2 Overview

Applicable Devices							
710	71	711	72	73	73A	74	74A

Timer2 is an 8-bit timer with a programmable prescaler and postscaler, as well as an 8-bit period register (PR2). Timer2 can be used with the CCP1 module (in PWM mode) as well as the Baud Rate Generator for the Synchronous Serial Port (SSP). The prescaler option allows Timer2 to increment at the following rates: 1:1, 1:4, 1:16.

The postscaler allows the TMR2 register to match the period register (PR2) a programmable number of times before generating an interrupt. The postscaler can be programmed from 1:1 to 1:16 (inclusive).

### 6.4 CCP Overview

Applicable Devices							
710	71	711	72	73	73A	74	74A

The CCP module(s) can operate in one of these three modes: 16-bit capture, 16-bit compare, or up to 10-bit Pulse Width Modulation (PWM).

Capture mode captures the 16-bit value of TMR1 into the CCPRxH:CCPRxL register pair. The capture event can be programmed for either the falling edge, rising edge, fourth rising edge, or the sixteenth rising edge of the CCPx pin.

Compare mode compares the TMR1H:TMR1L register pair to the CCPRxH:CCPRxL register pair. When a match occurs an interrupt can be generated, and the output pin CCPx can be forced to given state (High or Low), TMR1 can be reset (CCP1), or TMR1 reset and start A/D conversion (CCP2). This depends on the control bits CCPxM3:CCPxM0.

PWM mode compares the TMR2 register to a 10-bit duty cycle register (CCPRxH:CCPRxL<5:4>) as well as to an 8-bit period register (PR2). When the TMR2 register = Duty Cycle register, the CCPx pin will be forced low. When TMR2 = PR2, TMR2 is cleared to 00h, an interrupt can be generated, and the CCPx pin (if an output) will be forced high.

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NOTES:

## 7.0 TIMER0 MODULE

Applicable Devices							
710	71	711	72	73	73A	74	74A

The Timer0 module timer/counter has the following features:

- 8-bit timer/counter
- Readable and writable
- 8-bit software programmable prescaler
- Internal or external clock select
- Interrupt on overflow from FFh to 00h
- Edge select for external clock

Figure 7-1 is a simplified block diagram of the Timer0 module.

Timer mode is selected by clearing bit T0CS (OPTION<5>). In timer mode, the Timer0 module will increment every instruction cycle (without prescaler). If the TMR0 register is written, the increment is inhibited for the following two instruction cycles (Figure 7-2 and Figure 7-3). The user can work around this by writing an adjusted value to the TMR0 register.

Counter mode is selected by setting bit T0CS (OPTION<5>). In counter mode, Timer0 will increment either on every rising or falling edge of pin RA4/T0CKI. The incrementing edge is determined by the Timer0

Source Edge Select bit T0SE (OPTION<4>). Clearing bit T0SE selects the rising edge. Restrictions on the external clock input are discussed in detail in Section 7.2.

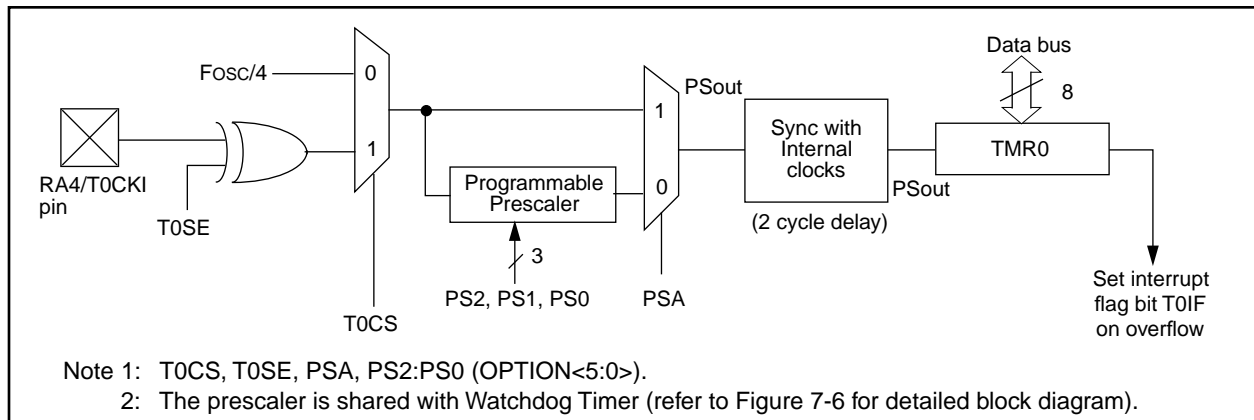
The prescaler is mutually exclusively shared between the Timer0 module and the Watchdog Timer. The prescaler assignment is controlled in software by control bit PSA (OPTION<3>). Clearing bit PSA will assign the prescaler to the Timer0 module. The prescaler is not readable or writable. When the prescaler is assigned to the Timer0 module, prescale values of 1:2, 1:4, ..., 1:256 are selectable. Section 7.3 details the operation of the prescaler.

### 7.1 Timer0 Interrupt

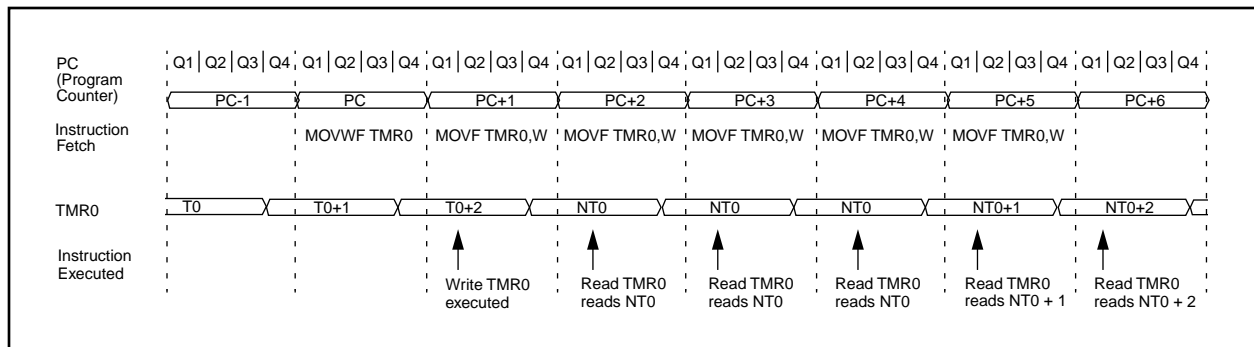
Applicable Devices							
710	71	711	72	73	73A	74	74A

The TMR0 interrupt is generated when the TMR0 register overflows from FFh to 00h. This overflow sets bit T0IF (INTCON<2>). The interrupt can be masked by clearing bit T0IE (INTCON<5>). Bit T0IF must be cleared in software by the Timer0 module interrupt service routine before re-enabling this interrupt. The TMR0 interrupt cannot awaken the processor from SLEEP since the timer is shut off during SLEEP. See Figure 7-4 for Timer0 interrupt timing.

**FIGURE 7-1: TIMER0 BLOCK DIAGRAM**

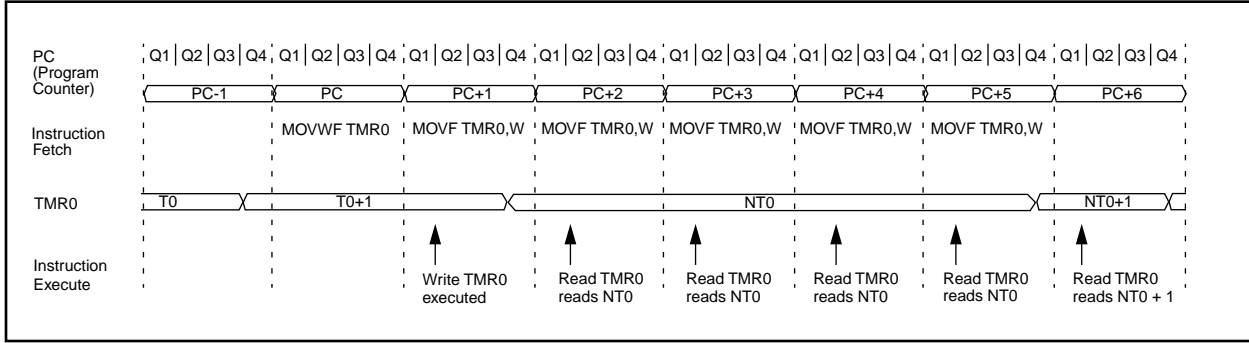


**FIGURE 7-2: TIMER0 TIMING: INTERNAL CLOCK/NO PRESCALE**

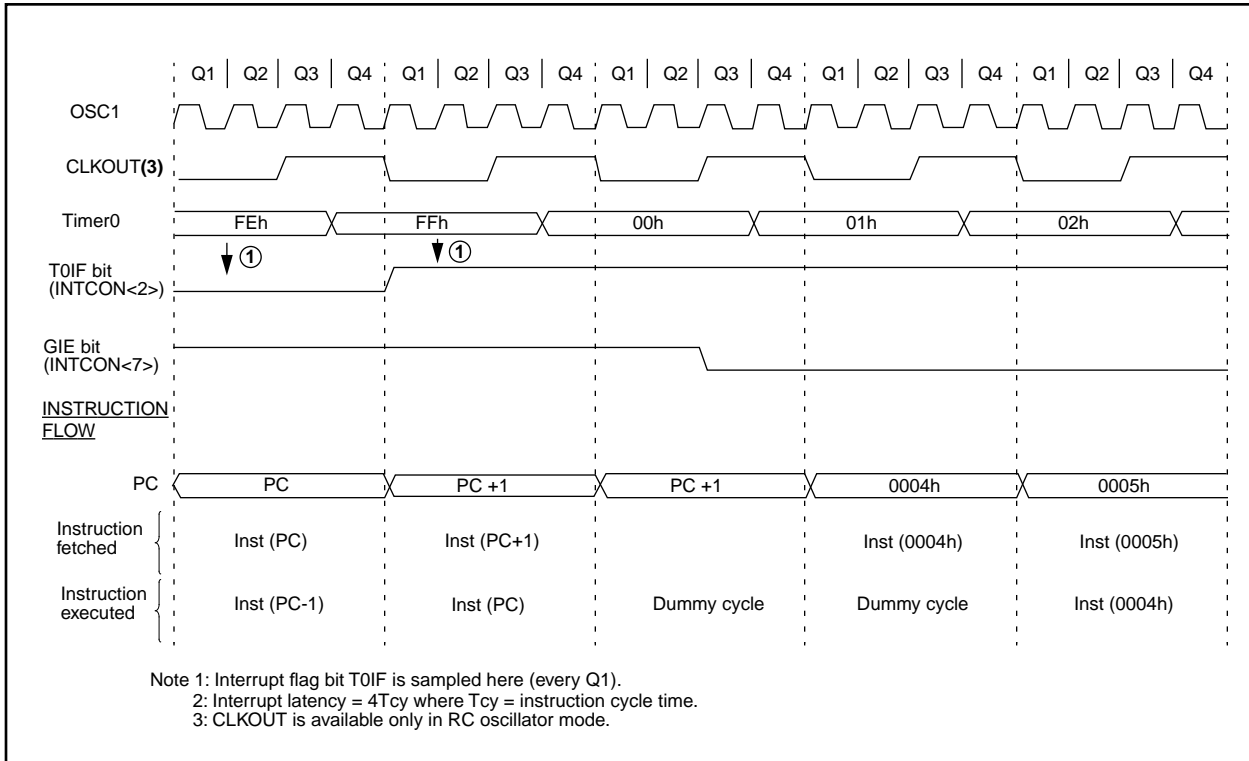


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**FIGURE 7-3: TIMER0 TIMING: INTERNAL CLOCK/PRESCALE 1:2**



**FIGURE 7-4: TIMER0 INTERRUPT TIMING**



## 7.2 Using Timer0 with an External Clock

Applicable Devices							
710	71	711	72	73	73A	74	74A

When an external clock input is used for Timer0, it must meet certain requirements. The requirements ensure the external clock can be synchronized with the internal phase clock (Tosc). Also, there is a delay in the actual incrementing of Timer0 after synchronization.

### 7.2.1 EXTERNAL CLOCK SYNCHRONIZATION

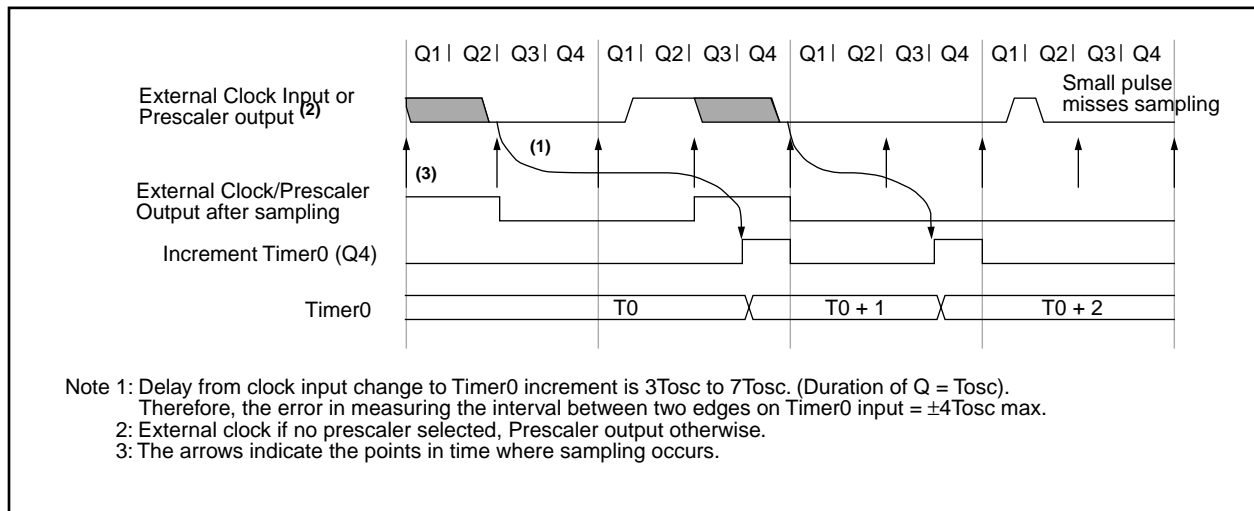
When no prescaler is used, the external clock input is the same as the prescaler output. The synchronization of T0CKI with the internal phase clocks is accomplished by sampling the prescaler output on the Q2 and Q4 cycles of the internal phase clocks (Figure 7-5). Therefore, it is necessary for T0CKI to be high for at least  $2T_{osc}$  (and a small RC delay of 20 ns) and low for at least  $2T_{osc}$  (and a small RC delay of 20 ns). Refer to the electrical specification of the desired device.

When a prescaler is used, the external clock input is divided by the asynchronous ripple-counter type prescaler so that the prescaler output is symmetrical. For the external clock to meet the sampling requirement, the ripple-counter must be taken into account. Therefore, it is necessary for T0CKI to have a period of at least  $4T_{osc}$  (and a small RC delay of 40 ns) divided by the prescaler value. The only requirement on T0CKI high and low time is that they do not violate the minimum pulse width requirement of 10 ns. Refer to parameters 40, 41 and 42 in the electrical specification of the desired device.

### 7.2.2 TMR0 INCREMENT DELAY

Since the prescaler output is synchronized with the internal clocks, there is a small delay from the time the external clock edge occurs to the time the Timer0 module is actually incremented. Figure 7-5 shows the delay from the external clock edge to the timer incrementing.

**FIGURE 7-5: TIMER0 TIMING WITH EXTERNAL CLOCK**



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## 7.3 Prescaler

Applicable Devices							
710	71	711	72	73	73A	74	74A

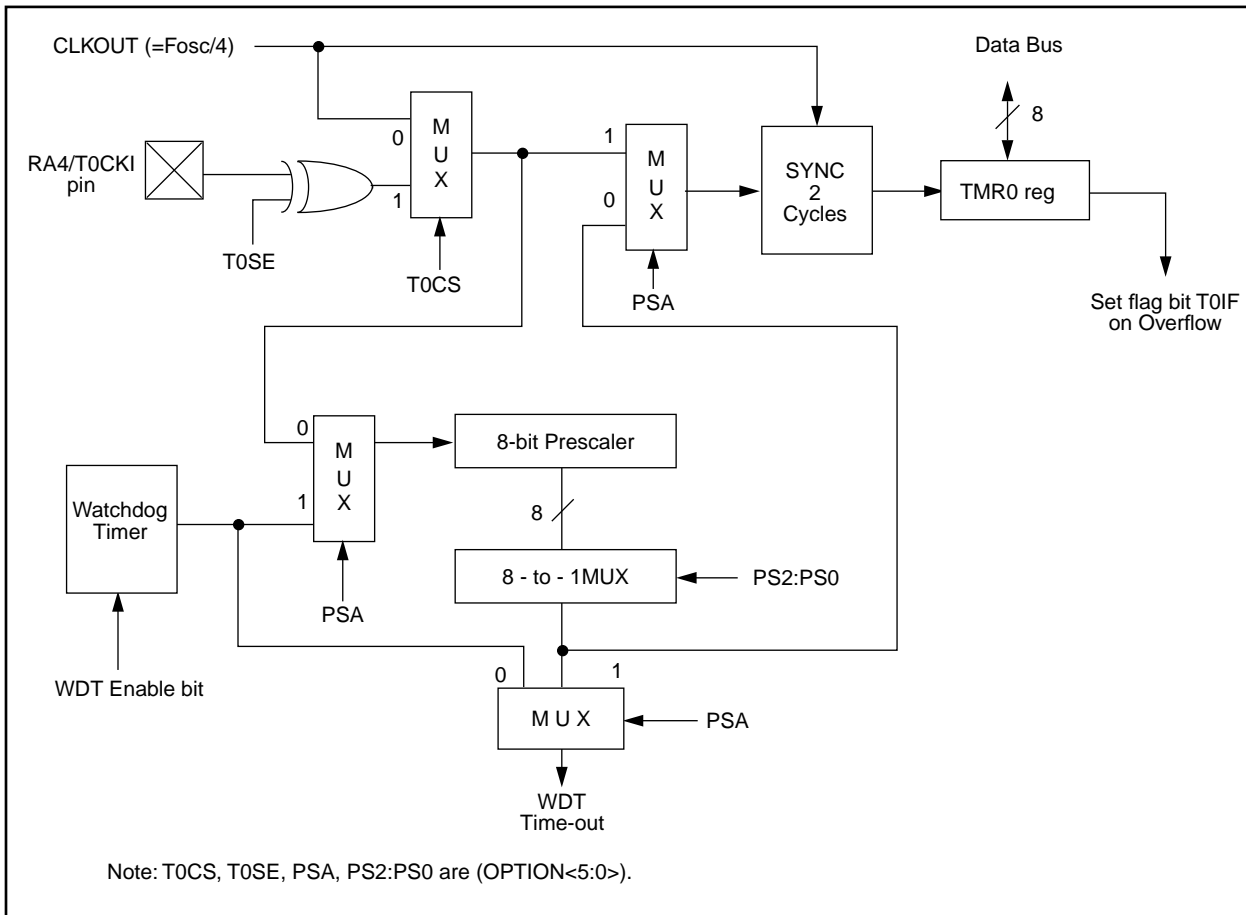
An 8-bit counter is available as a prescaler for the Timer0 module, or as a postscaler for the Watchdog Timer, respectively (Figure 7-6). For simplicity, this counter is being referred to as “prescaler” throughout this data sheet. Note that there is only one prescaler available which is mutually exclusively shared between the Timer0 module and the Watchdog Timer. Thus, a

prescaler assignment for the Timer0 module means that there is no prescaler for the Watchdog Timer, and vice-versa.

The PSA and PS2:PS0 bits (OPTION<3:0>) determine the prescaler assignment and prescale ratio.

When assigned to the Timer0 module, all instructions writing to the TMR0 register (e.g. `CLRF 1`, `MOVWF 1`, `BSF 1,x....etc.`) will clear the prescaler. When assigned to WDT, a `CLRWDT` instruction will clear the prescaler along with the Watchdog Timer. The prescaler is not readable or writable.

**FIGURE 7-6: BLOCK DIAGRAM OF THE TIMER0/WDT PRESCALER**



## 7.3.1 SWITCHING PRESCALER ASSIGNMENT

The prescaler assignment is fully under software control, i.e., it can be changed “on the fly” during program execution.

**Note:** To avoid an unintended device RESET, the following instruction sequence (shown in Example 7-1) must be executed when changing the prescaler assignment from Timer0 to the WDT. This sequence must be followed even if the WDT is disabled.

### EXAMPLE 7-1: CHANGING PRESCALER (TIMER0→WDT)

```
BCF STATUS, RP0 ;Bank 0
CLRF TMR0 ;Clear TMR0 & Prescaler
BSF STATUS, RP0 ;Bank 1
CLRWDT ;Clears WDT
MOVLW b'xxxxlxxx' ;Select new prescale
MOVWF OPTION_REG ;value & WDT
BCF STATUS, RP0 ;Bank 0
```

To change prescaler from the WDT to the Timer0 module use the sequence shown in Example 7-2.

### EXAMPLE 7-2: CHANGING PRESCALER (WDT→TIMER0)

```
CLRWDT ;Clear WDT and
;prescaler
BSF STATUS, RP0 ;Bank 1
MOVLW b'xxx0xxx' ;Select TMR0, new
;prescale value and
MOVWF OPTION_REG ;clock source
BCF STATUS, RP0 ;Bank 0
```

**TABLE 7-1: REGISTERS ASSOCIATED WITH TIMER0, PIC16C710/71/711**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets
01h	TMR0	Timer0 module's register								xxxx xxxx	uuuu uuuu
0Bh/8Bh	INTCON	GIE	ADIE	TOIE	INTE	RBIE	TOIF	INTF	RBIF	0000 000x	0000 000u
81h	OPTION	RBP <sup>U</sup>	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0	1111 1111	1111 1111
85h	TRISA	—	—	—	TRISA4	TRISA3	TRISA2	TRISA1	TRISA0	---1 1111	---1 1111

Legend: x = unknown, u = unchanged, - = unimplemented locations read as '0'. Shaded cells are not used by Timer0.

**TABLE 7-2: REGISTERS ASSOCIATED WITH TIMER0, PIC16C72/73/73A/74/74A**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets
01h	TMR0	Timer0 module's register								xxxx xxxx	uuuu uuuu
0Bh/8Bh	INTCON	GIE	PEIE	TOIE	INTE	RBIE	TOIF	INTF	RBIF	0000 000x	0000 000u
81h	OPTION	RBP <sup>U</sup>	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0	1111 1111	1111 1111
85h	TRISA	—	—	TRISA5	TRISA4	TRISA3	TRISA2	TRISA1	TRISA0	--11 1111	--11 1111

Legend: x = unknown, u = unchanged, - = unimplemented locations read as '0'. Shaded cells are not used by Timer0.

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NOTES:



## 8.0 TIMER1 MODULE

Applicable Devices							
710	711	711	72	73	73A	74	74A

The Timer1 module is a 16-bit timer/counter consisting of two 8-bit registers (TMR1H and TMR1L) which are readable and writable. The TMR1 Register pair (TMR1H + TMR1L) increments from 0000h to FFFFh and rolls over to 0000h. The TMR1 Interrupt, if enabled, is generated on overflow which is latched in interrupt flag bit TMR1IF (PIR1<0>). This interrupt can be enabled/disabled by setting/clearing TMR1 interrupt enable bit TMR1IE (PIE1<0>).

Timer1 can operate in one of two modes:

- As a timer
- As a counter

The operating mode is determined by the clock select bit, TMR1CS (T1CON<1>).

In timer mode, Timer1 increments every instruction cycle. In counter mode, it increments on every rising edge of the external clock input on pin RC0/T1OSO/T1CKI.

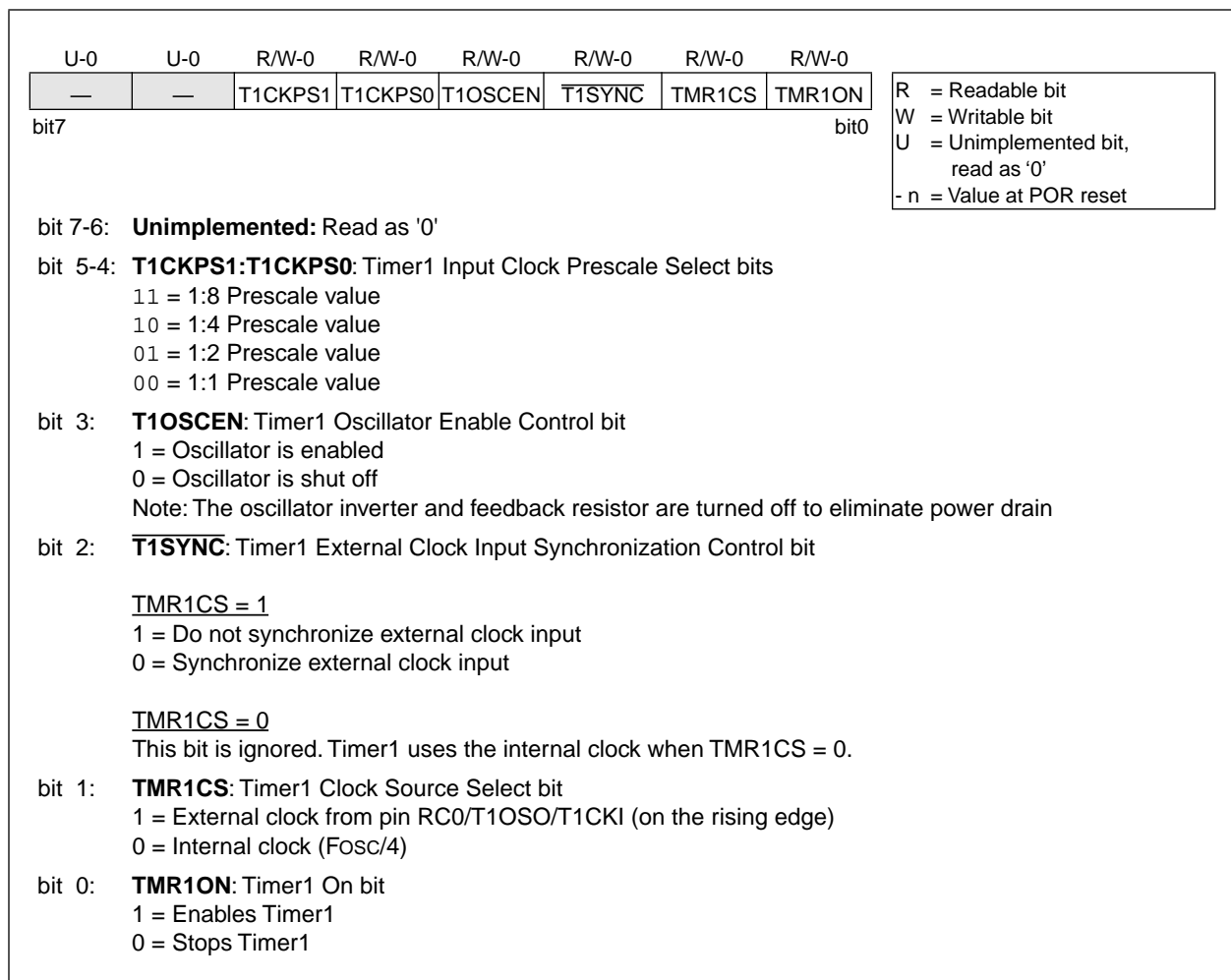
Timer1 can be turned on and off using the control bit TMR1ON (T1CON<0>).

Timer1 also has an internal "reset input". This reset can be generated by either of the two CCP modules (Section 10.0). Figure 8-1 shows the Timer1 control register.

For the PIC16C72/73A/74A, when the Timer1 oscillator is enabled (T1OSCN is set), the RC1/T1OSI/CCP2 and RC0/T1OSO/T1CKI pins become inputs. That is, the TRISC<1:0> value is ignored.

For the PIC16C73/74, when the Timer1 oscillator is enabled (T1OSCN is set), RC1/T1OSI/CCP2 pin becomes an input, however the RC0/T1OSO/T1CKI pin will have to be configured as an input by setting the TRISC<0> bit.

**FIGURE 8-1: T1CON: TIMER1 CONTROL REGISTER (ADDRESS 10h)**



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## 8.1 Timer1 Operation in Timer Mode

Applicable Devices							
710	71	711	72	73	73A	74	74A

Timer mode is selected by clearing the TMR1CS (T1CON<1>) bit. In this mode, the input clock to the timer is  $F_{osc}/4$ . The synchronize control bit  $\overline{T1SYNC}$  (T1CON<2>) has no effect since the internal clock is always in sync.

## 8.2 Timer1 Operation in Synchronized Counter Mode

Applicable Devices							
710	71	711	72	73	73A	74	74A

Counter mode is selected by setting bit TMR1CS. In this mode the timer increments on every rising edge of clock input on pin RC1/T1OSI/CCP2 when bit T1OSCE is set or pin RC0/T1OSO/T1CKI when bit T1OSCE is cleared.

If  $\overline{T1SYNC}$  is cleared, then the external clock input is synchronized with internal phase clocks. The synchronization is done after the prescaler stage. The prescaler stage is an asynchronous ripple-counter.

In this configuration, during SLEEP mode, Timer1 will not increment even if the external clock is present, since the synchronization circuit is shut off. The prescaler however will continue to increment.

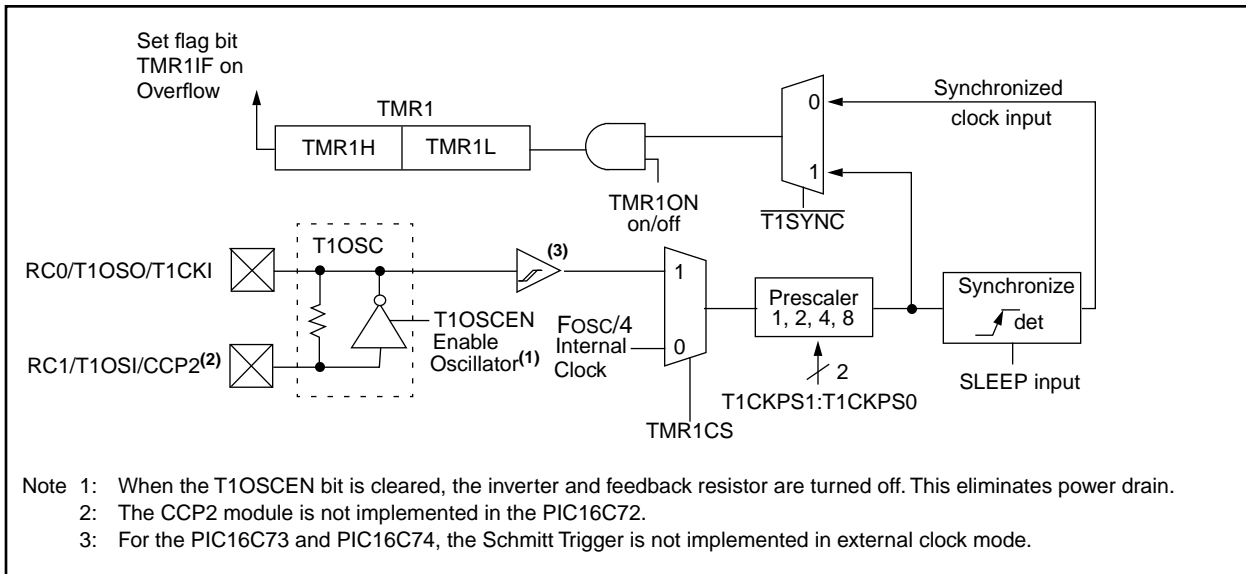
## 8.2.1 EXTERNAL CLOCK INPUT TIMING FOR SYNCHRONIZED COUNTER MODE

When an external clock input is used for Timer1 in synchronized counter mode, it must meet certain requirements. The external clock requirement is due to internal phase clock ( $T_{osc}$ ) synchronization. Also, there is a delay in the actual incrementing of TMR1 after synchronization.

When the prescaler is 1:1, the external clock input is the same as the prescaler output. The synchronization of T1CKI with the internal phase clocks is accomplished by sampling the prescaler output on the Q2 and Q4 cycles of the internal phase clocks. Therefore, it is necessary for T1CKI to be high for at least  $2T_{osc}$  (and a small RC delay of 20 ns) and low for at least  $2T_{osc}$  (and a small RC delay of 20 ns). Refer to the appropriate electrical specifications, parameters 45, 46, and 47.

When a prescaler other than 1:1 is used, the external clock input is divided by the asynchronous ripple-counter type prescaler so that the prescaler output is symmetrical. In order for the external clock to meet the sampling requirement, the ripple-counter must be taken into account. Therefore, it is necessary for T1CKI to have a period of at least  $4T_{osc}$  (and a small RC delay of 40 ns) divided by the prescaler value. The only requirement on T1CKI high and low time is that they do not violate the minimum pulse width requirements of 10 ns). Refer to the appropriate electrical specifications, parameters 40, 42, 45, 46, and 47.

FIGURE 8-2: TIMER1 BLOCK DIAGRAM



## 8.3 Timer1 Operation in Asynchronous Counter Mode

Applicable Devices							
710	71	711	72	73	73A	74	74A

If control bit  $\overline{T1SYNC}$  (T1CON<2>) is set, the external clock input is not synchronized. The timer continues to increment asynchronous to the internal phase clocks. The timer will continue to run during SLEEP and can generate an interrupt on overflow which will wake-up the processor. However, special precautions in software are needed to read/write the timer (Section 8.3.2).

In asynchronous counter mode, Timer1 can not be used as a time-base for capture or compare operations.

### 8.3.1 EXTERNAL CLOCK INPUT TIMING WITH UNSYNCHRONIZED CLOCK

If control bit  $\overline{T1SYNC}$  is set, the timer will increment completely asynchronously. The input clock must meet certain minimum high time and low time requirements. Refer to the appropriate Electrical Specifications Section, timing parameters 45, 46, and 47.

### 8.3.2 READING AND WRITING TIMER1 IN ASYNCHRONOUS COUNTER MODE

Reading TMR1H or TMR1L while the timer is running, from an external asynchronous clock, will guarantee a valid read (taken care of in hardware). However, the user should keep in mind that reading the 16-bit timer in two 8-bit values itself poses certain problems since the timer may overflow between the reads.

For writes, it is recommended that the user simply stop the timer and write the desired values. A write contention may occur by writing to the timer registers while the register is incrementing. This may produce an unpredictable value in the timer register.

Reading the 16-bit value requires some care. Example 8-1 is an example routine to read the 16-bit timer value. This is useful if the timer cannot be stopped.

## EXAMPLE 8-1: READING A 16-BIT FREE-RUNNING TIMER

```

; All interrupts are disabled
MOVWF TMR1H, W ;Read high byte
MOVWF TMPH ;
MOVWF TMR1L, W ;Read low byte
MOVWF TMPL ;
MOVWF TMR1H, W ;Read high byte
SUBWF TMPH, W ;Sub 1st read
; with 2nd read
BTFSC STATUS,Z ;Is result = 0
GOTO CONTINUE ;Good 16-bit read
;
; TMR1L may have rolled over between the read
; of the high and low bytes. Reading the high
; and low bytes now will read a good value.
;
MOVWF TMR1H, W ;Read high byte
MOVWF TMPH ;
MOVWF TMR1L, W ;Read low byte
MOVWF TMPL ;
; Re-enable the Interrupt (if required)
CONTINUE ;Continue with your code

```

## 8.4 Timer1 Oscillator

Applicable Devices							
710	71	711	72	73	73A	74	74A

A crystal oscillator circuit is built in between pins T1OSI (input) and T1OSO (amplifier output). It is enabled by setting control bit T1OSCEN (T1CON<3>). The oscillator is a low power oscillator rated up to 200 kHz. It will continue to run during SLEEP. It is primarily intended for a 32 kHz crystal. Table 8-1 shows the capacitor selection for the Timer1 oscillator.

The Timer1 oscillator is identical to the LP oscillator. The user must provide a software time delay to ensure proper oscillator start-up.

**TABLE 8-1: CAPACITOR SELECTION FOR THE TIMER1 OSCILLATOR**

Osc Type	Freq	C1	C2
LP	32 kHz <sup>(1)</sup>	15 pF	15 pF
	100 kHz	15 pF	15 pF
	200 kHz	0 - 15 pF	0 - 15 pF
Higher capacitance increases the stability of oscillator but also increases the start-up time. These values are for design guidance only. Note 1: For $V_{DD} > 4.5V$ , $C1 = C2 \approx 30$ pF is recommended.			
<b>Crystals Tested:</b>			
32.768 kHz	Epson C-001R32.768K-A	± 20 PPM	
100 kHz	Epson C-2 100.00 KC-P	± 20 PPM	
200 kHz	STD XTL 200.000 kHz	± 20 PPM	

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## 8.5 Resetting Timer1 using a CCP Trigger Output

Applicable Devices							
710	71	711	72	73	73A	74	74A

The CCP2 module is not implemented on the PIC16C72 device.

If the CCP1 or CCP2 module is configured in compare mode to generate a "special event trigger" (CCP1M3:CCP1M0 = 1011), this signal will reset Timer1.

**Note:** The special event triggers from the CCP1 and CCP2 modules will not set interrupt flag bit TMR1IF (PIR1<0>).

Timer1 must be configured for either timer or synchronized counter mode to take advantage of this feature. If Timer1 is running in asynchronous counter mode, this reset operation may not work.

In the event that a write to Timer1 coincides with a special event trigger from CCP1 or CCP2, the write will take precedence.

In this mode of operation, the CCPRxH:CCPRxL registers pair effectively becomes the period register for Timer1.

## 8.6 Resetting of Timer1 Register Pair (TMR1H, TMR1L)

Applicable Devices							
710	71	711	72	73	73A	74	74A

TMR1H and TMR1L registers are not reset on a POR or any other reset except by the CCP1 and CCP2 special event triggers.

T1CON register is reset to 00h on a Power-on Reset or a Brown-out Reset. In any other reset, the register is unaffected.

## 8.7 Timer1 Prescaler

Applicable Devices							
710	71	711	72	73	73A	74	74A

The prescaler counter is cleared on writes to the TMR1H or TMR1L registers.

**TABLE 8-2: REGISTERS ASSOCIATED WITH TIMER1 AS A TIMER/COUNTER**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets
0Bh/8Bh	INTCON	GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	0000 000x	0000 000u
0Ch	PIR1	PSPIF <sup>(1,2)</sup>	ADIF	RCIF <sup>(2)</sup>	TXIF <sup>(2)</sup>	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
8Ch	PIE1	PSPIE <sup>(1,2)</sup>	ADIE	RCIE <sup>(2)</sup>	TXIE <sup>(2)</sup>	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
0Eh	TMR1L	Holding register for the Least Significant Byte of the 16-bit TMR1 register								xxxx xxxx	uuuu uuuu
0Fh	TMR1H	Holding register for the Most Significant Byte of the 16-bit TMR1 register								xxxx xxxx	uuuu uuuu
10h	T1CON	—	—	T1CKPS1	T1CKPS0	T1OSCEN	T1SYNC	TMR1CS	TMR1ON	--00 0000	--uu uuuu

Legend: x = unknown, u = unchanged, - = unimplemented read as '0'. Shaded cells are not used by the Timer1 module.

Note 1: Bits PSPIE and PSPIF are reserved on the PIC16C73/73A, always maintain these bits clear.

Note 2: The PIC16C72 does not have a Parallel Slave Port or a USART, these bits are unimplemented, read as '0'.

## 9.0 TIMER2 MODULE

Applicable Devices							
710	71	711	72	73	73A	74	74A

Timer2 is an 8-bit timer with a prescaler and a postscaler. It can be used as the PWM time-base for PWM mode of the CCP module(s). The TMR2 register is readable and writable, and is cleared on any device reset.

The input clock ( $F_{osc}/4$ ) has a prescale option of 1:1, 1:4 or 1:16 (selected by control bits T2CKPS1:T2CKPS0 (T2CON<1:0>)).

The Timer2 module has an 8-bit period register PR2. Timer2 increments from 00h until it matches PR2 and then resets to 00h on the next increment cycle. PR2 is a readable and writable register. The PR2 register is set during RESET.

The match output of TMR2 goes through a 4-bit postscaler (which gives a 1:1 to 1:16 scaling inclusive) to generate a TMR2 interrupt (latched in flag bit TMR2IF, (PIR1<1>)).

Timer2 can be shut off by clearing control bit TMR2ON (T2CON<2>) to minimize power consumption.

Figure 9-2 shows the Timer2 control register.

## 9.1 Timer2 Prescaler and Postscaler

Applicable Devices							
710	71	711	72	73	73A	74	74A

The prescaler and postscaler counters are cleared when any of the following occurs:

- a write to the TMR2 register
- a write to the T2CON register
- any device reset (Power-on Reset,  $\overline{MCLR}$  reset, Watchdog Timer reset, or Brown-out Reset)

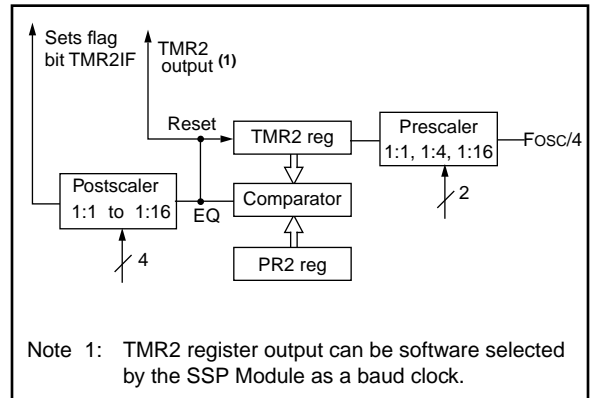
TMR2 will not clear when T2CON is written, only for a WDT, POR,  $\overline{MCLR}$ , and BOR reset.

## 9.2 Output of TMR2

Applicable Devices							
710	71	711	72	73	73A	74	74A

The output of TMR2 (before the postscaler) is fed to the Synchronous Serial Port module which optionally uses it to generate shift clock.

**FIGURE 9-1: TIMER2 BLOCK DIAGRAM**



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**FIGURE 9-2: T2CON:TIMER2 CONTROL REGISTER (ADDRESS 12h)**

U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0		
—	TOUTPS3	TOUTPS2	TOUTPS1	TOUTPS0	TMR2ON	T2CKPS1	T2CKPS0			
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 6-3: **TOUTPS3:TOUTPS0:** Timer2 Output Postscale Select bits  
0000 = 1:1 Postscale  
0001 = 1:2 Postscale  
•  
•  
•  
1111 = 1:16 Postscale

bit 2: **TMR2ON:** Timer2 On bit  
1 = Timer2 is on  
0 = Timer2 is off

bit 1-0: **T2CKPS1:T2CKPS0:** Timer2 Clock Prescale Select bits  
00 = Prescaler is 1  
01 = Prescaler is 4  
1x = Prescaler is 16

**TABLE 9-1: REGISTERS ASSOCIATED WITH TIMER2 AS A TIMER/COUNTER**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets
0Bh/8Bh	INTCON	GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	0000 000x	0000 000u
0Ch	PIR1	PSPIF <sup>(1,2)</sup>	ADIF	RCIF <sup>(2)</sup>	TXIF <sup>(2)</sup>	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
8Ch	PIE1	PSPIE <sup>(1,2)</sup>	ADIE	RCIE <sup>(2)</sup>	TXIE <sup>(2)</sup>	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
11h	TMR2	Timer2 module's register								0000 0000	0000 0000
12h	T2CON	—	TOUTPS3	TOUTPS2	TOUTPS1	TOUTPS0	TMR2ON	T2CKPS1	T2CKPS0	-000 0000	-000 0000
92h	PR2	Timer2 Period Register								1111 1111	1111 1111

Legend: x = unknown, u = unchanged, - = unimplemented read as '0'. Shaded cells are not used by the Timer2 module.

Note 1: Bits PSPIE and PSPIF are reserved on the PIC16C73/73A, always maintain these bits clear.

Note 2: The PIC16C72 does not have a Parallel Slave Port or a USART, these bits are unimplemented, read as '0'.

## 10.0 CAPTURE/COMPARE/PWM MODULE(s)

Applicable Devices								
710	71	711	72	73	73A	74	74A	CCP1 CCP2
710	71	711	72	73	73A	74	74A	

Each CCP (Capture/Compare/PWM) module contains a 16-bit register which can operate as a 16-bit capture register, as a 16-bit compare register or as a PWM master/slave Duty Cycle register. Both the CCP1 and CCP2 modules are identical in operation, with the exception of the operation of the special event trigger. Table 10-1 and Table 10-2 show the resources and interactions of the CCP module(s). In the following sections, the operation of a CCP module is described with respect to CCP1. CCP2 operates the same as CCP1, except where noted.

### CCP1 module:

Capture/Compare/PWM Register1 (CCPR1) is comprised of two 8-bit registers: CCPR1L (low byte) and CCPR1H (high byte). The CCP1CON register controls the operation of CCP1. All are readable and writable.

### CCP2 module:

Capture/Compare/PWM Register2 (CCPR2) is comprised of two 8-bit registers: CCPR2L (low byte) and CCPR2H (high byte). The CCP2CON register controls the operation of CCP2. All are readable and writable.

For use of the CCP modules, refer to the Embedded Control Handbook, "Using the CCP Modules" (AN594).

**TABLE 10-1: CCP MODE - TIMER RESOURCE**

CCP Mode	Timer Resource
Capture	Timer1
Compare	Timer1
PWM	Timer2

**TABLE 10-2: INTERACTION OF TWO CCP MODULES**

CCPx Mode	CCPy Mode	Interaction
Capture	Capture	Same TMR1 time-base.
Capture	Compare	The compare should be configured for the special event trigger, which clears TMR1.
Compare	Compare	The compare(s) should be configured for the special event trigger, which clears TMR1.
PWM	PWM	The PWMs will have the same frequency, and update rate (TMR2 interrupt).
PWM	Capture	None
PWM	Compare	None

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**FIGURE 10-1: CCP1CON REGISTER (ADDRESS 17h)/CCP2CON REGISTER (ADDRESS 1Dh)**

U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	
—	—	CCPxX	CCPxY	CCPxM3	CCPxM2	CCPxM1	CCPxM0	
bit7								bit0

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

bit 7-6: **Unimplemented:** Read as '0'

bit 5-4: **CCPxX:CCPxY:** PWM Least Significant bits  
Capture Mode: Unused  
Compare Mode: Unused  
PWM Mode: These bits are the two LSBs of the PWM duty cycle. The eight MSBs are found in CCPRxL.

bit 3-0: **CCPxM3:CCPxM0:** CCPx Mode Select bits  
0000 = Capture/Compare/PWM off (resets CCPx module)  
0100 = Capture mode, every falling edge  
0101 = Capture mode, every rising edge  
0110 = Capture mode, every 4th rising edge  
0111 = Capture mode, every 16th rising edge  
1000 = Compare mode, set output on match (CCPxIF bit is set)  
1001 = Compare mode, clear output on match (CCPxIF bit is set)  
1010 = Compare mode, generate software interrupt on match (CCPxIF bit is set, CCPx pin is unaffected)  
1011 = Compare mode, trigger special event (CCPxIF bit is set; CCP1 resets TMR1; CCP2 resets TMR1 and starts an A/D conversion (if A/D module is enabled))  
11xx = PWM mode

## 10.1 Capture Mode

Applicable Devices							
710	711	712	713	73A	74	74A	

In Capture mode, CCPR1H:CCPR1L captures the 16-bit value of the TMR1 register when an event occurs on pin RC2/CCP1. An event is defined as:

- Every falling edge
- Every rising edge
- Every 4th rising edge
- Every 16th rising edge

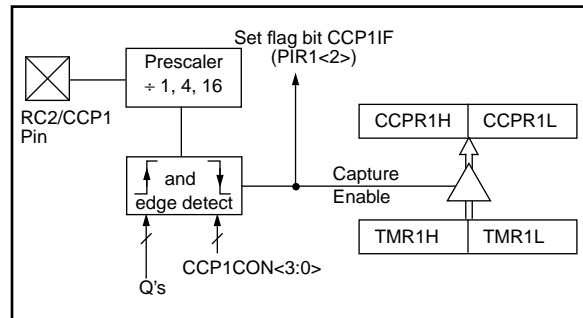
An event is selected by control bits CCP1M3:CCP1M0 (CCP1CON<3:0>). When a capture is made, the interrupt request flag bit CCP1IF (PIR1<2>) is set. It must be cleared in software. If another capture occurs before the value in register CCPR1 is read, the old captured value will be lost.

### 10.1.1 CCP PIN CONFIGURATION

In Capture mode, the RC2/CCP1 pin should be configured as an input by setting its corresponding TRIS bit.

**Note:** If the RC2/CCP1 is configured as an output, a write to the port can cause a capture condition.

**FIGURE 10-2: CAPTURE MODE OPERATION BLOCK DIAGRAM**



### 10.1.2 TIMER1 MODE SELECTION

Timer1 must be running in timer mode or synchronized counter mode for the CCP module to use the capture feature. In asynchronous counter mode, the capture operation may not work.

### 10.1.3 SOFTWARE INTERRUPT

When the Capture mode is changed, a false capture interrupt may be generated. The user should keep bit CCP1IE (PIE1<2>) clear to avoid false interrupts and should clear the flag bit CCP1IF following any such change in operating mode.



## 10.1.4 CCP PRESCALER

There are four prescaler settings, specified by bits CCP1M3:CCP1M0. Whenever the CCP module is turned off, or the CCP module is not in capture mode, the prescaler counter is cleared. This means that any reset will clear the prescaler counter.

Switching from one capture prescaler to another may generate an interrupt. Also, the prescaler counter will not be cleared, therefore the first capture may be from a non-zero prescaler. Example 10-1 shows the recommended method for switching between capture prescalers. This example also clears the prescaler counter and will not generate the "false" interrupt.

### EXAMPLE 10-1: CHANGING BETWEEN CAPTURE PRESCALERS

```
CLRF   CCP1CON      ;Turn CCP module off
MOVLW  NEW_CAPT_PS  ;Load the W reg with
                    ; the new prescaler
                    ; mode value and CCP ON
MOVWF  CCP1CON      ;Load CCP1CON with this
                    ; value
```

## 10.2 Compare Mode

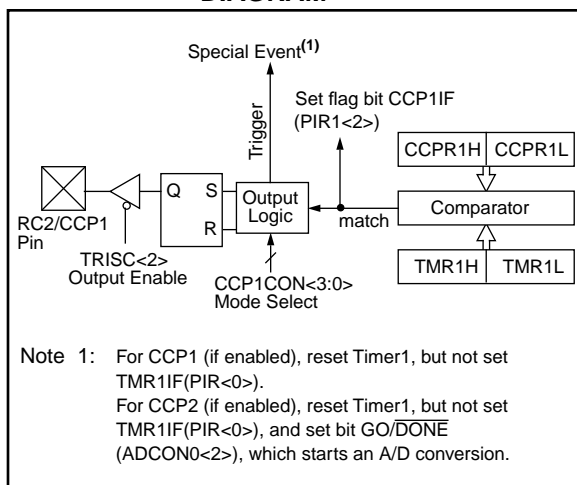
Applicable Devices							
710	71	711	72	73	73A	74	74A

In Compare mode, the 16-bit CCPR1 register value is constantly compared against the TMR1 register pair value. When a match occurs, the RC2/CCP1 pin is:

- Driven High
- Driven Low
- Remains Unchanged

The action on the pin is based on the value of control bits CCP1M3:CCP1M0 (CCP1CON<3:0>). At the same time, a compare interrupt is also generated.

**FIGURE 10-3: COMPARE MODE OPERATION BLOCK DIAGRAM**



## 10.2.1 CCP PIN CONFIGURATION

The user must configure the RC2/CCP1 pin as an output by clearing the TRISC<2> bit.

**Note:** Clearing the CCP1CON register will force the RC2/CCP1 compare output latch to the default low level. This is not the data latch.

## 10.2.2 TIMER1 MODE SELECTION

Timer1 must be running in Timer mode or Synchronized Counter mode if the CCP module is using the compare feature. In Asynchronous Counter mode, the compare operation may not work.

## 10.2.3 SOFTWARE INTERRUPT MODE

When generate software interrupt is chosen the CCP1 pin is not affected. Only a CCP interrupt is generated (if enabled).

## 10.2.4 SPECIAL EVENT TRIGGER

In this mode, an internal hardware trigger is generated which may be used to initiate an action.

The special event trigger output of CCP1 resets the TMR1 register pair. This allows the CCPR1 register to effectively be a 16-bit programmable period register for Timer1.

The special trigger output of CCP2 resets the TMR1 register pair, and starts an A/D conversion (if the A/D module is enabled).

For the PIC16C72 only, the special event trigger output of CCP1 resets the TMR1 register pair, and starts an A/D conversion (if the A/D module is enabled).

**Note:** The special event trigger from the CCP1 and CCP2 modules will not set interrupt flag bit TMR1IF (PIR1<0>).

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## 10.3 PWM Mode

Applicable Devices									
61	62	62A	R62	63	64	64A	R64	65	65A

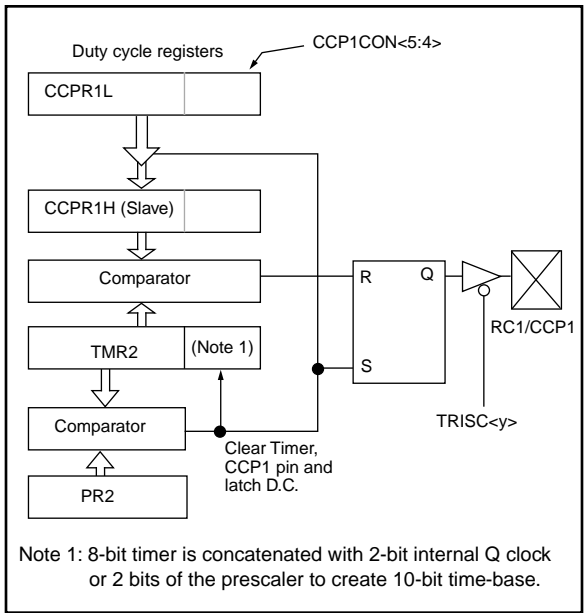
In Pulse Width Modulation (PWM) mode, the CCPx pin produces up to a 10-bit resolution PWM output. Since the CCPx pin is multiplexed with the PORTC data latch, the corresponding TRISC bit must be cleared to make the CCPx pin an output.

**Note:** Clearing the CCP1CON register will force the CCP1 PWM output latch to the default low level. This is not the PORTC I/O data latch.

Figure 10-4 shows a simplified block diagram of the CCP module in PWM mode.

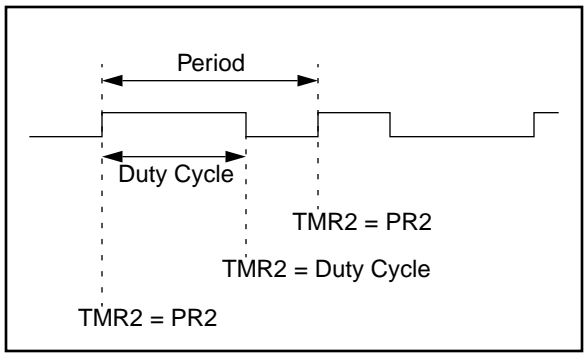
For a step by step procedure on how to set up the CCP module for PWM operation, see Section 10.3.3.

**FIGURE 10-4: SIMPLIFIED PWM BLOCK DIAGRAM**



A PWM output (Figure 10-5) has a time base (period) and a time that the output stays high (duty cycle). The frequency of the PWM is the inverse of the period (1/period).

**FIGURE 10-5: PWM OUTPUT**



### 10.3.1 PWM PERIOD

The PWM period is specified by writing to the PR2 register. The PWM period can be calculated using the following formula:

$$\text{PWM period} = [(\text{PR2}) + 1] \cdot 4 \cdot \text{Tosc} \cdot (\text{TMR2 prescale value})$$

PWM frequency is defined as  $1 / [\text{PWM period}]$ .

When TMR2 is equal to PR2, the following three events occur on the next increment cycle:

- TMR2 is cleared
- The CCP1 pin is set (exception: if PWM duty cycle = 0%, the CCP1 pin will not be set)
- The PWM duty cycle is latched from CCPR1L into CCPR1H

**Note:** The Timer2 postscaler (see Section 9.1) is not used in the determination of the PWM frequency. The postscaler could be used to have a servo update rate at a different frequency than the PWM output.

### 10.3.2 PWM DUTY CYCLE

The PWM duty cycle is specified by writing to the CCPR1L register and to the CCP1CON<5:4> bits. Up to 10-bit resolution is available: the CCPR1L contains the eight MSBs and the CCP1CON<5:4> contains the two LSbs. This 10-bit value is represented by CCPR1L:CCP1CON<5:4>. The following equation is used to calculate the PWM duty cycle:

$$\text{PWM duty cycle} = (\text{CCPR1L}:\text{CCP1CON}\langle 5:4 \rangle) \cdot \text{Tosc} \cdot (\text{TMR2 prescale value})$$

CCPR1L and CCP1CON<5:4> can be written to at any time, but the duty cycle value is not latched into CCPR1H until after a match between PR2 and TMR2 occurs (i.e., the period is complete). In PWM mode, CCPR1H is a read-only register.

The CCPR1H register and a 2-bit internal latch are used to double buffer the PWM duty cycle. This double buffering is essential for glitchless PWM operation.

When the CCPR1H and 2-bit latch match TMR2 concatenated with an internal 2-bit Q clock or 2 bits of the TMR2 prescaler, the CCP1 pin is cleared.

Maximum PWM resolution (bits) for a given PWM frequency:

$$= \frac{\log\left(\frac{F_{\text{OSC}}}{F_{\text{PWM}}}\right)}{\log(2)} \text{ bits}$$

**Note:** If the PWM duty cycle value is longer than the PWM period (PWM duty cycle = 100%), the CCP1 pin will not be cleared.

## EXAMPLE 10-2: PWM PERIOD AND DUTY CYCLE CALCULATION

Desired PWM frequency is 78.125 kHz,  
 $F_{osc} = 20$  MHz  
 TMR2 prescale = 1

$$1/78.125 \text{ kHz} = [(PR2) + 1] \cdot 4 \cdot 1/20 \text{ MHz} \cdot 1$$

$$12.8 \mu\text{s} = [(PR2) + 1] \cdot 4 \cdot 50 \text{ ns} \cdot 1$$

$$PR2 = 63$$

Find the maximum resolution of the duty cycle that can be used with a 78.125 kHz frequency and 20 MHz oscillator:

$$1/78.125 \text{ kHz} = 2^{\text{PWM RESOLUTION}} \cdot 1/20 \text{ MHz} \cdot 1$$

$$12.8 \mu\text{s} = 2^{\text{PWM RESOLUTION}} \cdot 50 \text{ ns} \cdot 1$$

$$256 = 2^{\text{PWM RESOLUTION}}$$

$$\log(256) = (\text{PWM Resolution}) \cdot \log(2)$$

$$8.0 = \text{PWM Resolution}$$

At most, an 8-bit resolution duty cycle can be obtained from a 78.125 kHz frequency and a 20 MHz oscillator, i.e.,  $0 \leq \text{CCPR1L:CCP1CON}\langle 5:4 \rangle \leq 255$ . Any value greater than 255 will result in a 100% duty cycle.

In order to achieve higher resolution, the PWM frequency must be decreased. In order to achieve higher PWM frequency, the resolution must be decreased.

Table 10-3 lists example PWM frequencies and resolutions for  $F_{osc} = 20$  MHz. TMR2 prescaler and PR2 values are also shown.

### 10.3.3 SET-UP FOR PWM OPERATION

The following steps should be taken when configuring the CCP module for PWM operation:

1. Set the PWM period by writing to the PR2 register.
2. Set the PWM duty cycle by writing to the CCPR1L register and CCP1CON<5:4> bits.
3. Make the CCP1 pin an output by clearing the appropriate TRISC bit.
4. Set the TMR2 prescale value and enable Timer2 by writing to T2CON.
5. Configure the CCP module for PWM operation.

**TABLE 10-3: EXAMPLE PWM FREQUENCIES AND RESOLUTIONS AT 20 MHz**

PWM Frequency	1.22 kHz	4.88 kHz	19.53 kHz	78.12 kHz	156.3 kHz	208.3 kHz
Timer Prescaler (1, 4, 16)	16	4	1	1	1	1
PR2 Value	0xFF	0xFF	0xFF	0x3F	0x1F	0x17
Maximum Resolution (bits)	10	10	10	8	7	5.5

**TABLE 10-4: REGISTERS ASSOCIATED WITH CAPTURE, COMPARE, AND TIMER1**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets
0Bh/8Bh	INTCON	GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	0000 000x	0000 000u
0Ch	PIR1	PSPIF <sup>(1,2)</sup>	ADIF	RCIF <sup>(2)</sup>	TXIF <sup>(2)</sup>	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
0Dh <sup>(2)</sup>	PIR2	—	—	—	—	—	—	—	CCP2IF	---- --0	---- --0
8Ch	PIE1	PSPIE <sup>(1,2)</sup>	ADIE	RCIE <sup>(2)</sup>	TXIE <sup>(2)</sup>	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
8Dh <sup>(2)</sup>	PIE2	—	—	—	—	—	—	—	CCP2IE	---- --0	---- --0
87h	TRISC	TRISC7	TRISC6	TRISC5	TRISC4	TRISC3	TRISC2	TRISC1	TRISC0	1111 1111	1111 1111
0Eh	TMR1L	Holding register for the Least Significant Byte of the 16-bit TMR1 register								xxxx xxxx	uuuu uuuu
0Fh	TMR1H	Holding register for the Most Significant Byte of the 16-bit TMR1 register								xxxx xxxx	uuuu uuuu
10h	T1CON	—	—	T1CKPS1	T1CKPS0	T1OSCEN	T1SYNC	TMR1CS	TMR1ON	--00 0000	--uu uuuu
15h	CCPR1L	Capture/Compare/PWM register1 (LSB)								xxxx xxxx	uuuu uuuu
16h	CCPR1H	Capture/Compare/PWM register1 (MSB)								xxxx xxxx	uuuu uuuu
17h	CCP1CON	—	—	CCP1X	CCP1Y	CCP1M3	CCP1M2	CCP1M1	CCP1M0	--00 0000	--00 0000
1Bh <sup>(2)</sup>	CCPR2L	Capture/Compare/PWM register2 (LSB)								xxxx xxxx	uuuu uuuu
1Ch <sup>(2)</sup>	CCPR2H	Capture/Compare/PWM register2 (MSB)								xxxx xxxx	uuuu uuuu
1Dh <sup>(2)</sup>	CCP2CON	—	—	CCP2X	CCP2Y	CCP2M3	CCP2M2	CCP2M1	CCP2M0	--00 0000	--00 0000

Legend: x = unknown, u = unchanged, - = unimplemented read as '0'. Shaded cells are not used by Capture and Timer1.

Note 1: Bits PSPIE and PSPIF are reserved on the PIC16C73/73A, always maintain these bits clear.

Note 2: The PIC16C72 does not have a Parallel Slave Port, USART or CCP2 module, these bits are unimplemented, read as '0'.

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**TABLE 10-5: REGISTERS ASSOCIATED WITH PWM AND TIMER2**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets
0Bh/8Bh	INTCON	GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBFIF	0000 000x	0000 000u
0Ch	PIR1	PSPIF <sup>(1,2)</sup>	ADIF	RCIF <sup>(2)</sup>	TXIF <sup>(2)</sup>	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
0Dh <sup>(2)</sup>	PIR2	—	—	—	—	—	—	—	CCP2IF	---- --0	---- --0
8Ch	PIE1	PSPIE <sup>(1,2)</sup>	ADIE	RCIE <sup>(2)</sup>	TXIE <sup>(2)</sup>	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
8Dh <sup>(2)</sup>	PIE2	—	—	—	—	—	—	—	CCP2IE	---- --0	---- --0
87h	TRISC	TRISC7	TRISC6	TRISC5	TRISC4	TRISC3	TRISC2	TRISC1	TRISC0	1111 1111	1111 1111
11h	TMR2	Timer2 module's register								0000 0000	0000 0000
92h	PR2	Timer2 module's period register								1111 1111	1111 1111
12h	T2CON	—	TOUTPS3	TOUTPS2	TOUTPS1	TOUTPS0	TMR2ON	T2CKPS1	T2CKPS0	-000 0000	-000 0000
15h	CCPR1L	Capture/Compare/PWM register1 (LSB)								xxxx xxxx	uuuu uuuu
16h	CCPR1H	Capture/Compare/PWM register1 (MSB)								xxxx xxxx	uuuu uuuu
17h	CCP1CON	—	—	CCP1X	CCP1Y	CCP1M3	CCP1M2	CCP1M1	CCP1M0	--00 0000	--00 0000
1Bh <sup>(2)</sup>	CCPR2L	Capture/Compare/PWM register2 (LSB)								xxxx xxxx	uuuu uuuu
1Ch <sup>(2)</sup>	CCPR2H	Capture/Compare/PWM register2 (MSB)								xxxx xxxx	uuuu uuuu
1Dh <sup>(2)</sup>	CCP2CON	—	—	CCP2X	CCP2Y	CCP2M3	CCP2M2	CCP2M1	CCP2M0	--00 0000	--00 0000

Legend: x = unknown, u = unchanged, - = unimplemented read as '0'. Shaded cells are not used by PWM and Timer2.

Note 1: Bits PSPIE and PSPIF are reserved on the PIC16C73/73A, always maintain these bits clear.

Note 2: The PIC16C72 does not have a Parallel Slave Port, USART or CCP2 module, these bits are unimplemented, read as '0'.

## 11.0 SYNCHRONOUS SERIAL PORT (SSP) MODULE

Refer to Application Note AN578, "Use of the SSP Module in the I<sup>2</sup>C Multi-Master Environment."

Applicable Devices							
710	711	721	731	73A	741	74A	

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 (I<sup>2</sup>C)

**FIGURE 11-1: SSPSTAT: SYNC SERIAL PORT STATUS REGISTER (ADDRESS 94h)**

U-0	U-0	R-0	R-0	R-0	R-0	R-0	R-0	
—	—	D/ $\bar{A}$	P	S	R/ $\bar{W}$	UA	BF	
bit7								bit0
<p>bit 7-6: <b>Unimplemented:</b> Read as '0'</p> <p>bit 5: <b>D/<math>\bar{A}</math>:</b> Data/Address bit (I<sup>2</sup>C mode only)            1 = Indicates that the last byte received or transmitted was data            0 = Indicates that the last byte received or transmitted was address</p> <p>bit 4: <b>P:</b> Stop bit (I<sup>2</sup>C mode only. This bit is cleared when the SSP module is disabled, SSPEN is cleared)            1 = Indicates that a stop bit has been detected last (this bit is '0' on RESET)            0 = Stop bit was not detected last</p> <p>bit 3: <b>S:</b> Start bit (I<sup>2</sup>C mode only. This bit is cleared when the SSP module is disabled, SSPEN is cleared)            1 = Indicates that a start bit has been detected last (this bit is '0' on RESET)            0 = Start bit was not detected last</p> <p>bit 2: <b>R/<math>\bar{W}</math>:</b> Read/Write bit information (I<sup>2</sup>C mode only)            This bit holds the R/W bit information following the last address match. This bit is only valid during the transmission.            1 = Read            0 = Write</p> <p>bit 1: <b>UA:</b> Update Address (10-bit I<sup>2</sup>C mode only)            1 = Indicates that the user needs to update the address in the SSPADD register            0 = Address does not need to be updated</p> <p>bit 0: <b>BF:</b> Buffer Full Status bit</p> <p><u>Receive</u> (SPI and I<sup>2</sup>C modes)            1 = Receive complete, SSPBUF is full            0 = Receive not complete, SSPBUF is empty</p> <p><u>Transmit</u> (I<sup>2</sup>C mode only)            1 = Transmit in progress, SSPBUF is full            0 = Transmit complete, SSPBUF is empty</p>								

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**FIGURE 11-2: SSPCON: SYNC SERIAL PORT CONTROL REGISTER (ADDRESS 14h)**

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
WCOL	SSPOV	SSPEN	CKP	SSPM3	SSPM2	SSPM1	SSPM0
bit7							bit0

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

bit 7: **WCOL**: Write Collision Detect bit  
1 = The SSPBUF register is written while it is still transmitting the previous word (must be cleared in software)  
0 = No collision

bit 6: **SSPOV**: Receive Overflow Indicator bit  
In SPI mode  
1 = A new byte is received while the SSPBUF register is still holding the previous data. In case of overflow, the data in SSPSR is lost. Overflow can only occur in slave mode. The user must read the SSPBUF, even if only transmitting data, to avoid setting overflow. In master mode the overflow bit is not set since each new reception (and transmission) is initiated by writing to the SSPBUF register.  
0 = No overflow  
In I<sup>2</sup>C mode  
1 = A byte is received while the SSPBUF register is still holding the previous byte. SSPOV is a "don't care" in transmit mode. SSPOV must be cleared in software in either mode.  
0 = No overflow

bit 5: **SSPEN**: Synchronous Serial Port Enable bit  
In SPI mode  
1 = Enables serial port and configures SCK, SDO, and SDI as serial port pins  
0 = Disables serial port and configures these pins as I/O port pins  
In I<sup>2</sup>C mode  
1 = Enables the serial port and configures the SDA and SCL pins as serial port pins  
0 = Disables serial port and configures these pins as I/O port pins  
In both modes, when enabled, these pins must be properly configured as input or output.

bit 4: **CKP**: Clock Polarity Select bit  
In SPI mode  
1 = Transmit happens on falling edge, receive on rising edge. Idle state for clock is a high level  
0 = Transmit happens on rising edge, receive on falling edge. Idle state for clock is a low level  
In I<sup>2</sup>C mode  
SCK release control  
1 = Enable clock  
0 = Holds clock low (clock stretch) (Used to ensure data setup time)

bit 3-0: **SSPM3:SSPM0**: Synchronous Serial Port Mode Select bits  
0000 = SPI master mode, clock = FOSC/4  
0001 = SPI master mode, clock = FOSC/16  
0010 = SPI master mode, clock = FOSC/64  
0011 = SPI master mode, clock = TMR2 output/2  
0100 = SPI slave mode, clock = SCK pin.  $\overline{SS}$  pin control enabled.  
0101 = SPI slave mode, clock = SCK pin.  $\overline{SS}$  pin control disabled.  $\overline{SS}$  can be used as I/O pin  
0110 = I<sup>2</sup>C slave mode, 7-bit address  
0111 = I<sup>2</sup>C slave mode, 10-bit address  
1011 = I<sup>2</sup>C start and stop bit interrupts enabled (slave idle)  
1110 = I<sup>2</sup>C slave mode, 7-bit address with start and stop bit interrupts enabled  
1111 = I<sup>2</sup>C slave mode, 10-bit address with start and stop bit interrupts enabled

## 11.1 SPI Mode

Applicable Devices							
710	71	711	72	73	73A	74	74A

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

- Serial Data Out (SDO) RC5/SDO
- Serial Data In (SDI) RC4/SDI
- Serial Clock (SCK) RC3/SCK

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

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

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>). These control bits allow the following to be specified:

- Master Mode (SCK is the clock output)
- Slave Mode (SCK is the clock input)
- Clock Polarity (Output/Input data on the Rising/Falling edge of SCK)
- Clock Rate (Master mode only)
- Slave Select Mode (Slave mode only)

The SSP consists of a transmit/receive Shift Register (SSPSR) and a Buffer register (SSPBUF). The SSPSR shifts the data in and out of the device, MSB first. The SSPBUF holds the data that was previously written to the SSPSR, until the received data is ready. Once the 8-bits of data have been received, that information is moved to the SSPBUF register. Then the buffer full detect bit BF (SSPSTAT <0>) and interrupt flag bit SSPIF (PIR1<3>) are set. This double buffering of the received data (SSPBUF) allows the next byte to start reception before reading the data that was received. Any write to the SSPBUF register during transmission/reception of data will be ignored, and the write collision detect bit WCOL (SSPCON<7>) will be set. User software must clear the WCOL bit so that it can be determined if the following write(s) to the SSPBUF register completed successfully. When the application software is expecting to receive valid data, the SSPBUF should be read before the next byte of data to transfer is written to the SSPBUF. Buffer full bit BF (SSPSTAT<0>) indicates when SSPBUF has been loaded with the received data (transmission is complete). When the SSPBUF is read, bit BF is cleared. This data may be irrelevant if the SPI is only a transmitter. Generally the SSP Interrupt is used to determine when the transmission/reception has completed. The SSPBUF can then be read (if data is meaningful) and/or the SSPBUF (SSPSR) can be written. If the interrupt method is not going to be used, then software polling can be done to ensure that a write collision does not occur. Example 11-1 shows the loading of the SSPBUF (SSPSR) for data transmission. The shaded instruction is only required if the received data is meaningful.

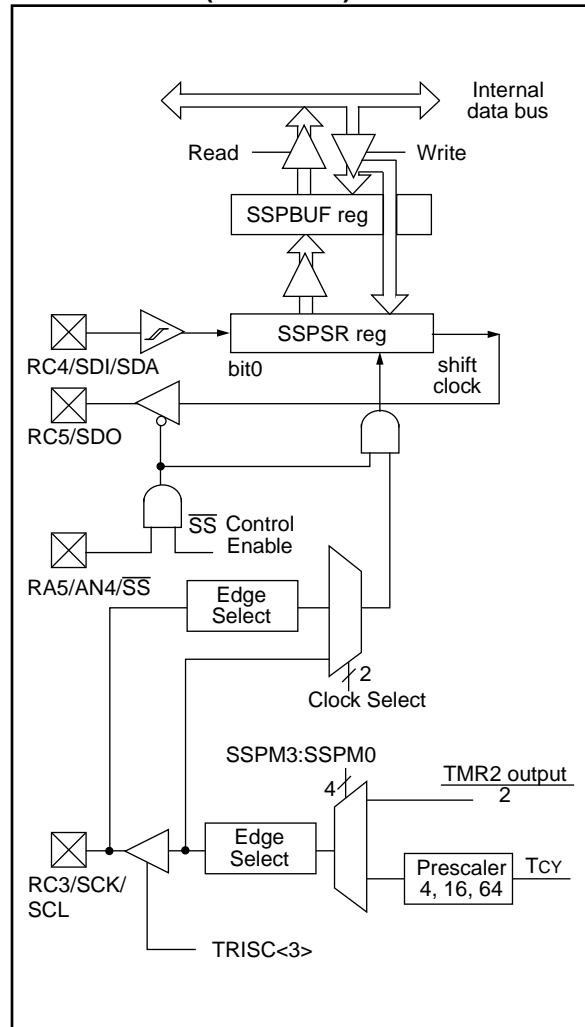
### EXAMPLE 11-1: LOADING THE SSPBUF (SSPSR) REGISTER

```

BSF STATUS, RP0 ;Specify Bank 1
LOOP BTFSS SSPSTAT, BF ;Has data been
;received
;(transmit
;complete)?
GOTO LOOP ;No
BCF STATUS, RP0 ;Specify Bank 0
MOVWF SSPBUF, W ;W reg = contents
; of SSPBUF
MOVWF RXDATA ;Save in user RAM
MOVWF TXDATA, W ;W reg = contents
; of TXDATA
MOVWF SSPBUF ;New data to xmit
    
```

The block diagram of the SSP module, when in SPI mode (Figure 11-3), shows that the SSPSR is not directly readable or writable, and can only be accessed from addressing the SSPBUF register. Additionally, the SSP status register (SSPSTAT) indicates the various status conditions.

**FIGURE 11-3: SSP BLOCK DIAGRAM (SPI MODE)**



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To enable the serial port, SSP enable bit SSPEN (SSP-CON<5>) must be set. To reset or reconfigure SPI mode, clear bit SSPEN, re-initialize the SSPCON register, 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 mode) must have TRISC<3> cleared
- SCK (Slave mode) must have TRISC<3> set
- $\overline{SS}$  must have TRISA<5> set

Any serial port function that is not desired may be overridden by programming the corresponding data direction (TRIS) register to the opposite value. An example would be in master mode where you are only sending data (to a display driver), then both SDI and  $\overline{SS}$  could be used as general purpose outputs by clearing their corresponding TRIS register bits.

Figure 11-4 shows a typical connection between two microcontrollers. The master controller (Processor 1) initiates the data transfer by sending the SCK signal. Data is shifted out of both shift registers on their programmed clock edge, and latched on the opposite edge of the clock. Both processors should be programmed to same Clock Polarity (CKP), then both controllers would send and receive data at the same time. Whether the data is meaningful (or dummy data) depends on the application software. This leads to three scenarios for data transmission:

- Master sends data — Slave sends dummy data
- Master sends data — Slave sends data
- Master sends dummy data — Slave sends data

The master can initiate the data transfer at any time because it controls the SCK. The master determines when the slave (Processor 2) wishes to broadcast data by the software protocol.

In master mode the data is transmitted/received as soon as the SSPBUF register is written to. If the SPI is only going to receive, the SCK output could be disabled (programmed as an input). The SSPSR register will continue to shift in the signal present on the SDI pin at the programmed clock rate. As each byte is received, it will be loaded into the SSPBUF register as if a normal received byte (interrupts and status bits appropriately set). This could be useful in receiver applications as a “line activity monitor” mode.

In slave mode, the data is transmitted and received as the external clock pulses appear on SCK. When the last bit is latched the interrupt flag bit SSPIF (PIR1<3>) is set.

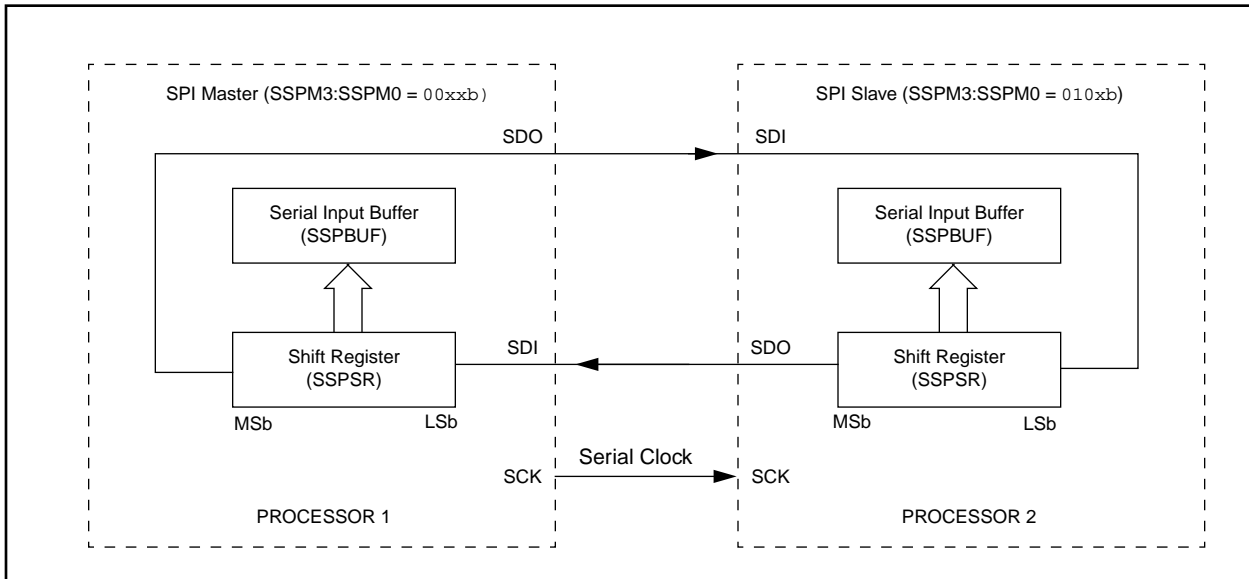
The clock polarity is selected by appropriately programming bit CKP (SSPCON<4>). This then would give waveforms for SPI communication as shown in Figure 11-5 and Figure 11-6 where the MSB is transmitted first. In master mode, the SPI clock rate (bit rate) is user programmable to be one of the following:

- $F_{OSC}/4$  (or  $T_{CY}$ )
- $F_{OSC}/16$  (or  $4 \cdot T_{CY}$ )
- $F_{OSC}/64$  (or  $16 \cdot T_{CY}$ )
- Timer2 output/2

This allows a maximum bit clock frequency (at 20 MHz) of 5 MHz. When in slave mode the external clock must meet the minimum high and low times.

In sleep mode, the slave can transmit and receive data and wake the device from sleep.

**FIGURE 11-4: SPI MASTER/SLAVE CONNECTION**

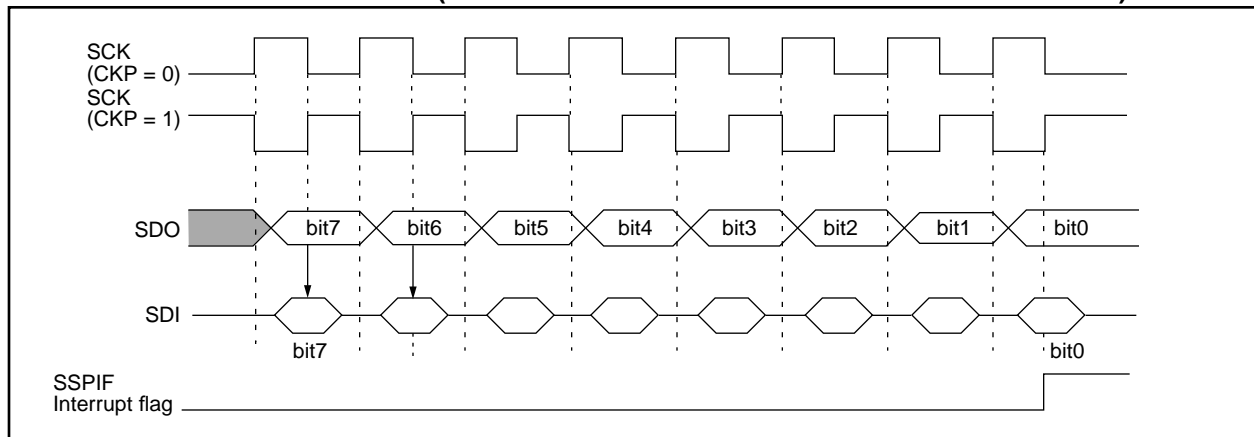




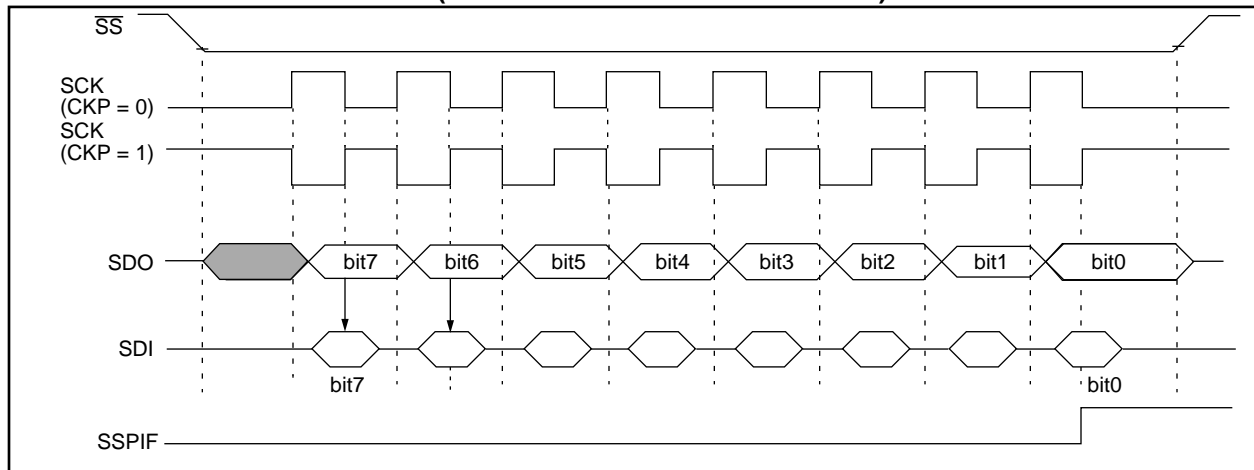
The  $\overline{SS}$  pin allows a synchronous slave mode. The SPI must be in slave mode ( $SSPCON\langle 3:0 \rangle = 04h$ ) and the  $TRISA\langle 5 \rangle$  bit must be set for the synchronous slave mode to be enabled. When the  $\overline{SS}$  pin is low, transmission and reception are enabled and the SDO pin is driven. When the  $\overline{SS}$  pin goes high, the SDO pin is no longer driven, even if in the middle of a transmitted byte, and becomes a floating output. If the  $\overline{SS}$  pin is taken low without resetting SPI mode, the transmission will continue from the point at which it was taken high. External pull-up/pull-down resistors may be desirable, depending on the application.

To emulate two-wire communication, the SDO pin can be connected to the SDI pin. When the SPI needs to operate as a receiver the SDO pin can be configured as an input. This disables transmissions from the SDO. The SDI can always be left as an input (SDI function) since it cannot create a bus conflict.

**FIGURE 11-5: SPI MODE TIMING (MASTER MODE OR SLAVE MODE W/O  $\overline{SS}$  CONTROL)**



**FIGURE 11-6: SPI MODE TIMING (SLAVE MODE WITH  $\overline{SS}$  CONTROL)**



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**TABLE 11-1: REGISTERS ASSOCIATED WITH SPI OPERATION**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets
0Bh/8Bh	INTCON	GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	0000 000x	0000 000u
0Ch	PIR1	PSPIF <sup>(1,2)</sup>	ADIF	RCIF <sup>(2)</sup>	TXIF <sup>(2)</sup>	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
8Ch	PIE1	PSPIE <sup>(1,2)</sup>	ADIE	RCIE <sup>(2)</sup>	TXIE <sup>(2)</sup>	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
87h	TRISC	TRISC7	TRISC6	TRISC5	TRISC4	TRISC3	TRISC2	TRISC1	TRISC0	1111 1111	1111 1111
13h	SSPBUF	Synchronous Serial Port Receive Buffer/Transmit Register								xxxx xxxx	uuuu uuuu
14h	SSPCON	WCOL	SSPOV	SSPEN	CKP	SSPM3	SSPM2	SSPM1	SSPM0	0000 0000	0000 0000
85h	TRISA	—	—	TRISA5	TRISA4	TRISA3	TRISA2	TRISA1	TRISA0	--11 1111	--11 1111
94h	SSPSTAT	—	—	D/ $\bar{A}$	P	S	R/ $\bar{W}$	UA	BF	--00 0000	--00 0000

Legend: x = unknown, u = unchanged, - = unimplemented read as '0'. Shaded cells are not used by the SSP in SPI mode.

Note 1: Bits PSPIE and PSPIF are reserved on the PIC16C73/73A, always maintain these bits clear.

2: The PIC16C72 does not have a Parallel Slave Port or USART, these bits are unimplemented, read as '0'.

## 11.2 I<sup>2</sup>C™ Overview

Applicable Devices							
710	71	711	72	73	73A	74	74A

This section provides an overview of the Inter-Integrated Circuit (I<sup>2</sup>C) bus, with Section 11.3 discussing the operation of the SSP module in I<sup>2</sup>C mode.

The I<sup>2</sup>C bus is a two-wire serial interface developed by the Philips Corporation. The original specification, or standard mode, was for data transfers of up to 100 Kbps. An enhanced specification, or fast mode, supports data transmission up to 400 Kbps. Both standard mode and fast mode devices will inter-operate if attached to the same bus.

The I<sup>2</sup>C interface employs a comprehensive protocol to ensure reliable transmission and reception of data. When transmitting data, one device is the “master” (generates the clock), while the other device(s) acts as the “slave.” All portions of the slave protocol are implemented in the SSP module’s hardware, while portions of the master protocol need to be addressed in the PIC16CXX software. Table 11-2 defines some of the I<sup>2</sup>C bus terminology. For additional information on the I<sup>2</sup>C interface specification, refer to the Philips document “*The I<sup>2</sup>C bus and how to use it.*”, which can be obtained from the Philips Corporation.

In the I<sup>2</sup>C interface protocol each device has an address. When a master wishes to initiate a data transfer, it first transmits the address of the device that it wishes to “talk” to. All devices “listen” to see if this is their address. Within this address, a bit specifies if the master wishes to read-from/write-to the slave device. The master and slave are always in opposite modes (transmitter/receiver) of operation during a data transfer. That is they can be thought of operating in either of these two relations:

- Master-transmitter and Slave-receiver
- Slave-transmitter and Master-receiver

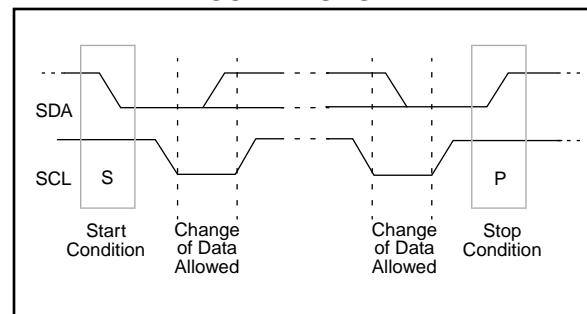
In both cases the master generates the clock signal.

The output stages of the clock (SCL) and data (SDA) lines must have an open-drain or open-collector in order to perform the wired-AND function of the bus. External pull-up resistors are used to ensure a high level when no device is pulling the line down. The number of devices that may be attached to the I<sup>2</sup>C bus is limited only by the maximum bus loading specification of 400 pF.

### 11.2.1 INITIATING AND TERMINATING DATA TRANSFER

During times of no data transfer (idle time), both the clock line (SCL) and the data line (SDA) are pulled high through the external pull-up resistors. The START and STOP conditions determine the start and stop of data transmission. The START condition is defined as a high to low transition of the SDA when the SCL is high. The STOP condition is defined as a low to high transition of the SDA when the SCL is high. Figure 11-7 shows the START and STOP conditions. The master generates these conditions for starting and terminating data transfer. Due to the definition of the START and STOP conditions, when data is being transmitted, the SDA line can only change state when the SCL line is low.

**FIGURE 11-7: START AND STOP CONDITIONS**



**TABLE 11-2: I<sup>2</sup>C BUS TERMINOLOGY**

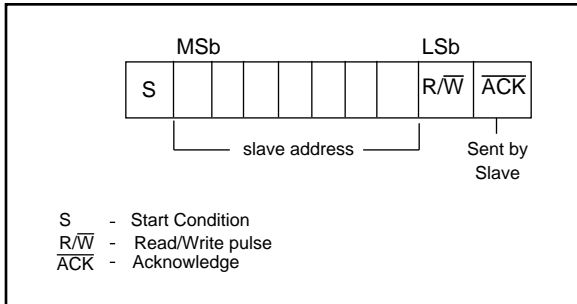
Term	Description
Transmitter	The device that sends the data to the bus.
Receiver	The device that receives the data from the bus.
Master	The device which initiates the transfer, generates the clock and terminates the transfer.
Slave	The device addressed by a master.
Multi-master	More than one master device in a system. These masters can attempt to control the bus at the same time without corrupting the message.
Arbitration	Procedure that ensures that only one of the master devices will control the bus. This ensure that the transfer data does not get corrupted.
Synchronization	Procedure where the clock signals of two or more devices are synchronized.

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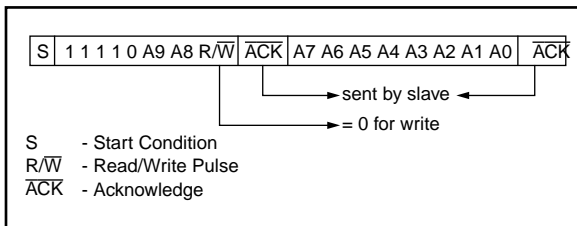
## 11.2.2 ADDRESSING I<sup>2</sup>C DEVICES

There are two address formats. The simplest is the 7-bit address format with a R/W bit (Figure 11-8). The more complex is the 10-bit address with a R/W bit (Figure 11-9). For 10-bit address format, two bytes must be transmitted with the first five bits specifying this to be a 10-bit address.

**FIGURE 11-8: 7-BIT ADDRESS FORMAT**



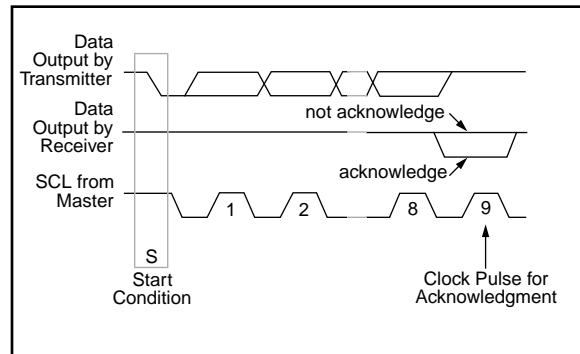
**FIGURE 11-9: I<sup>2</sup>C 10-BIT ADDRESS FORMAT**



## 11.2.3 TRANSFER ACKNOWLEDGE

All data must be transmitted per byte, with no limit to the number of bytes transmitted per data transfer. After each byte, the slave-receiver generates an acknowledge bit (ACK) (Figure 11-10). When a slave-receiver doesn't acknowledge the slave address or received data, the master must abort the transfer. The slave must leave SDA high so that the master can generate the STOP condition (Figure 11-7).

**FIGURE 11-10: SLAVE-RECEIVER ACKNOWLEDGE**



If the master is receiving the data (master-receiver), it generates an acknowledge signal for each received byte of data, except for the last byte. To signal the end of data to the slave-transmitter, the master does not generate an acknowledge (not acknowledge). The slave then releases the SDA line so the master can generate the STOP condition. The master can also generate the STOP condition during the acknowledge pulse for valid termination of data transfer.

If the slave needs to delay the transmission of the next byte, holding the SCL line low will force the master into a wait state. Data transfer continues when the slave releases the SCL line. This allows the slave to move the received data or fetch the data it needs to transfer before allowing the clock to start. This wait state technique can also be implemented at the bit level, Figure 11-11. The slave will inherently stretch the clock when it is a transmitter but will not when it is a receiver. The slave will have to clear the SSPCON<4> bit to enable clock stretching when it is a receiver.

**FIGURE 11-11: DATA TRANSFER WAIT STATE**

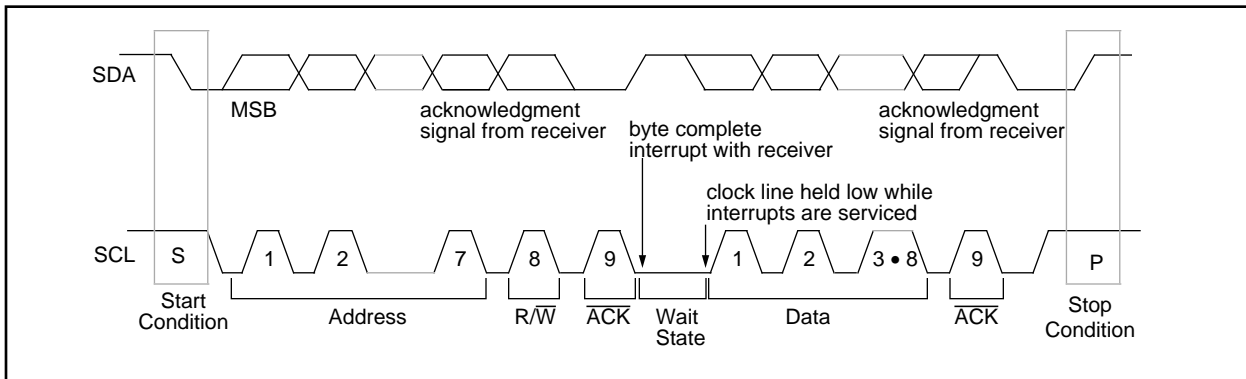
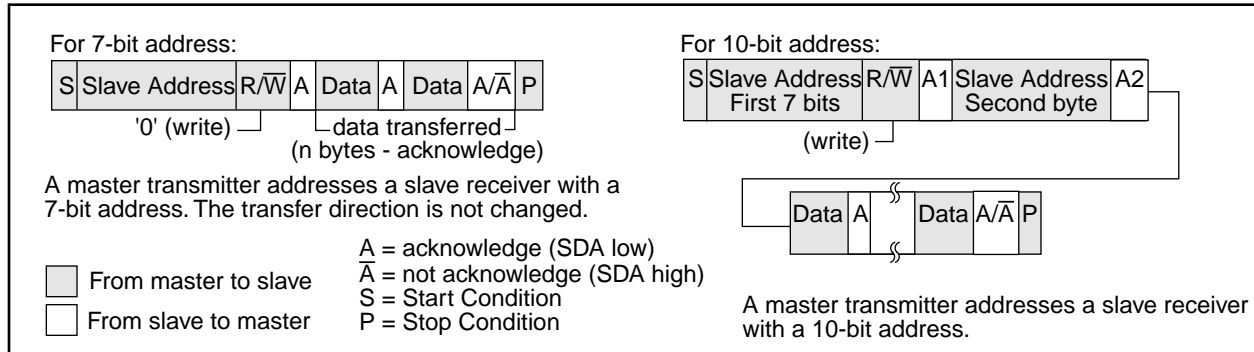


Figure 11-12 and Figure 11-13 show Master-transmitter and Master-receiver data transfer sequences.

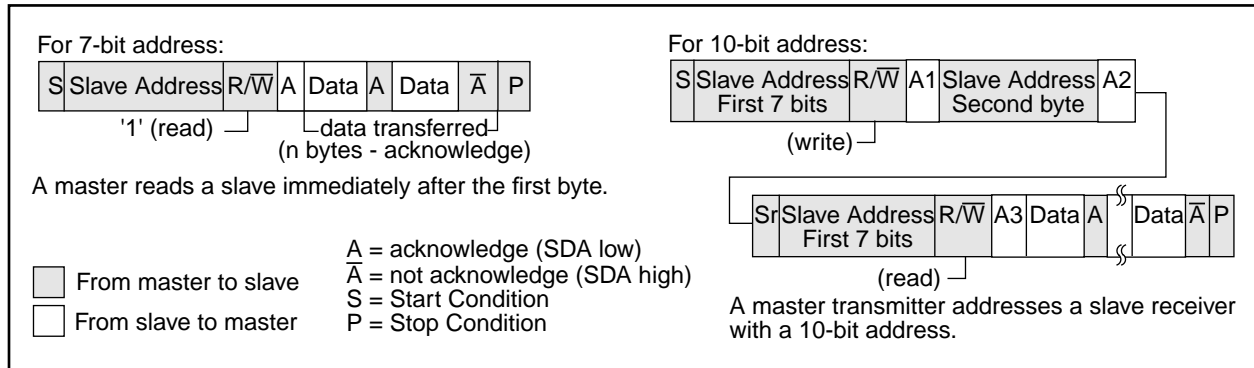
When a master does not wish to relinquish the bus (by generating a STOP condition), a repeated START condition (Sr) must be generated. This condition is identical to the start condition (S) (SDA goes high-to-low while

SCL is high), but occurs after a data transfer acknowledge pulse (not the bus-free state). This allows a master to send "commands" to the slave and then receive the requested information or to address a different slave device. This sequence is shown in Figure 11-14.

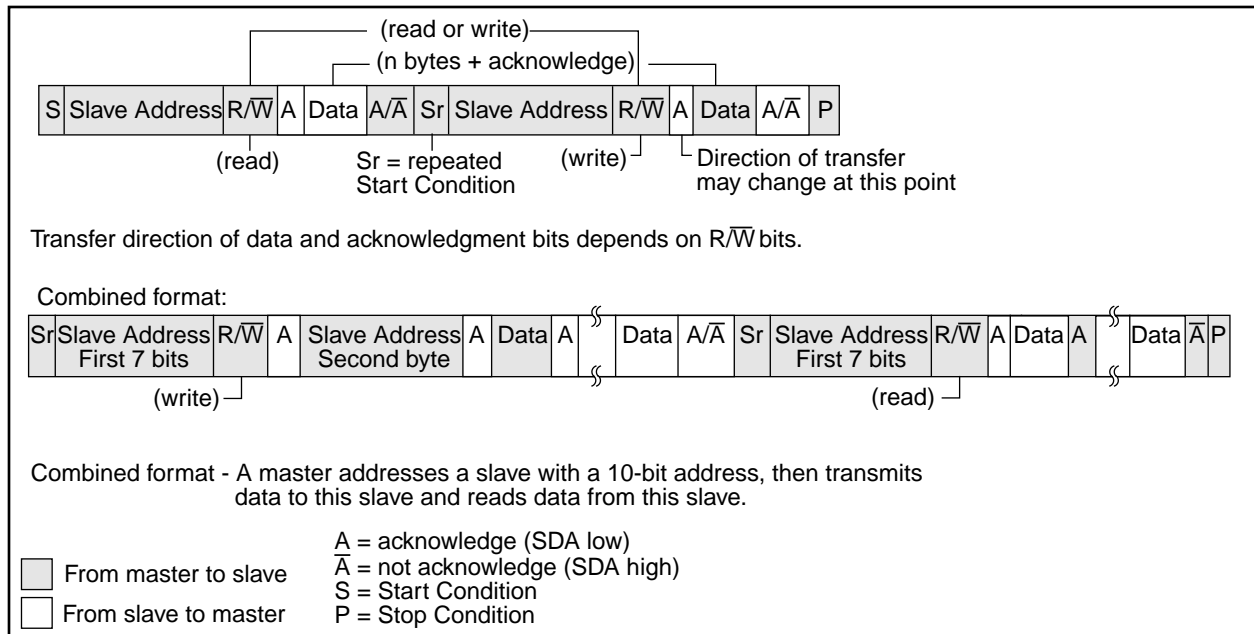
**FIGURE 11-12: MASTER-TRANSMITTER SEQUENCE**



**FIGURE 11-13: MASTER-RECEIVER SEQUENCE**



**FIGURE 11-14: COMBINED FORMAT**



# PIC16C7X

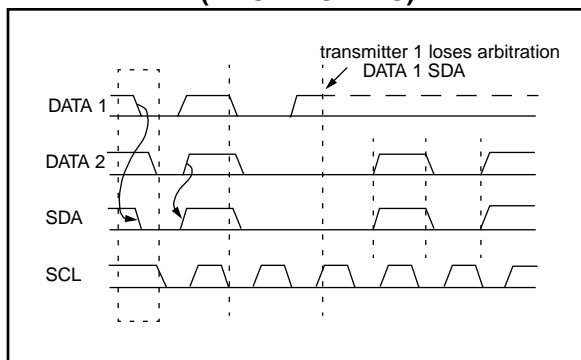
## 11.2.4 MULTI-MASTER

The I<sup>2</sup>C protocol allows a system to have more than one master. This is called multi-master. When two or more masters try to transfer data at the same time, arbitration and synchronization occur.

### 11.2.4.1 ARBITRATION

Arbitration takes place on the SDA line, while the SCL line is high. The master which transmits a high when the other master transmits a low loses arbitration (Figure 11-15), and turns off its data output stage. A master which lost arbitration can generate clock pulses until the end of the data byte where it lost arbitration. When the master devices are addressing the same device, arbitration continues into the data.

**FIGURE 11-15: MULTI-MASTER ARBITRATION (TWO MASTERS)**



Masters that also incorporate the slave function, and have lost arbitration must immediately switch over to slave-receiver mode. This is because the winning master-transmitter may be addressing it.

Arbitration is not allowed between:

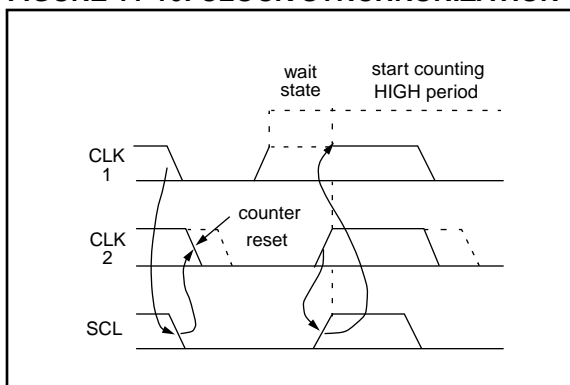
- A repeated START condition
- A STOP condition and a data bit
- A repeated START condition and a STOP condition

Care needs to be taken to ensure that these conditions do not occur.

### 11.2.4.2 CLOCK SYNCHRONIZATION

Clock synchronization occurs after the devices have started arbitration. This is performed using a wired-AND connection to the SCL line. A high to low transition on the SCL line causes the concerned devices to start counting off their low period. Once a device clock has gone low, it will hold the SCL line low until its SCL high state is reached. The low to high transition of this clock may not change the state of the SCL line, if another device clock is still within its low period. The SCL line is held low by the device with the longest low period. Devices with shorter low periods enter a high wait-state, until the SCL line comes high. When the SCL line comes high, all devices start counting off their high periods. The first device to complete its high period will pull the SCL line low. The SCL line high time is determined by the device with the shortest high period, Figure 11-16.

**FIGURE 11-16: CLOCK SYNCHRONIZATION**

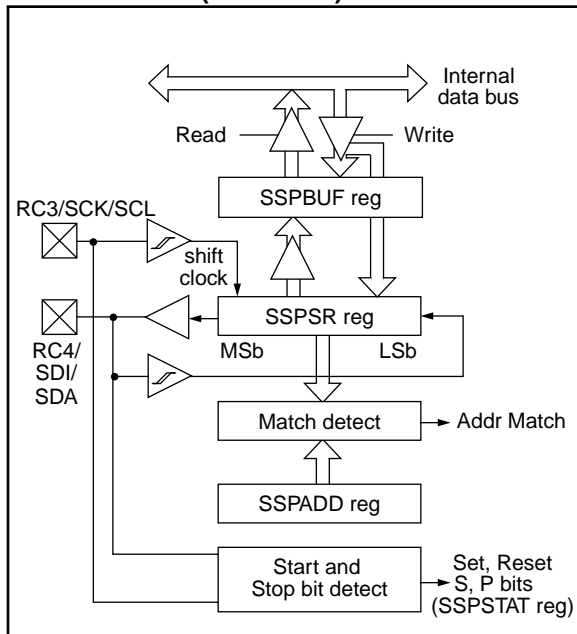


## 11.3 SSP I<sup>2</sup>C Operation

Applicable Devices							
710	711	711	72	73	73A	74	74A

The SSP module in I<sup>2</sup>C mode fully implements all slave functions, and provides interrupts on start and stop bits in hardware to facilitate software implementations of the master functions. The SSP module implements the standard and fast mode specifications as well as 7-bit and 10-bit addressing. Two pins are used for data transfer. These are the RC3/SCK/SCL pin, which is the clock (SCL), and the RC4/SDI/SDA pin, which is the data (SDA). The user must configure these pins as inputs or outputs through the TRISC<4:3> bits. The SSP module functions are enabled by setting SSP Enable bit SSPEN (SSPCON<5>).

**FIGURE 11-17: SSP BLOCK DIAGRAM (I<sup>2</sup>C MODE)**



The SSP module has five registers for I<sup>2</sup>C operation. These are the:

- SSP Control Register (SSPCON)
- SSP Status Register (SSPSTAT)
- Serial Receive/Transmit Buffer (SSPBUF)
- SSP Shift Register (SSPSR) - Not directly accessible
- SSP Address Register (SSPADD)

The SSPCON register allows control of the I<sup>2</sup>C operation. Four mode selection bits (SSPCON<3:0>) allow one of the following I<sup>2</sup>C modes to be selected:

- I<sup>2</sup>C Slave mode (7-bit address)
- I<sup>2</sup>C Slave mode (10-bit address)
- I<sup>2</sup>C Slave mode (7-bit address), with start and stop bit interrupts enabled
- I<sup>2</sup>C Slave mode (10-bit address), with start and stop bit interrupts enabled
- I<sup>2</sup>C start and stop bit interrupts enabled, slave is idle

Selection of any I<sup>2</sup>C mode, with the SSPEN bit set, forces the SCL and SDA pins to be open drain, provided these pins are programmed to inputs by setting the appropriate TRISC bits.

The SSPSTAT register gives the status of the data transfer. This information includes detection of a START or STOP bit, specifies if the received byte was data or address if the next byte is the completion of 10-bit address, and if this will be a read or write data transfer. The SSPSTAT register is read only.

The SSPBUF is the register to which transfer data is written to or read from. The SSPSR register shifts the data in or out of the device. In receive operations, the SSPBUF and SSPSR create a doubled buffered receiver. This allows reception of the next byte to begin before reading the last byte of received data. When the complete byte is received, it is transferred to the SSPBUF register and flag bit SSPIF is set. If another complete byte is received before the SSPBUF register is read, a receiver overflow has occurred and bit SSPOV (SSPCON<6>) is set.

The SSPADD register holds the slave address. In 10-bit mode, the user needs to write the high byte of the address (1111 0 A9 A8 0). Following the high byte address match, the low byte of the address needs to be loaded (A7:A0).

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## 11.3.1 SLAVE MODE

In slave mode, the SCL and SDA pins must be configured as inputs (TRISC<4:3> set). The SSP module will override the input state with the output data when required (slave-transmitter).

When an address is matched or the data transfer after an address match is received, the hardware automatically will generate the acknowledge ( $\overline{ACK}$ ) pulse, and then load the SSPBUF register with the received value currently in the SSPSR register.

There are certain conditions that will cause the SSP module not to give this  $\overline{ACK}$  pulse. These are if either (or both):

- a) The buffer full bit BF (SSPSTAT<0>) was set before the transfer was received.
- b) The overflow bit SSPOV (SSPCON<6>) was set before the transfer was received.

In this case, the SSPSR register value is not loaded into the SSPBUF, but bit SSPIF (PIR1<3>) is set. Table 11-3 shows what happens when a data transfer byte is received, given the status of bits BF and SSPOV. The shaded cells show the condition where user software did not properly clear the overflow condition. Flag bit BF is cleared by reading the SSPBUF register while bit SSPOV is cleared through software.

The SCL clock input must have a minimum high and low time for proper operation. The high and low times of the I<sup>2</sup>C specification as well as the requirement of the SSP module is shown in timing parameter #100 and parameter #101 (see Electrical Specification section).

### 11.3.1.1 ADDRESSING

Once the SSP module has been enabled, it waits for a START condition to occur. Following the START condition, the 8-bits are shifted into the SSPSR register. All incoming bits are sampled with the rising edge of the clock (SCL) line. The value of register SSPSR<7:1> is compared to the value of the SSPADD register. The address is compared on the falling edge of the eighth clock (SCL) pulse. If the addresses match, and the BF and SSPOV bits are clear, the following events occur:

- a) The SSPSR register value is loaded into the SSPBUF register.
- b) The buffer full bit, BF is set.
- c) An  $\overline{ACK}$  pulse is generated.
- d) SSP interrupt flag bit, SSPIF (PIR1<3>) is set (interrupt is generated if enabled) - on the falling edge of the ninth SCL pulse.

In 10-bit address mode, two address bytes need to be received by the slave (Figure 11-9). The five Most Significant bits (MSBs) of the first address byte specify if this is a 10-bit address. Bit  $R/\overline{W}$  (SSPSTAT<2>) must specify a write, so the slave device will receive the second address byte. For a 10-bit address the first byte would equal '1111 0 A9 A8 0', where A9 and A8 are the two MSBs of the address. The sequence of events for a 10-bit address is as follows, with steps 7- 9 for slave-transmitter:

1. Receive first (high) byte of Address (bits SSPIF, BF, and bit UA (SSPSTAT<1>) are set).
2. Update the SSPADD register with second (low) byte of Address (clears bit UA and releases the SCL line).
3. Read the SSPBUF register (clears bit BF) and clear flag bit SSPIF.
4. Receive second (low) byte of Address (bits SSPIF, BF, and UA are set).
5. Update the SSPADD register with the first (high) byte of Address (clears bit UA, if match releases SCL line).
6. Read the SSPBUF register (clears bit BF) and clear flag bit SSPIF.
7. Receive repeated START condition.
8. Receive first (high) byte of Address (bits SSPIF and BF are set).
9. Read the SSPBUF register (clears bit BF) and clear flag bit SSPIF.

**TABLE 11-3: DATA TRANSFER RECEIVED BYTE ACTIONS**

Status Bits as Data Transfer is Received		SSPSR → SSPBUF	Generate $\overline{ACK}$ Pulse	Set bit SSPIF (SSP Interrupt occurs if Enabled)
BF	SSPOV			
0	0	Yes	Yes	Yes
1	0	No	No	Yes
1	1	No	No	Yes
0	1	No	No	Yes



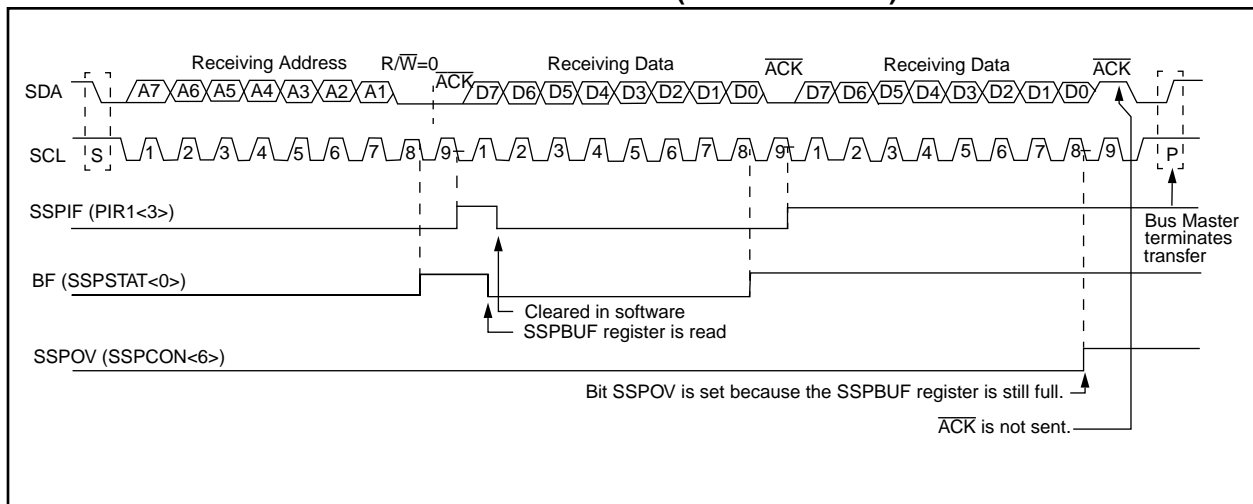
## 11.3.1.2 RECEPTION

When the  $R/\overline{W}$  bit of the address byte is clear and an address match occurs, the  $R/\overline{W}$  bit of the SSPSTAT register is cleared. The received address is loaded into the SSPBUF register.

When the address byte overflow condition exists, then no acknowledge ( $\overline{ACK}$ ) pulse is given. An overflow condition is defined as either bit BF (SSPSTAT<0>) is set or bit SSPOV (SSPCON<6>) is set.

An SSP interrupt is generated for each data transfer byte. Flag bit SSPIF (PIR1<3>) must be cleared in software, and the SSPSTAT register is used to determine the status of the byte.

**FIGURE 11-18: I<sup>2</sup>C WAVEFORMS FOR RECEPTION (7-BIT ADDRESS)**



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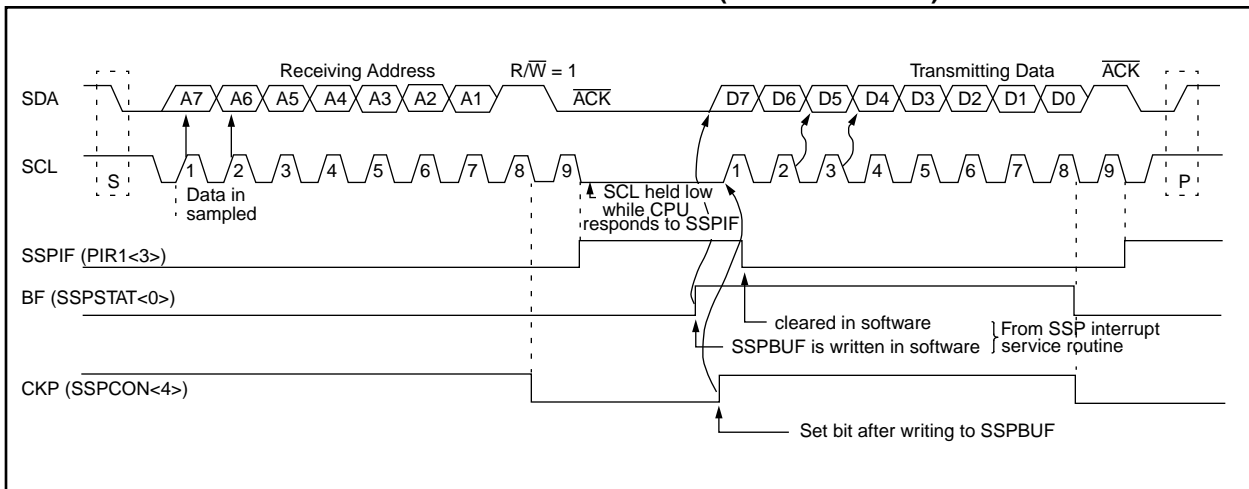
## 11.3.1.3 TRANSMISSION

When the  $R/\bar{W}$  bit of the incoming address byte is set and an address match occurs, the  $R/\bar{W}$  bit of the SSPSTAT register is set. The received address is loaded into the SSPBUF register. The  $\bar{ACK}$  pulse will be sent on the ninth bit, and pin RC3/SCK/SCL is held low. The transmit data must be loaded into the SSPBUF register, which also loads the SSPSR register. Then pin RC3/SCK/SCL should be enabled by setting bit CKP (SSPCON<4>). The eight data bits are shifted out on the falling edge of the SCL input. This ensures that the SDA signal is valid during the SCL high time (Figure 11-19).

An SSP interrupt is generated for each data transfer byte. Flag bit SSPIF must be cleared in software, and the SSPSTAT register is used to determine the status of the byte. Flag bit SSPIF is set on the falling edge of the ninth clock pulse.

As a slave-transmitter, the  $\bar{ACK}$  pulse from the master-receiver is latched on the rising edge of the ninth SCL input pulse. If the SDA line was high (not  $\bar{ACK}$ ), then the data transfer is complete. The slave then monitors for another occurrence of the START bit. If the SDA line was low ( $\bar{ACK}$ ), the transmit data must be loaded into the SSPBUF register, which also loads the SSPSR register. Then pin RC3/SCK/SCL should be enabled by setting bit CKP.

**FIGURE 11-19: I<sup>2</sup>C WAVEFORMS FOR TRANSMISSION (7-BIT ADDRESS)**



## 11.3.2 MASTER MODE

Master mode of operation is supported by interrupt generation on the detection of the START and STOP conditions. The STOP (P) and START (S) bits are cleared from a reset or when the SSP module is disabled. Control of the I<sup>2</sup>C bus may be taken when the P bit is set, or the bus is idle with both the S and P bits clear.

In master mode the SCL and SDA lines are manipulated by clearing the corresponding TRISC<4:3> bit(s). The output level is always low, irrespective of the value(s) in PORTC<4:3>. So when transmitting data, a '1' data bit must have the TRISC<4> bit set (input) and a '0' data bit must have the TRISC<4> bit cleared (output). The same scenario is true for the SCL line with the TRISC<3> bit.

The following events will cause the SSP Interrupt Flag bit SSIIF to be set (SSP Interrupt if enabled):

- START condition
- STOP condition
- Data transfer byte transmitted/received

Master mode of operation can be done with either the slave mode idle (SSPM3:SSPM0 = 1011) or with the slave active. When both master and slave modes are enabled, the software needs to differentiate the source(s) of the interrupt.

## 11.3.3 MULTI-MASTER MODE

In multi-master mode, the interrupt generation on the detection of the START and STOP conditions allows the determination of when the bus is free. The STOP (P) and START (S) bits are cleared from a reset or when the SSP module is disabled. Control of the I<sup>2</sup>C bus may be taken when bit P (SSPSTAT<4>) is set, or the bus is idle with both the S and P bits clear. When the bus is busy, enabling the SSP Interrupt will generate the interrupt when the STOP condition occurs.

In multi-master operation, the SDA line must be monitored to see if the signal level is the expected output level. This check only needs to be done when a high level is output. If a high level is expected and a low level is present, the device needs to release the SDA and SCL lines (set TRISC<4:3>). There are two stages where this arbitration can be lost, they are:

- Address Transfer
- Data Transfer

When the slave logic is enabled, the slave continues to receive. If arbitration was lost during the address transfer stage, the device may be being addressed. If addressed an  $\overline{\text{ACK}}$  pulse will be generated. If arbitration was lost during the data transfer stage, the device will need to re-transfer the data at a later time.

**TABLE 11-4: REGISTERS ASSOCIATED WITH I<sup>2</sup>C OPERATION**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets
0Bh/8Bh	INTCON	GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	0000 000x	0000 000u
0Ch	PIR1	PSPIF <sup>(1,2)</sup>	ADIF	RCIF <sup>(2)</sup>	TXIF <sup>(2)</sup>	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
8Ch	PIE1	PSPIE <sup>(1,2)</sup>	ADIE	RCIE <sup>(2)</sup>	TXIE <sup>(2)</sup>	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
13h	SSPBUF	Synchronous Serial Port Receive Buffer/Transmit Register								xxxx xxxx	uuuu uuuu
93h	SSPADD	Synchronous Serial Port (I <sup>2</sup> C mode) Address Register								0000 0000	0000 0000
14h	SSPCON	WCOL	SSPOV	SSPEN	CKP	SSPM3	SSPM2	SSPM1	SSPM0	0000 0000	0000 0000
94h	SSPSTAT	—	—	D/ $\overline{\text{A}}$	P	S	R/ $\overline{\text{W}}$	UA	BF	--00 0000	--00 0000
87h	TRISC	TRISC7	TRISC6	TRISC5	TRISC4	TRISC3	TRISC2	TRISC1	TRISC0	1111 1111	1111 1111

Legend: x = unknown, u = unchanged, - = unimplemented read as '0'. Shaded cells are not used by SSP in I<sup>2</sup>C mode.

Note 1: Bits PSPIE and PSPIF are reserved on the PIC16C73/73A, always maintain these bits clear.

2: The PIC16C72 does not have a Parallel Slave Port or USART, these bits are unimplemented, read as '0'.

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FIGURE 11-20: OPERATION OF THE I<sup>2</sup>C MODULE IN IDLE\_MODE, RCV\_MODE OR XMIT\_MODE

<pre><b>IDLE_MODE (7-bit):</b> if (Addr_match)          {     Set interrupt;     if (R/W = 1)          {         Send <math>\overline{ACK}</math> = 0;         set XMIT_MODE;     }     else if (R/W = 0) set RCV_MODE; } }</pre>
<pre><b>RCV_MODE:</b> if ((SSPBUF=Full) OR (SSPOV = 1))     {         Set SSPOV;         Do not acknowledge;     } else     {         transfer SSPSR → SSPBUF;         send <math>\overline{ACK}</math> = 0;     } } Receive 8-bits in SSPSR; Set interrupt;</pre>
<pre><b>XMIT_MODE:</b> While ((SSPBUF = Empty) AND (CKP=0)) Hold SCL Low; Send byte; Set interrupt; if ( <math>\overline{ACK}</math> Received = 1)          {     End of transmission;     Go back to IDLE_MODE; } else if ( <math>\overline{ACK}</math> Received = 0) Go back to XMIT_MODE;</pre>
<pre><b>IDLE_MODE (10-Bit):</b> If (High_byte_addr_match AND (R/W = 0))     {         PRIOR_ADDR_MATCH = FALSE;         Set interrupt;         if ((SSPBUF = Full) OR ((SSPOV = 1))             {                 Set SSPOV;                 Do not acknowledge;             }         else             {                 Set UA = 1;                 Send <math>\overline{ACK}</math> = 0;                 While (SSPADD not updated) Hold SCL low;                 Clear UA = 0;                 Receive Low_addr_byte;                 Set interrupt;                 Set UA = 1;                 If (Low_byte_addr_match)                     {                         PRIOR_ADDR_MATCH = TRUE;                         Send <math>\overline{ACK}</math> = 0;                         while (SSPADD not updated) Hold SCL low;                         Clear UA = 0;                         Set RCV_MODE;                     }             }     } else if (High_byte_addr_match AND (R/W = 1))     {         if (PRIOR_ADDR_MATCH)             {                 send <math>\overline{ACK}</math> = 0;                 set XMIT_MODE;             }         else PRIOR_ADDR_MATCH = FALSE;     } }</pre>

## 12.0 UNIVERSAL SYNCHRONOUS ASYNCHRONOUS RECEIVER TRANSMITTER (USART)

Applicable Devices							
710	711	712	713	73A	74	74A	

The Universal Synchronous Asynchronous Receiver Transmitter (USART) module is one of the two serial I/O modules. (USART is also known as a Serial Communications Interface or SCI). The USART can be configured as a full duplex asynchronous system that can communicate with peripheral devices such as CRT terminals and personal computers, or it can be configured

as a half duplex synchronous system that can communicate with peripheral devices such as A/D or D/A integrated circuits, Serial EEPROMs etc.

The USART can be configured in the following modes:

- Asynchronous (full duplex)
- Synchronous - Master (half duplex)
- Synchronous - Slave (half duplex)

Bit SPEN (RCSTA<7>), and bits TRISC<7:6>, have to be set in order to configure pins RC6/TX/CK and RC7/RX/DT for the Serial Communication Interface.

**FIGURE 12-1: TXSTA: TRANSMIT STATUS AND CONTROL REGISTER (ADDRESS 98h)**

R/W-0	R/W-0	R/W-0	R/W-0	U-0	R/W-0	R-1	R/W-0	
CSRC	TX9	TXEN	SYNC	—	BRGH	TRMT	TX9D	
bit7								bit0

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

bit 7: **CSRC:** Clock Source Select bit

Asynchronous mode  
Don't care

Synchronous mode  
1 = Master mode (Clock generated internally from BRG)  
0 = Slave mode (Clock from external source)

bit 6: **TX9:** 9-bit Transmit Enable bit  
1 = Selects 9-bit transmission  
0 = Selects 8-bit transmission

bit 5: **TXEN:** Transmit Enable bit  
1 = Transmit enabled  
0 = Transmit disabled  
Note: SREN/CREN overrides TXEN in SYNC mode.

bit 4: **SYNC:** USART Mode Select bit  
1 = Synchronous mode  
0 = Asynchronous mode

bit 3: **Unimplemented:** Read as '0'

bit 2: **BRGH:** High Baud Rate Select bit

Asynchronous mode  
1 = High speed

**Note:** At the time of this printing, the asynchronous high speed mode (BRGH is set) may experience a high rate of receive errors. It is recommended to have the BRGH bit cleared. If you desire a higher baud rate than BRGH=0 can support, refer to the device errata for additional information.

0 = Low speed

Synchronous mode  
Unused in this mode

bit 1: **TRMT:** Transmit Shift Register Status bit  
1 = TSR empty  
0 = TSR full

bit 0: **TX9D:** 9th bit of transmit data. Can be parity bit.

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**FIGURE 12-2: RCSTA: RECEIVE STATUS AND CONTROL REGISTER (ADDRESS 18h)**

R/W-0	R/W-0	R/W-0	R/W-0	U-0	R-0	R-0	R-x
SPEN	RX9	SREN	CREN	—	FERR	OERR	RX9D
							bit0
<div style="border: 1px solid black; padding: 5px; float: right; width: 150px;">                     R = Readable bit                      W = Writable bit                      U = Unimplemented bit,                      read as '0'                      - n =Value at POR reset                 </div>							
bit 7:	<b>SPEN:</b> Serial Port Enable bit 1 = Serial port enabled (Configures RC7/RX/DT and RC6/TX/CK pins as serial port pins) 0 = Serial port disabled						
bit 6:	<b>RX9:</b> 9-bit Receive Enable bit 1 = Selects 9-bit reception 0 = Selects 8-bit reception						
bit 5:	<b>SREN:</b> Single Receive Enable bit <u>Asynchronous mode</u> Don't care <u>Synchronous mode - master</u> 1 = Enables single receive 0 = Disables single receive This bit is cleared after reception is complete. <u>Synchronous mode - slave</u> Unused in this mode						
bit 4:	<b>CREN:</b> Continuous Receive Enable bit <u>Asynchronous mode</u> 1 = Enables continuous receive 0 = Disables continuous receive <u>Synchronous mode</u> 1 = Enables continuous receive until enable bit CREN is cleared (CREN overrides SREN) 0 = Disables continuous receive						
bit 3:	<b>Unimplemented:</b> Read as '0'						
bit 2:	<b>FERR:</b> Framing Error bit 1 = Framing error (Can be updated by reading RCREG register and receive next valid byte) 0 = No framing error						
bit 1:	<b>OERR:</b> Overrun Error bit 1 = Overrun error (Can be cleared by clearing bit CREN) 0 = No overrun error						
bit 0:	<b>RX9D:</b> 9th bit of received data (Can be parity bit)						

## 12.1 USART Baud Rate Generator (BRG)

Applicable Devices							
710	711	712	713	73A	74	74A	

The BRG supports both the Asynchronous and Synchronous modes of the USART. It is a dedicated 8-bit baud rate generator. The SPBRG register controls the period of a free running 8-bit timer. In asynchronous mode bit BRGH (TXSTA<2>) also controls the baud rate. In synchronous mode bit BRGH is ignored. Table 12-1 shows the formula for computation of the baud rate for different USART modes which only apply in master mode (internal clock).

Given the desired baud rate and Fosc, the nearest integer value for the SPBRG register can be calculated using the formula in Table 12-1. From this, the error in baud rate can be determined.

Example 12-1 shows the calculation of the baud rate error for the following conditions:

FOSC = 16 MHz  
 Desired Baud Rate = 9600  
 BRGH = 0  
 SYNC = 0

### EXAMPLE 12-1: CALCULATING BAUD RATE ERROR

$$\begin{aligned} \text{Desired Baud rate} &= F_{osc} / (64 (X + 1)) \\ 9600 &= 16000000 / (64 (X + 1)) \\ X &= \lfloor 25.042 \rfloor = 25 \\ \text{Calculated Baud Rate} &= 16000000 / (64 (25 + 1)) \\ &= 9615 \\ \text{Error} &= \frac{(\text{Calculated Baud Rate} - \text{Desired Baud Rate})}{\text{Desired Baud Rate}} \\ &= (9615 - 9600) / 9600 \\ &= 0.16\% \end{aligned}$$

It may be advantageous to use the high baud rate (BRGH = 1) even for slower baud clocks. This is because the  $F_{OSC}/(16(X + 1))$  equation can reduce the baud rate error in some cases.

**Note:** At the time of this printing, the asynchronous high speed mode (BRGH is set) may experience a high rate of receive errors. It is recommended to have the BRGH bit cleared. If you desire a higher baud rate than BRGH=0 can support, refer to the device errata for additional information.

Writing a new value to the SPBRG register, causes the BRG timer to be reset (or cleared), this ensures the BRG does not wait for a timer overflow before outputting the new baud rate.

**TABLE 12-1: BAUD RATE FORMULA**

SYNC	BRGH = 0 (Low Speed)	BRGH = 1 (High Speed)
0	(Asynchronous) Baud Rate = $F_{OSC}/(64(X+1))$	Baud Rate = $F_{OSC}/(16(X+1))$
1	(Synchronous) Baud Rate = $F_{OSC}/(4(X+1))$	NA

X = value in SPBRG (0 to 255)

**TABLE 12-2: REGISTERS ASSOCIATED WITH BAUD RATE GENERATOR**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets
98h	TXSTA	CSRC	TX9	TXEN	SYNC	—	BRGH	TRMT	TX9D	0000 -010	0000 -010
18h	RCSTA	SPEN	RX9	SREN	CREN	—	FERR	OERR	RX9D	0000 -00x	0000 -00x
99h	SPBRG	Baud Rate Generator Register								0000 0000	0000 0000

Legend: x = unknown, - = unimplemented read as '0'. Shaded cells are not used by the BRG.

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**TABLE 12-3: BAUD RATES FOR SYNCHRONOUS MODE**

BAUD RATE (K)	FOSC = 20 MHz			16 MHz			10 MHz			7.15909 MHz		
	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)
0.3	NA	-	-	NA	-	-	NA	-	-	NA	-	-
1.2	NA	-	-	NA	-	-	NA	-	-	NA	-	-
2.4	NA	-	-	NA	-	-	NA	-	-	NA	-	-
9.6	NA	-	-	NA	-	-	9.766	+1.73	255	9.622	+0.23	185
19.2	19.53	+1.73	255	19.23	+0.16	207	19.23	+0.16	129	19.24	+0.23	92
76.8	76.92	+0.16	64	76.92	+0.16	51	75.76	-1.36	32	77.82	+1.32	22
96	96.15	+0.16	51	95.24	-0.79	41	96.15	+0.16	25	94.20	-1.88	18
300	294.1	-1.96	16	307.69	+2.56	12	312.5	+4.17	7	298.3	-0.57	5
500	500	0	9	500	0	7	500	0	4	NA	-	-
HIGH	5000	-	0	4000	-	0	2500	-	0	1789.8	-	0
LOW	19.53	-	255	15.625	-	255	9.766	-	255	6.991	-	255

BAUD RATE (K)	FOSC = 5.0688 MHz			4 MHz			3.579545 MHz			1 MHz			32.768 kHz		
	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)
0.3	NA	-	-	NA	-	-	NA	-	-	NA	-	-	0.303	+1.14	26
1.2	NA	-	-	NA	-	-	NA	-	-	1.202	+0.16	207	1.170	-2.48	6
2.4	NA	-	-	NA	-	-	NA	-	-	2.404	+0.16	103	NA	-	-
9.6	9.6	0	131	9.615	+0.16	103	9.622	+0.23	92	9.615	+0.16	25	NA	-	-
19.2	19.2	0	65	19.231	+0.16	51	19.04	-0.83	46	19.24	+0.16	12	NA	-	-
76.8	79.2	+3.13	15	76.923	+0.16	12	74.57	-2.90	11	83.34	+8.51	2	NA	-	-
96	97.48	+1.54	12	1000	+4.17	9	99.43	+3.57	8	NA	-	-	NA	-	-
300	316.8	+5.60	3	NA	-	-	298.3	-0.57	2	NA	-	-	NA	-	-
500	NA	-	-	NA	-	-	NA	-	-	NA	-	-	NA	-	-
HIGH	1267	-	0	100	-	0	894.9	-	0	250	-	0	8.192	-	0
LOW	4.950	-	255	3.906	-	255	3.496	-	255	0.9766	-	255	0.032	-	255

**TABLE 12-4: BAUD RATES FOR ASYNCHRONOUS MODE (BRGH = 0)**

BAUD RATE (K)	FOSC = 20 MHz			16 MHz			10 MHz			7.15909 MHz		
	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)
0.3	NA	-	-	NA	-	-	NA	-	-	NA	-	-
1.2	1.221	+1.73	255	1.202	+0.16	207	1.202	+0.16	129	1.203	+0.23	92
2.4	2.404	+0.16	129	2.404	+0.16	103	2.404	+0.16	64	2.380	-0.83	46
9.6	9.469	-1.36	32	9.615	+0.16	25	9.766	+1.73	15	9.322	-2.90	11
19.2	19.53	+1.73	15	19.23	+0.16	12	19.53	+1.73	7	18.64	-2.90	5
76.8	78.13	+1.73	3	83.33	+8.51	2	78.13	+1.73	1	NA	-	-
96	104.2	+8.51	2	NA	-	-	NA	-	-	NA	-	-
300	312.5	+4.17	0	NA	-	-	NA	-	-	NA	-	-
500	NA	-	-	NA	-	-	NA	-	-	NA	-	-
HIGH	312.5	-	0	250	-	0	156.3	-	0	111.9	-	0
LOW	1.221	-	255	0.977	-	255	0.6104	-	255	0.437	-	255

BAUD RATE (K)	FOSC = 5.0688 MHz			4 MHz			3.579545 MHz			1 MHz			32.768 kHz		
	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)
0.3	0.31	+3.13	255	0.3005	-0.17	207	0.301	+0.23	185	0.300	+0.16	51	0.256	-14.67	1
1.2	1.2	0	65	1.202	+1.67	51	1.190	-0.83	46	1.202	+0.16	12	NA	-	-
2.4	2.4	0	32	2.404	+1.67	25	2.432	+1.32	22	2.232	-6.99	6	NA	-	-
9.6	9.9	+3.13	7	NA	-	-	9.322	-2.90	5	NA	-	-	NA	-	-
19.2	19.8	+3.13	3	NA	-	-	18.64	-2.90	2	NA	-	-	NA	-	-
76.8	79.2	+3.13	0	NA	-	-	NA	-	-	NA	-	-	NA	-	-
96	NA	-	-	NA	-	-	NA	-	-	NA	-	-	NA	-	-
300	NA	-	-	NA	-	-	NA	-	-	NA	-	-	NA	-	-
500	NA	-	-	NA	-	-	NA	-	-	NA	-	-	NA	-	-
HIGH	79.2	-	0	62.500	-	0	55.93	-	0	15.63	-	0	0.512	-	0
LOW	0.3094	-	255	3.906	-	255	0.2185	-	255	0.0610	-	255	0.0020	-	255



**TABLE 12-5: BAUD RATES FOR ASYNCHRONOUS MODE (BRGH = 1)**

BAUD RATE (K)	FOSC = 20 MHz			16 MHz			10 MHz			7.16 MHz		
	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)
9.6	9.615	+0.16	129	9.615	+0.16	103	9.615	+0.16	64	9.520	-0.83	46
19.2	19.230	+0.16	64	19.230	+0.16	51	18.939	-1.36	32	19.454	+1.32	22
38.4	37.878	-1.36	32	38.461	+0.16	25	39.062	+1.7	15	37.286	-2.90	11
57.6	56.818	-1.36	21	58.823	+2.12	16	56.818	-1.36	10	55.930	-2.90	7
115.2	113.636	-1.36	10	111.111	-3.55	8	125	+8.51	4	111.860	-2.90	3
250	250	0	4	250	0	3	NA	-	-	NA	-	-
625	625	0	1	NA	-	-	625	0	0	NA	-	-
1250	1250	0	0	NA	-	-	NA	-	-	NA	-	-

BAUD RATE (K)	FOSC = 5.068 MHz			4 MHz			3.579 MHz			1 MHz			32.768 kHz		
	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)	KBAUD	% ERROR	SPBRG value (decimal)
9.6	9.6	0	32	NA	-	-	9.727	+1.32	22	8.928	-6.99	6	NA	-	-
19.2	18.645	-2.94	16	1.202	+0.17	207	18.643	-2.90	11	20.833	+8.51	2	NA	-	-
38.4	39.6	+3.12	7	2.403	+0.13	103	37.286	-2.90	5	31.25	-18.61	1	NA	-	-
57.6	52.8	-8.33	5	9.615	+0.16	25	55.930	-2.90	3	62.5	+8.51	0	NA	-	-
115.2	105.6	-8.33	2	19.231	+0.16	12	111.860	-2.90	1	NA	-	-	NA	-	-
250	NA	-	-	NA	-	-	223.721	-10.51	0	NA	-	-	NA	-	-
625	NA	-	-	NA	-	-	NA	-	-	NA	-	-	NA	-	-
1250	NA	-	-	NA	-	-	NA	-	-	NA	-	-	NA	-	-

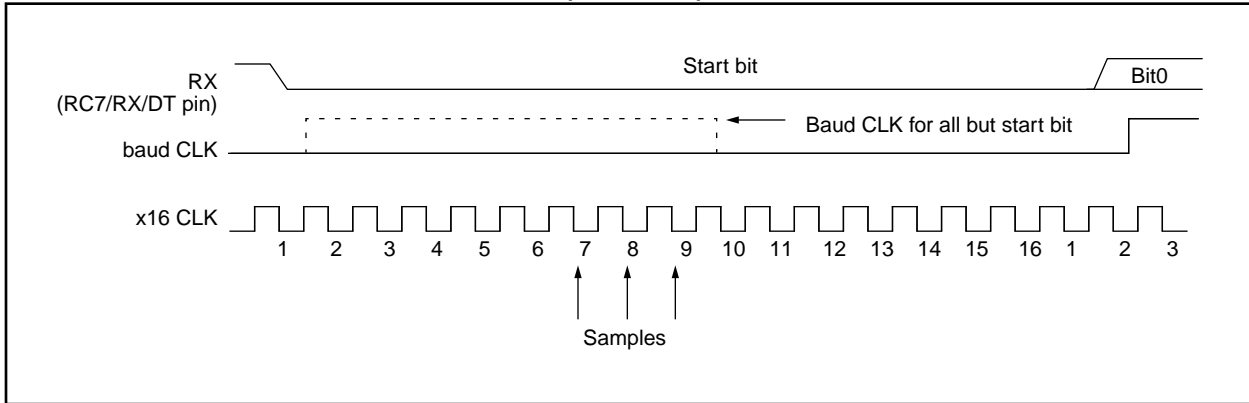
# PIC16C7X

## 12.1.1 SAMPLING

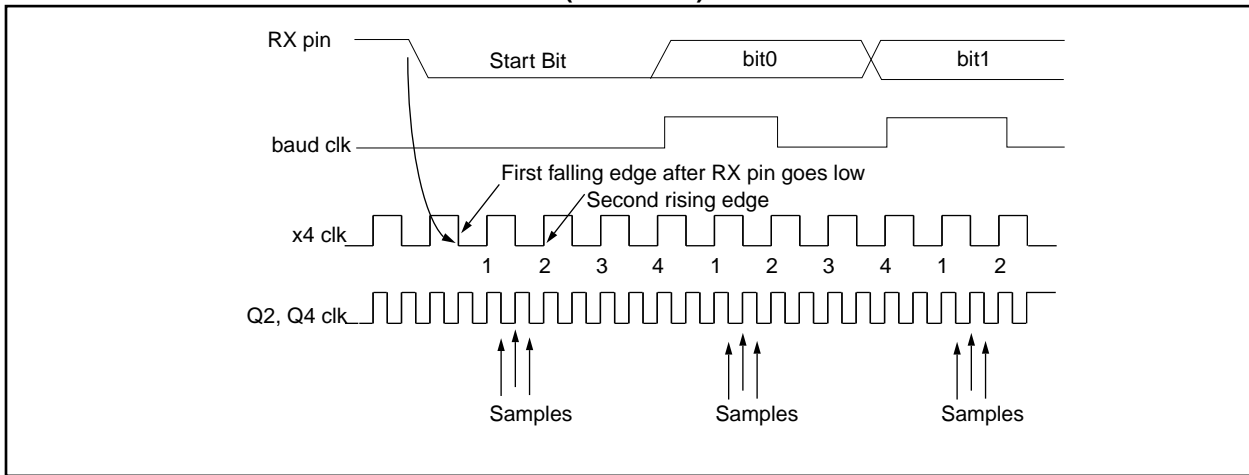
The data on the RC7/RX/DT pin is sampled three times by a majority detect circuit to determine if a high or a low level is present at the RX pin. If bit BRGH (TXSTA<2>) is clear (i.e., at the low baud rates), the sampling is done on the seventh, eighth and ninth falling edges of a x16 clock (Figure 12-3). If bit BRGH is

set (i.e., at the high baud rates), the sampling is done on the 3 clock edges preceding the second rising edge after the first falling edge of a x4 clock (Figure 12-4 and Figure 12-5).

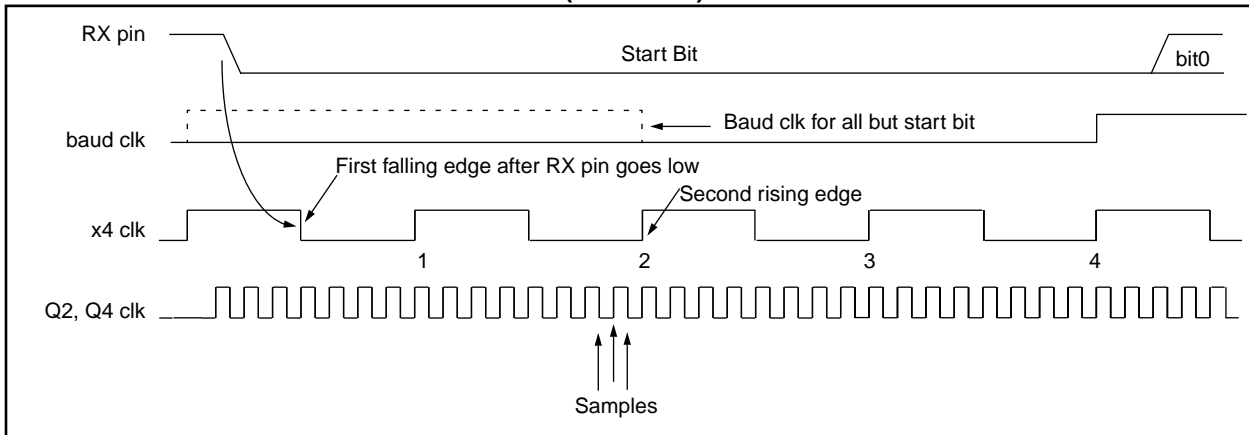
**FIGURE 12-3: RX PIN SAMPLING SCHEME (BRGH = 0)**



**FIGURE 12-4: RX PIN SAMPLING SCHEME (BRGH = 1)**



**FIGURE 12-5: RX PIN SAMPLING SCHEME (BRGH = 1)**



## 12.2 USART Asynchronous Mode

Applicable Devices							
710	711	711	72	73	73A	74	74A

In this mode, the USART uses standard nonreturn-to-zero (NRZ) format (one start bit, eight or nine data bits and one stop bit). The most common data format is 8-bits. An on-chip dedicated 8-bit baud rate generator can be used to derive standard baud rate frequencies from the oscillator. The USART transmits and receives the LSb first. The USART's transmitter and receiver are functionally independent but use the same data format and baud rate. The baud rate generator produces a clock either x16 or x64 of the bit shift rate, depending on bit BRGH (TXSTA<2>). Parity is not supported by the hardware, but can be implemented in software (and stored as the ninth data bit). Asynchronous mode is stopped during SLEEP.

Asynchronous mode is selected by clearing bit SYNC (TXSTA<4>).

The USART Asynchronous module consists of the following important elements:

- Baud Rate Generator
- Sampling Circuit
- Asynchronous Transmitter
- Asynchronous Receiver

### 12.2.1 USART ASYNCHRONOUS TRANSMITTER

The USART transmitter block diagram is shown in Figure 12-6. The heart of the transmitter is the transmit (serial) shift register (TSR). The shift register obtains its data from the read/write transmit buffer, TXREG. The TXREG register is loaded with data in software. The TSR register is not loaded until the STOP bit has been transmitted from the previous load. As soon as the STOP bit is transmitted, the TSR is loaded with new data from the TXREG register (if available). Once the TXREG register transfers the data to the TSR register (occurs in one T<sub>cy</sub>), the TXREG register is empty and

flag bit TXIF (PIR1<4>) is set. This interrupt can be enabled/disabled by setting/clearing enable bit TXIE (PIE1<4>). Flag bit TXIF will be set regardless of the state of enable bit TXIE and cannot be cleared in software. It will reset only when new data is loaded into the TXREG register. While flag bit TXIF indicated the status of the TXREG register, another bit TRMT (TXSTA<1>) shows the status of the TSR register. Status bit TRMT is a read only bit which is set when the TSR register is empty. No interrupt logic is tied to this bit, so the user has to poll this bit in order to determine if the TSR register is empty.

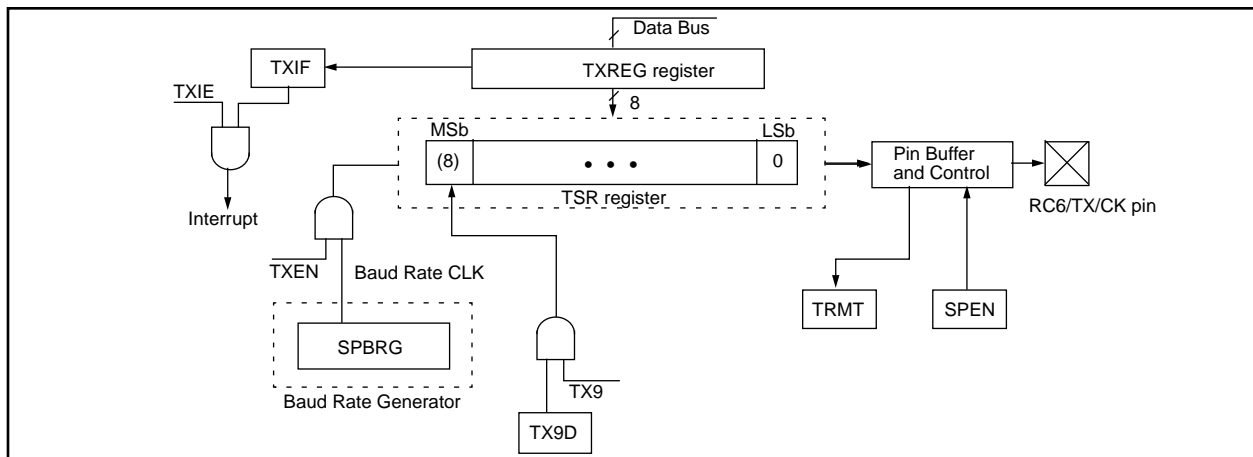
**Note 1:** The TSR register is not mapped in data memory so it is not available to the user.

**Note 2:** Flag bit TXIF is set when enable bit TXEN is set.

Transmission is enabled by setting enable bit TXEN (TXSTA<5>). The actual transmission will not occur until the TXREG register has been loaded with data and the baud rate generator (BRG) has produced a shift clock (Figure 12-6). The transmission can also be started by first loading the TXREG register and then setting enable bit TXEN. Normally when transmission is first started, the TSR register is empty, so a transfer to the TXREG register will result in an immediate transfer to TSR resulting in an empty TXREG. A back-to-back transfer is thus possible (Figure 12-8). Clearing enable bit TXEN during a transmission will cause the transmission to be aborted and will reset the transmitter. As a result the RC6/TX/CK pin will revert to high impedance.

In order to select 9-bit transmission, transmit bit TX9 (TXSTA<6>) should be set and the ninth bit should be written to TX9D (TXSTA<0>). The ninth bit must be written before writing the 8-bit data to the TXREG register. This is because a data write to the TXREG register can result in an immediate transfer of the data to the TSR register (if the TSR is empty). In such a case, an incorrect ninth data bit maybe loaded in the TSR register.

**FIGURE 12-6: USART TRANSMIT BLOCK DIAGRAM**

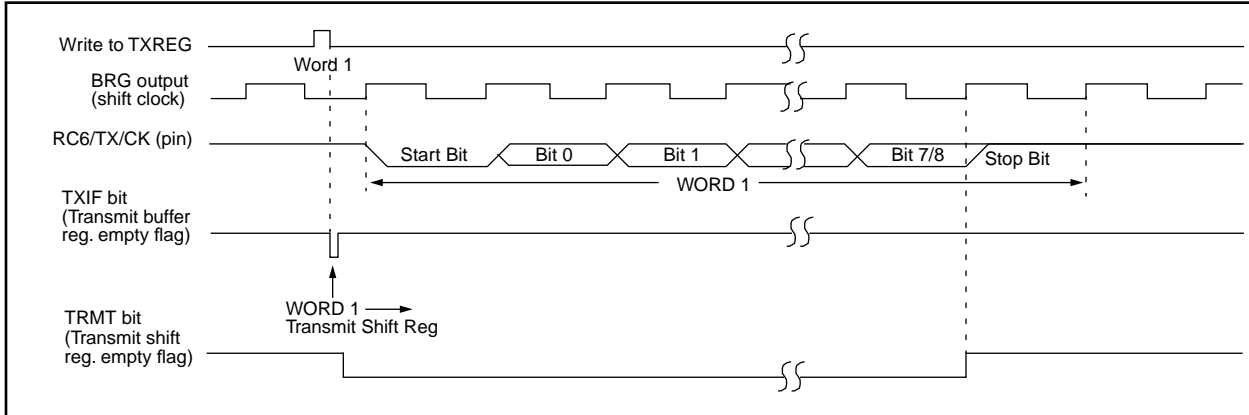


# PIC16C7X

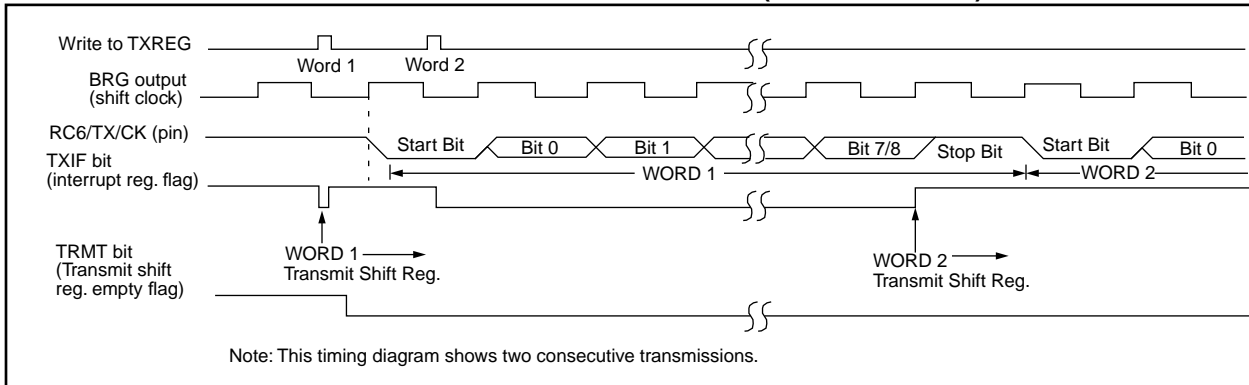
Steps to follow when setting up a Asynchronous Transmission:

1. Initialize the SPBRG register for the appropriate baud rate. If a high speed baud rate is desired, set bit BRGH. (Section 12.1)
2. Enable the asynchronous serial port by clearing bit SYNC and setting bit SPEN.
3. If interrupts are desired, then set enable bit TXIE.
4. If 9-bit transmission is desired, then set transmit bit TX9.
5. Enable the transmission by setting bit TXEN, which will also set bit TXIF.
6. If 9-bit transmission is selected, the ninth bit should be loaded in bit TX9D.
7. Load data to the TXREG register (starts transmission).

**FIGURE 12-7: ASYNCHRONOUS MASTER TRANSMISSION**



**FIGURE 12-8: ASYNCHRONOUS MASTER TRANSMISSION (BACK TO BACK)**



**TABLE 12-6: REGISTERS ASSOCIATED WITH ASYNCHRONOUS TRANSMISSION**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other Resets
0Ch	PIR1	PSPIF <sup>(1)</sup>	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
18h	RCSTA	SPEN	RX9	SREN	CREN	—	FERR	OERR	RX9D	0000 -00x	0000 -00x
19h	TXREG	TX7	TX6	TX5	TX4	TX3	TX2	TX1	TX0	0000 0000	0000 0000
8Ch	PIE1	PSPIE <sup>(1)</sup>	ADIE	RCIE	TXIE	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
98h	TXSTA	CSRC	TX9	TXEN	SYNC	—	BRGH	TRMT	TX9D	0000 -010	0000 -010
99h	SPBRG	Baud Rate Generator Register								0000 0000	0000 0000

Legend: x = unknown, - = unimplemented locations read as '0'. Shaded cells are not used for Asynchronous Transmission.

Note 1: Bits PSPIE and PSPIF are reserved on the PIC16C73/73A, always maintain these bits clear.

## 12.2.2 USART ASYNCHRONOUS RECEIVER

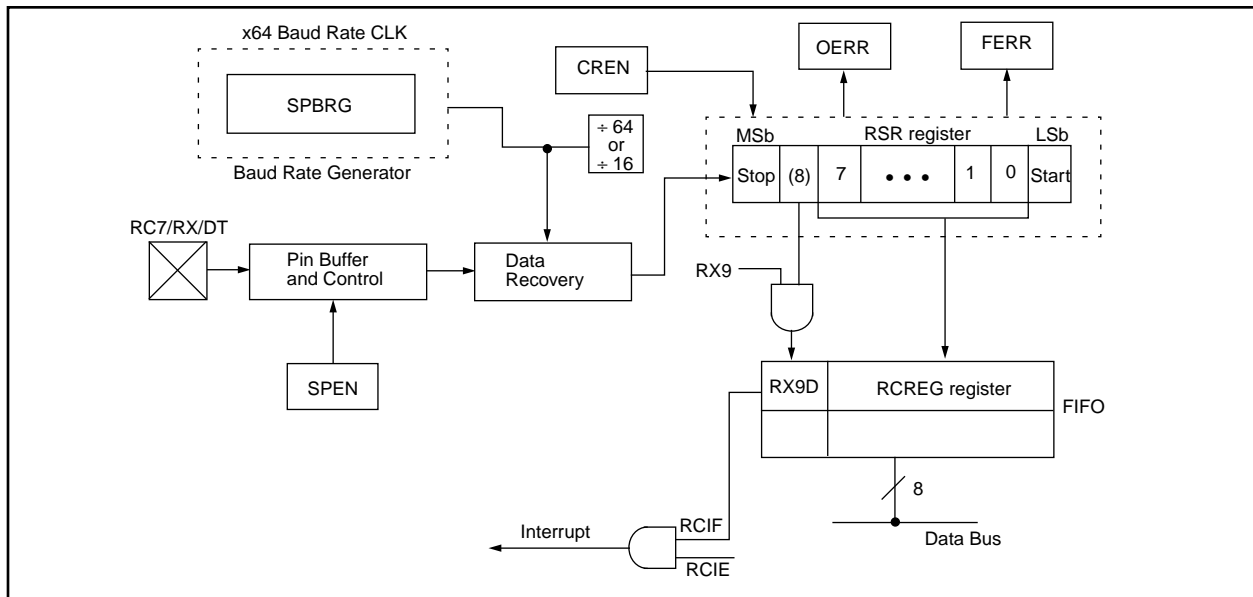
The receiver block diagram is shown in Figure 12-9. The data is received on the RC7/RX/DT pin and drives the data recovery block. The data recovery block is actually a high speed shifter operating at x16 times the baud rate, whereas the main receive serial shifter operates at the bit rate or at FOSC.

Once Asynchronous mode is selected, reception is enabled by setting bit CREN (RCSTA<4>).

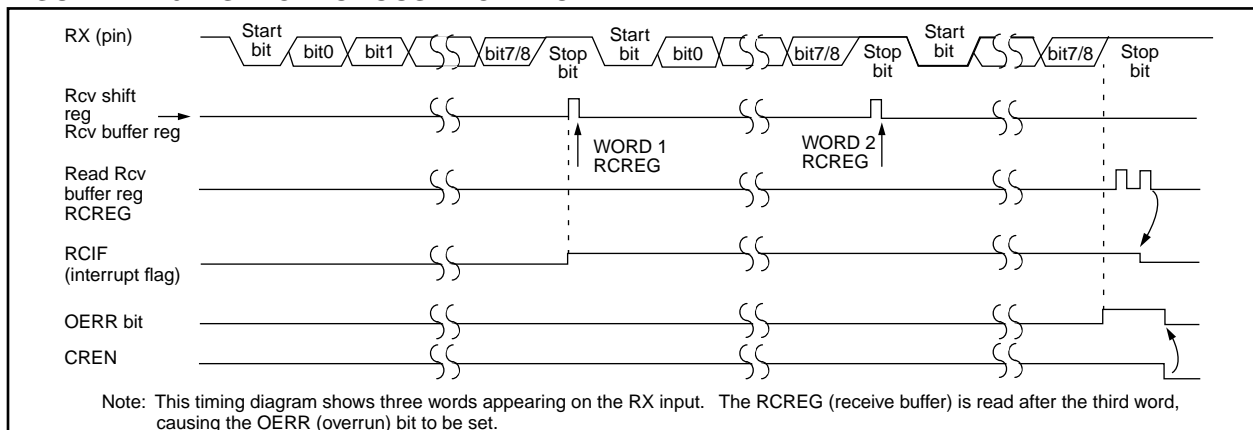
The heart of the receiver is the receive (serial) shift register (RSR). After sampling the STOP bit, the received data in the RSR is transferred to the RCREG register (if it is empty). If the transfer is complete, flag bit RCIF (PIR1<5>) is set. The actual interrupt can be enabled/disabled by setting/clearing enable bit RCIE (PIE1<5>). Flag bit RCIF is a read only bit which is cleared by the hardware. It is cleared when the RCREG register has been read and is empty. The RCREG is a double buffered register, i.e. it is a two deep FIFO. It is

possible for two bytes of data to be received and transferred to the RCREG FIFO and a third byte begin shifting to the RSR register. On the detection of the STOP bit of the third byte, if the RCREG register is still full then overrun error bit OERR (RCSTA<1>) will be set. The word in the RSR will be lost. The RCREG register can be read twice to retrieve the two bytes in the FIFO. Overrun bit OERR has to be cleared in software. This is done by resetting the receive logic (CREN is cleared and then set). If bit OERR is set, transfers from the RSR register to the RCREG register are inhibited, so it is essential to clear error bit OERR if it is set. Framing error bit FERR (RCSTA<2>) is set if a stop bit is detected as clear. Bit FERR and the 9th receive bit are buffered the same way as the receive data. Reading the RCREG, will load bits RX9D and FERR with new values, therefore it is essential for the user to read the RCSTA register before reading RCREG register in order not to lose the old FERR and RX9D information.

**FIGURE 12-9: USART RECEIVE BLOCK DIAGRAM**



**FIGURE 12-10: ASYNCHRONOUS RECEPTION**



# PIC16C7X

Steps to follow when setting up an Asynchronous Reception:

1. Initialize the SPBRG register for the appropriate baud rate. If a high speed baud rate is desired, set bit BRGH. (Section 12.1).
2. Enable the asynchronous serial port by clearing bit SYNC, and setting bit SPEN.
3. If interrupts are desired, then set enable bit RCIE.
4. If 9-bit reception is desired, then set bit RX9.
5. Enable the reception by setting bit CREN.
6. Flag bit RCIF will be set when reception is complete and an interrupt will be generated if enable bit RCIE was set.
7. Read the RCSTA register to get the ninth bit (if enabled) and determine if any error occurred during reception.
8. Read the 8-bit received data by reading the RCREG register.
9. If any error occurred, clear the error by clearing enable bit CREN.

**TABLE 12-7: REGISTERS ASSOCIATED WITH ASYNCHRONOUS RECEPTION**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other Resets
0Ch	PIR1	PSPIF <sup>(1)</sup>	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
18h	RCSTA	SPEN	RX9	SREN	CREN	—	FERR	OERR	RX9D	0000 -00x	0000 -00x
1Ah	RCREG	RX7	RX6	RX5	RX4	RX3	RX2	RX1	RX0	0000 0000	0000 0000
8Ch	PIE1	PSPIE <sup>(1)</sup>	ADIE	RCIE	TXIE	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
98h	TXSTA	CSRC	TX9	TXEN	SYNC	—	BRGH	TRMT	TX9D	0000 -010	0000 -010
99h	SPBRG	Baud Rate Generator Register								0000 0000	0000 0000

Legend: x = unknown, - = unimplemented locations read as '0'. Shaded cells are not used for Asynchronous Reception.

Note 1: Bits PSPIE and PSPIF are reserved on the PIC16C73/73A, always maintain these bits clear.

## 12.3 USART Synchronous Master Mode

Applicable Devices							
710	711	711	72	73	73A	74	74A

In Synchronous Master mode, the data is transmitted in a half-duplex manner i.e. transmission and reception do not occur at the same time. When transmitting data, the reception is inhibited and vice versa. Synchronous mode is entered by setting bit SYNC (TXSTA<4>). In addition enable bit SPEN (RCSTA<7>) is set in order to configure the RC6/TX/CK and RC7/RX/DT I/O pins to CK (clock) and DT (data) lines respectively. The Master mode indicates that the processor transmits the master clock on the CK line. The Master mode is entered by setting bit CSRC (TXSTA<7>).

### 12.3.1 USART SYNCHRONOUS MASTER TRANSMISSION

The USART transmitter block diagram is shown in Figure 12-6. The heart of the transmitter is the transmit (serial) shift register (TSR). The shift register obtains its data from the read/write transmit buffer register TXREG. The TXREG register is loaded with data in software. The TSR register is not loaded until the last bit has been transmitted from the previous load. As soon as the last bit is transmitted, the TSR is loaded with new data from the TXREG (if available). Once the TXREG register transfers the data to the TSR register (occurs in one Tcycle), the TXREG is empty and interrupt bit, TXIF (PIR1<4>) is set. The interrupt can be enabled/disabled by setting/clearing enable bit TXIE (PIE1<4>). Flag bit TXIF will be set regardless of the state of enable bit TXIE and cannot be cleared in software. It will reset only when new data is loaded into the TXREG register. While flag bit TXIF indicates the status of the TXREG register, another bit TRMT (TXSTA<1>) shows the status of the TSR register. TRMT is a read only bit which is set when the TSR is empty. No interrupt logic is tied to this bit, so the user has to poll this bit in order to determine if the TSR register is empty. The TSR is not mapped in data memory so it is not available to the user.

Transmission is enabled by setting enable bit TXEN (TXSTA<5>). The actual transmission will not occur until the TXREG register has been loaded with data. The first data bit will be shifted out on the next available rising edge of the clock on the CK line. Data out is stable around the falling edge of the synchronous clock (Figure 12-11). The transmission can also be started by first loading the TXREG register and then setting bit TXEN. This is advantageous when slow baud rates are selected, since the BRG is kept in reset when bits TXEN, CREN, and SREN are clear. Setting enable bit TXEN will start the BRG, creating a shift clock immediately. Normally when transmission is first started, the TSR register is empty, so a transfer to the TXREG register will result in an immediate transfer to TSR resulting in an empty TXREG. Back-to-back transfers are possible.

Clearing enable bit TXEN, during a transmission, will cause the transmission to be aborted and will reset the transmitter. The DT and CK pins will revert to hi-impedance. If either bit CREN or bit SREN is set, during a transmission, the transmission is aborted and the DT pin reverts to a hi-impedance state (for a reception). The CK pin will remain an output if bit CSRC is set (internal clock). The transmitter logic however is not reset although it is disconnected from the pins. In order to reset the transmitter, the user has to clear bit TXEN. If bit SREN is set (to interrupt an on-going transmission and receive a single word), then after the single word is received, bit SREN will be cleared and the serial port will revert back to transmitting since bit TXEN is still set. The DT line will immediately switch from hi-impedance receive mode to transmit and start driving. To avoid this, bit TXEN should be cleared.

In order to select 9-bit transmission, the TX9 (TXSTA<6>) bit should be set and the ninth bit should be written to bit TX9D (TXSTA<0>). The ninth bit must be written before writing the 8-bit data to the TXREG register. This is because a data write to the TXREG can result in an immediate transfer of the data to the TSR register (if the TSR is empty). If the TSR was empty and the TXREG was written before writing the "new" TX9D, the "present" value of bit TX9D is loaded.

Steps to follow when setting up a Synchronous Master Transmission:

1. Initialize the SPBRG register for the appropriate baud rate (Section 12.1).
2. Enable the synchronous master serial port by setting bits SYNC, SPEN, and CSRC.
3. If interrupts are desired, then set enable bit TXIE.
4. If 9-bit transmission is desired, then set bit TX9.
5. Enable the transmission by setting bit TXEN.
6. If 9-bit transmission is selected, the ninth bit should be loaded in bit TX9D.
7. Start transmission by loading data to the TXREG register.

# PIC16C7X

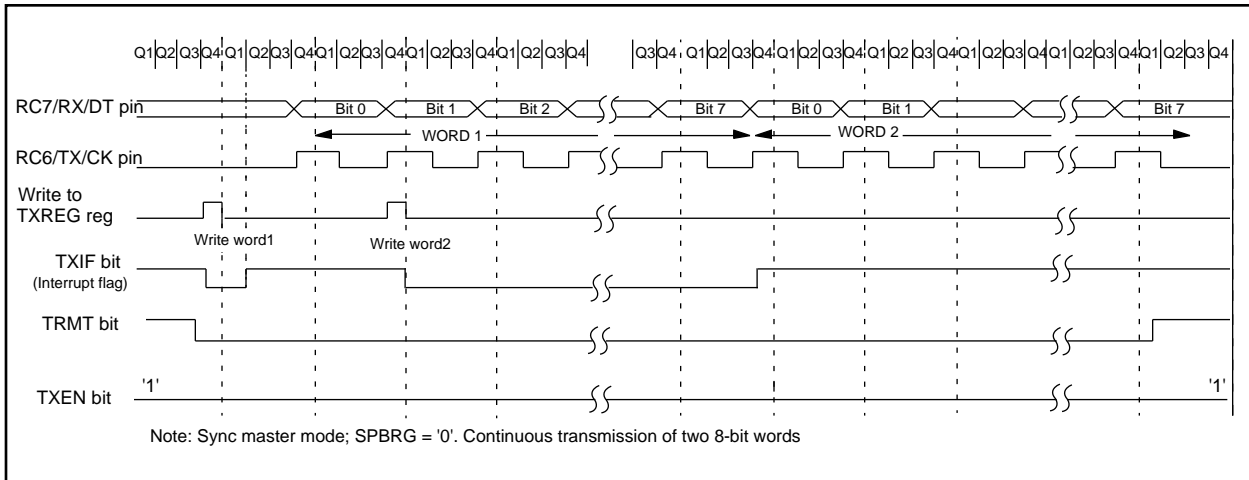
**TABLE 12-8: REGISTERS ASSOCIATED WITH SYNCHRONOUS MASTER TRANSMISSION**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other Resets
0Ch	PIR1	PSPIF <sup>(1)</sup>	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
18h	RCSTA	SPEN	RX9	SREN	CREN	—	FERR	OERR	RX9D	0000 -00x	0000 -00x
19h	TXREG	TX7	TX6	TX5	TX4	TX3	TX2	TX1	TX0	0000 0000	0000 0000
8Ch	PIE1	PSPIE <sup>(1)</sup>	ADIE	RCIE	TXIE	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
98h	TXSTA	CSRC	TX9	TXEN	SYNC	—	BRGH	TRMT	TX9D	0000 -010	0000 -010
99h	SPBRG	Baud Rate Generator Register								0000 0000	0000 0000

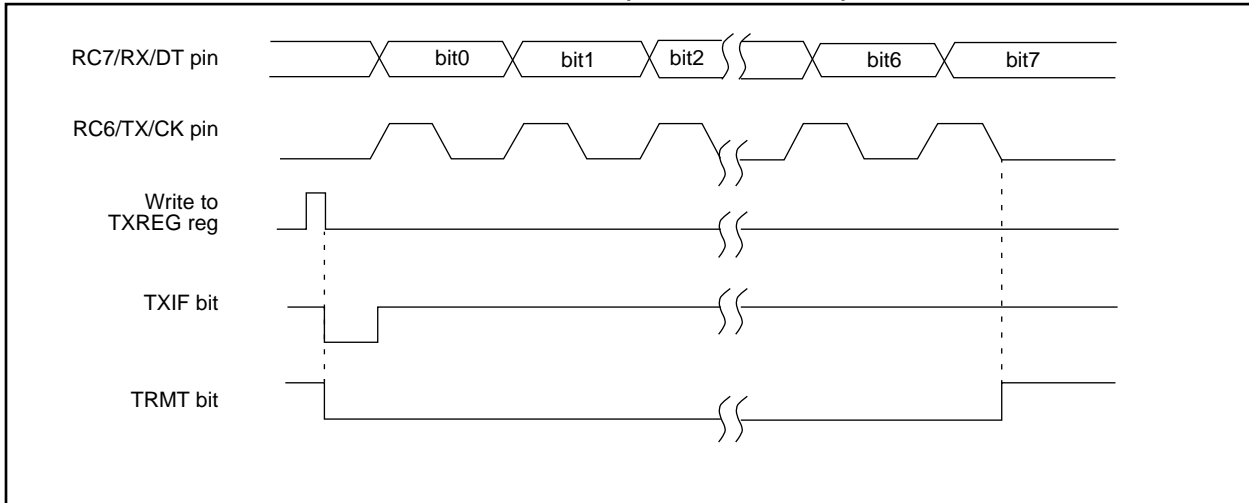
Legend: x = unknown, - = unimplemented, read as '0'. Shaded cells are not used for Synchronous Master Transmission.

Note 1: Bits PSPIE and PSPIF are reserved on the PIC16C73/73A, always maintain these bits clear.

**FIGURE 12-11: SYNCHRONOUS TRANSMISSION**



**FIGURE 12-12: SYNCHRONOUS TRANSMISSION (THROUGH TXEN)**





## 12.3.2 USART SYNCHRONOUS MASTER RECEPTION

Once Synchronous mode is selected, reception is enabled by setting either enable bit SREN (RCSTA<5>) or enable bit CREN (RCSTA<4>). Data is sampled on the RC7/RX/DT pin on the falling edge of the clock. If enable bit SREN is set, then only a single word is received. If enable bit CREN is set, the reception is continuous until CREN is cleared. If both bits are set then CREN takes precedence. After clocking the last bit, the received data in the Receive Shift Register (RSR) is transferred to the RCREG register (if it is empty). When the transfer is complete, interrupt flag bit RCIF (PIR1<5>) is set. The actual interrupt can be enabled/disabled by setting/clearing enable bit RCIE (PIE1<5>). Flag bit RCIF is a read only bit which is reset by the hardware. In this case it is reset when the RCREG register has been read and is empty. The RCREG is a double buffered register, i.e. it is a two deep FIFO. It is possible for two bytes of data to be received and transferred to the RCREG FIFO and a third byte to begin shifting into the RSR register. On the clocking of the last bit of the third byte, if the RCREG register is still full then overrun error bit OERR (RCSTA<1>) is set. The word in the RSR will be lost. The RCREG register can be read twice to retrieve the two bytes in the FIFO. Bit OERR has to be cleared in software (by clearing bit CREN). If bit OERR is set, transfers from the RSR to the RCREG are inhibited, so

it is essential to clear bit OERR if it is set. The 9th receive bit is buffered the same way as the receive data. Reading the RCREG register, will load bit RX9D with a new value, therefore it is essential for the user to read the RCSTA register before reading RCREG in order not to lose the old RX9D information.

Steps to follow when setting up a Synchronous Master Reception:

1. Initialize the SPBRG register for the appropriate baud rate. (Section 12.1)
2. Enable the synchronous master serial port by setting bits SYNC, SPEN, and CSRC.
3. Ensure bits CREN and SREN are clear.
4. If interrupts are desired, then set enable bit RCIE.
5. If 9-bit reception is desired, then set bit RX9.
6. If a single reception is required, set bit SREN. For continuous reception set bit CREN.
7. Interrupt flag bit RCIF will be set when reception is complete and an interrupt will be generated if enable bit RCIE was set.
8. Read the RCSTA register to get the ninth bit (if enabled) and determine if any error occurred during reception.
9. Read the 8-bit received data by reading the RCREG register.
10. If any error occurred, clear the error by clearing bit CREN.

**TABLE 12-9: REGISTERS ASSOCIATED WITH SYNCHRONOUS MASTER RECEPTION**

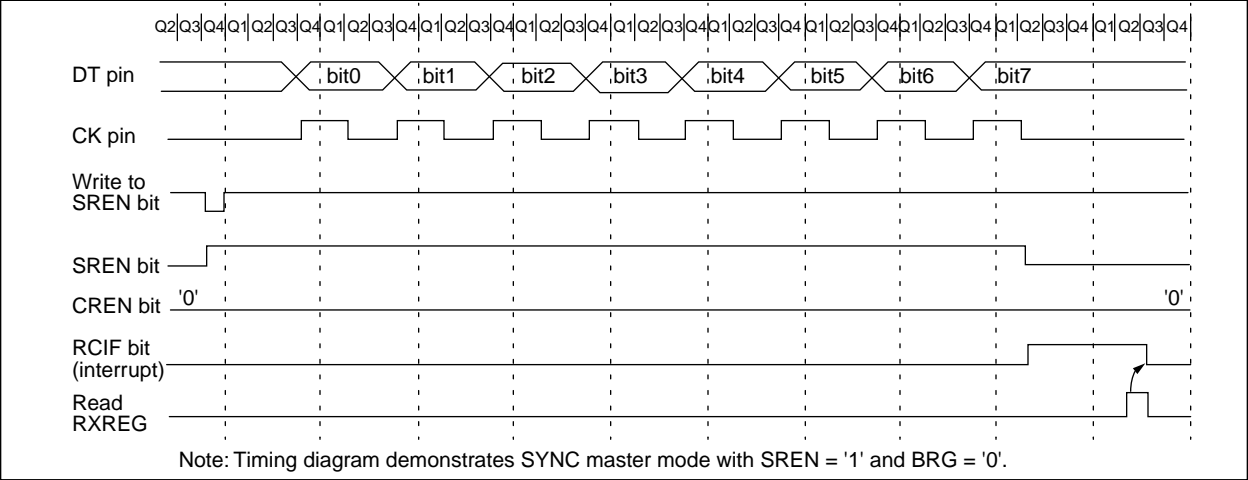
Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other Resets
0Ch	PIR1	PSPIF <sup>(1)</sup>	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
18h	RCSTA	SPEN	RX9	SREN	CREN	—	FERR	OERR	RX9D	0000 -00x	0000 -00x
1Ah	RCREG	RX7	RX6	RX5	RX4	RX3	RX2	RX1	RX0	0000 0000	0000 0000
8Ch	PIE1	PSPIE <sup>(1)</sup>	ADIE	RCIE	TXIE	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
98h	TXSTA	CSRC	TX9	TXEN	SYNC	—	BRGH	TRMT	TX9D	0000 -010	0000 -010
99h	SPBRG	Baud Rate Generator Register								0000 0000	0000 0000

Legend: x = unknown, - = unimplemented read as '0'. Shaded cells are not used for Synchronous Master Reception.

Note 1: Bits PSPIE and PSPIF are reserved on the PIC16C73/73A, always maintain these bits clear.

# PIC16C7X

**FIGURE 12-13: SYNCHRONOUS RECEPTION (MASTER MODE, SREN)**



## 12.4 USART Synchronous Slave Mode

Applicable Devices							
710	711	711	72	73	73A	74	74A

Synchronous slave mode differs from the Master mode in the fact that the shift clock is supplied externally at the RC6/TX/CK pin (instead of being supplied internally in master mode). This allows the device to transfer or receive data while in SLEEP mode. Slave mode is entered by clearing bit CSRC (TXSTA<7>).

### 12.4.1 USART SYNCHRONOUS SLAVE TRANSMIT

The operation of the synchronous master and slave modes are identical except in the case of the SLEEP mode.

If two words are written to the TXREG and then the SLEEP instruction is executed, the following will occur:

- The first word will immediately transfer to the TSR register and transmit.
- The second word will remain in TXREG register.
- Flag bit TXIF will not be set.
- When the first word has been shifted out of TSR, the TXREG register will transfer the second word to the TSR and flag bit TXIF will now be set.
- If enable bit TXIE is set, the interrupt will wake the chip from SLEEP and if the global interrupt is enabled, the program will branch to the interrupt vector (0004h).

Steps to follow when setting up a Synchronous Slave Transmission:

- Enable the synchronous slave serial port by setting bits SYNC and SPEN and clearing bit CSRC.
- Clear bits CREN and SREN.
- If interrupts are desired, then set enable bit TXIE.
- If 9-bit transmission is desired, then set bit TX9.
- Enable the transmission by setting enable bit TXEN.
- If 9-bit transmission is selected, the ninth bit should be loaded in bit TX9D.
- Start transmission by loading data to the TXREG register.

### 12.4.2 USART SYNCHRONOUS SLAVE RECEPTION

The operation of the synchronous master and slave modes is identical except in the case of the SLEEP mode. Also, bit SREN is a don't care in slave mode.

If receive is enabled, by setting bit CREN, prior to the SLEEP instruction, then a word may be received during SLEEP. On completely receiving the word, the RSR register will transfer the data to the RCREG register and if enable bit RCIE bit is set, the interrupt generated will wake the chip from SLEEP. If the global interrupt is enabled, the program will branch to the interrupt vector (0004h).

Steps to follow when setting up a Synchronous Slave Reception:

- Enable the synchronous master serial port by setting bits SYNC and SPEN and clearing bit CSRC.
- If interrupts are desired, then set enable bit RCIE.
- If 9-bit reception is desired, then set bit RX9.
- To enable reception, set enable bit CREN.
- Flag bit RCIF will be set when reception is complete and an interrupt will be generated, if enable bit RCIE was set.
- Read the RCSTA register to get the ninth bit (if enabled) and determine if any error occurred during reception.
- Read the 8-bit received data by reading the RCREG register.
- If any error occurred, clear the error by clearing bit CREN.

# PIC16C7X

**TABLE 12-10: REGISTERS ASSOCIATED WITH SYNCHRONOUS SLAVE TRANSMISSION**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other Resets
0Ch	PIR1	PSPIF <sup>(1)</sup>	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
18h	RCSTA	SPEN	RX9	SREN	CREN	—	FERR	OERR	RX9D	0000 -00x	0000 -00x
19h	TXREG	TX7	TX6	TX5	TX4	TX3	TX2	TX1	TX0	0000 0000	0000 0000
8Ch	PIE1	PSPIE <sup>(1)</sup>	ADIE	RCIE	TXIE	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
98h	TXSTA	CSRC	TX9	TXEN	SYNC	—	BRGH	TRMT	TX9D	0000 -010	0000 -010
99h	SPBRG	Baud Rate Generator Register								0000 0000	0000 0000

Legend: x = unknown, - = unimplemented read as '0'. Shaded cells are not used for Synchronous Slave Transmission.

Note 1: Bits PSPIE and PSPIF are reserved on the PIC16C73/73A, always maintain these bits clear.

**TABLE 12-11: REGISTERS ASSOCIATED WITH SYNCHRONOUS SLAVE RECEPTION**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other Resets
0Ch	PIR1	PSPIF <sup>(1)</sup>	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
18h	RCSTA	SPEN	RX9	SREN	CREN	—	FERR	OERR	RX9D	0000 -00x	0000 -00x
1Ah	RCREG	RX7	RX6	RX5	RX4	RX3	RX2	RX1	RX0	0000 0000	0000 0000
8Ch	PIE1	PSPIE <sup>(1)</sup>	ADIE	RCIE	TXIE	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
98h	TXSTA	CSRC	TX9	TXEN	SYNC	—	BRGH	TRMT	TX9D	0000 -010	0000 -010
99h	SPBRG	Baud Rate Generator Register								0000 0000	0000 0000

Legend: x = unknown, - = unimplemented read as '0'. Shaded cells are not used for Synchronous Slave Reception.

Note 1: Bits PSPIE and PSPIF are reserved on the PIC16C73/73A, always maintain these bits clear.

## 13.0 ANALOG-TO-DIGITAL CONVERTER (A/D) MODULE

Applicable Devices							
710	711	72	73	73A	74	74A	

The analog-to-digital (A/D) converter module has four analog inputs for the PIC16C710/711/711, five inputs for the PIC16C72/73/73A, and eight for the PIC16C74/74A.

The A/D allows conversion of an analog input signal to a corresponding 8-bit digital number (refer to Application Note AN546 for use of A/D Converter). The output of the sample and hold is the input into the converter, which generates the result via successive approximation. The analog reference voltage is software selectable to either the device's positive supply voltage (VDD)

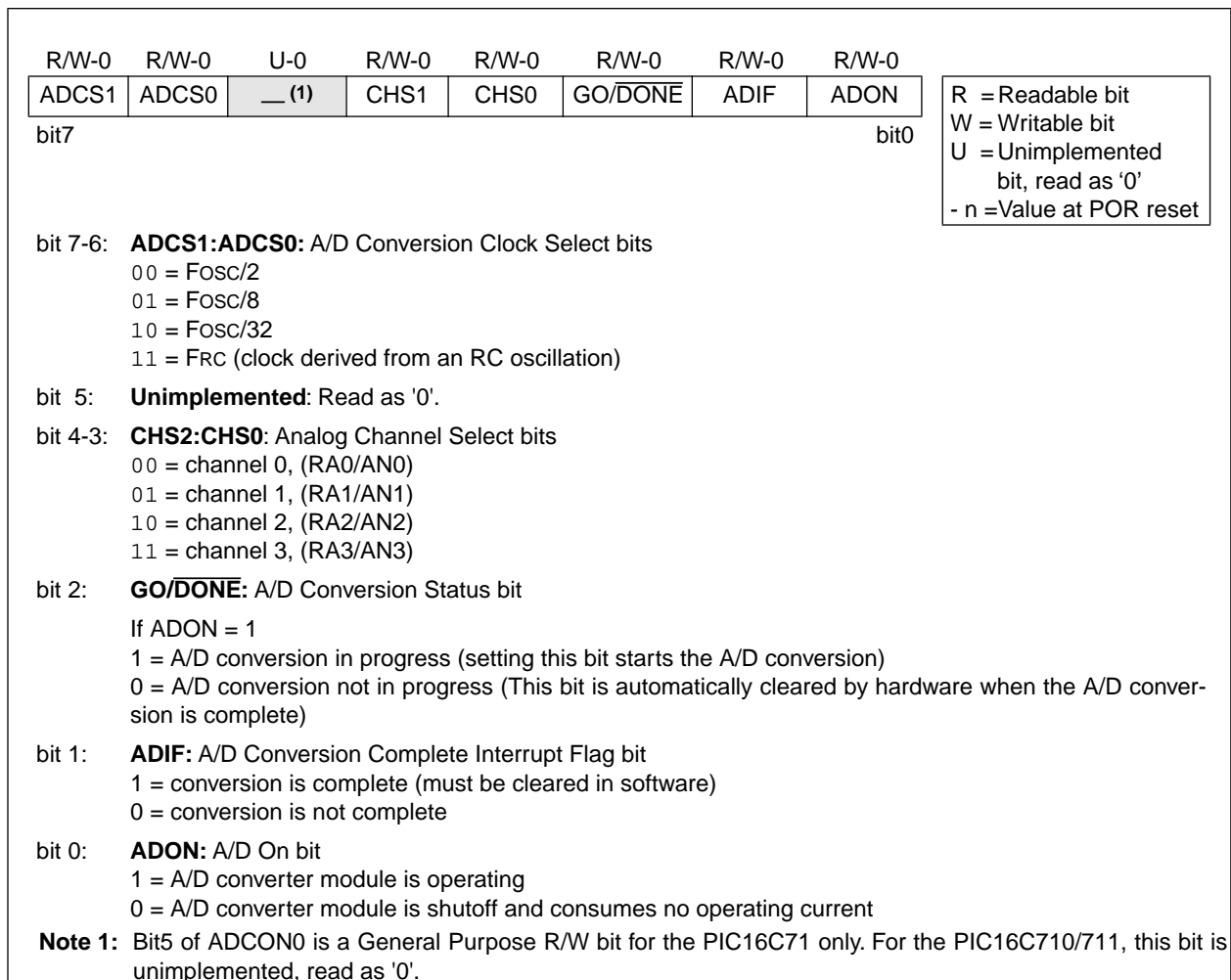
or the voltage level on the RA3/AN3/VREF pin. The A/D converter has a unique feature of being able to operate while the device is in SLEEP mode.

The A/D module has three registers. These registers are:

- A/D Result Register (ADRES)
- A/D Control Register 0 (ADCON0)
- A/D Control Register 1 (ADCON1)

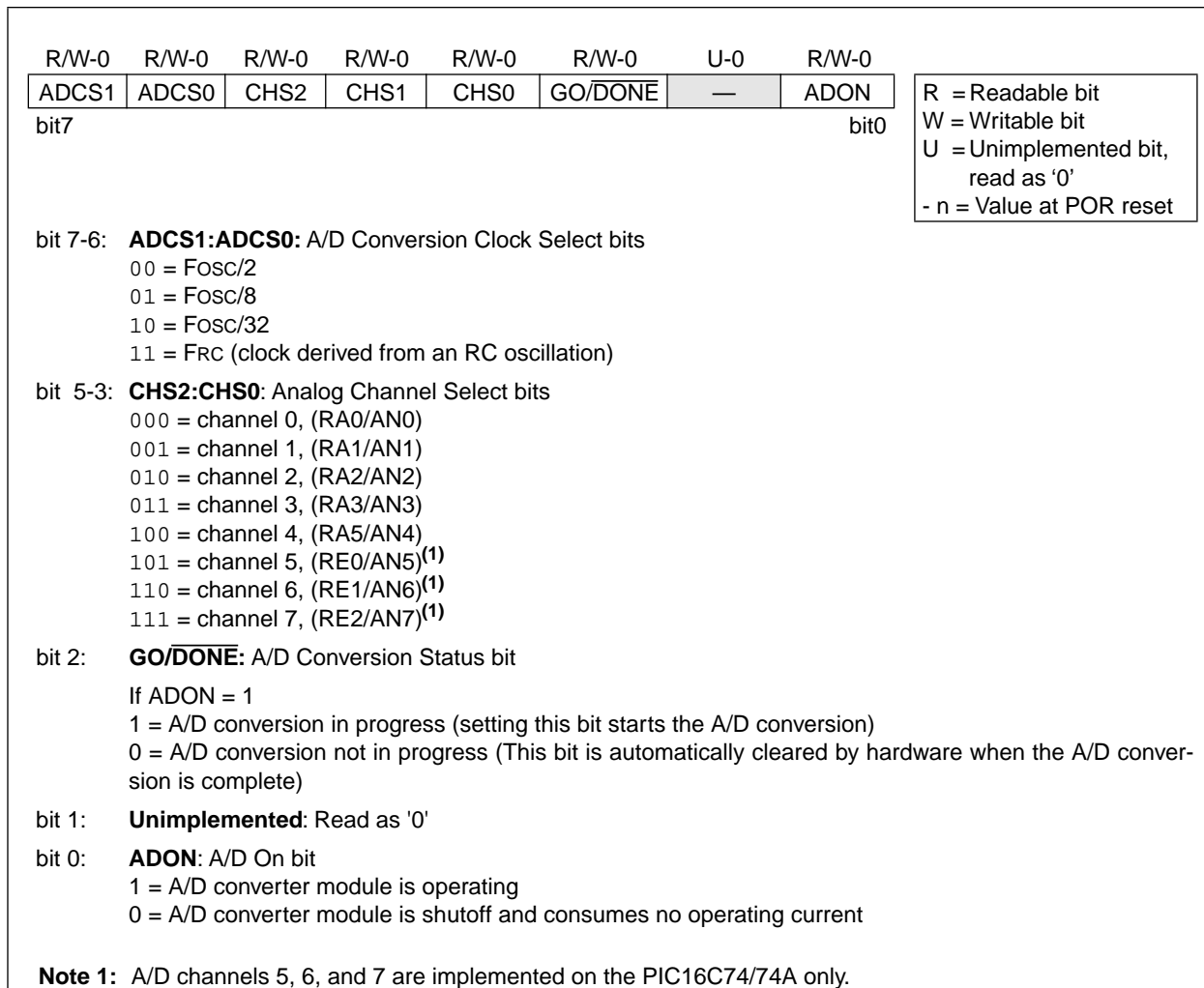
The ADCON0 register, shown in Figure 13-1 and Figure 13-2, controls the operation of the A/D module. The ADCON1 register, shown in Figure 13-3 and Figure 13-4, configures the functions of the port pins. The port pins can be configured as analog inputs (RA3 can also be a voltage reference) or as digital I/O.

**FIGURE 13-1: ADCON0 REGISTER, PIC16C710/711/711 (ADDRESS 08h)**

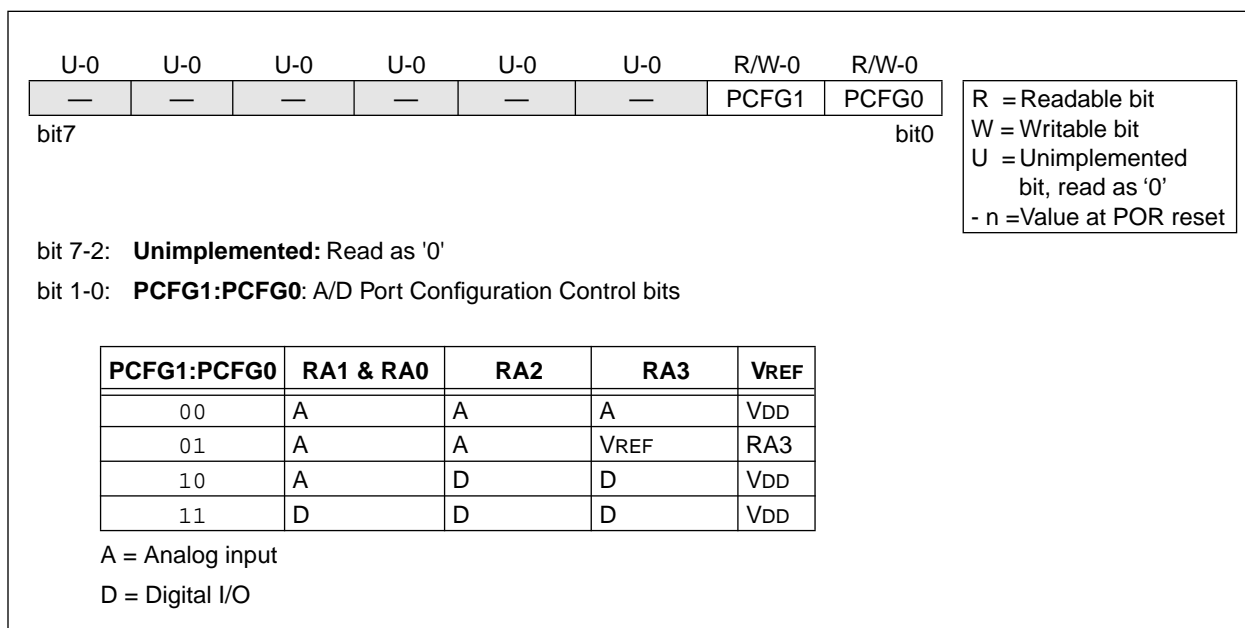


# PIC16C7X

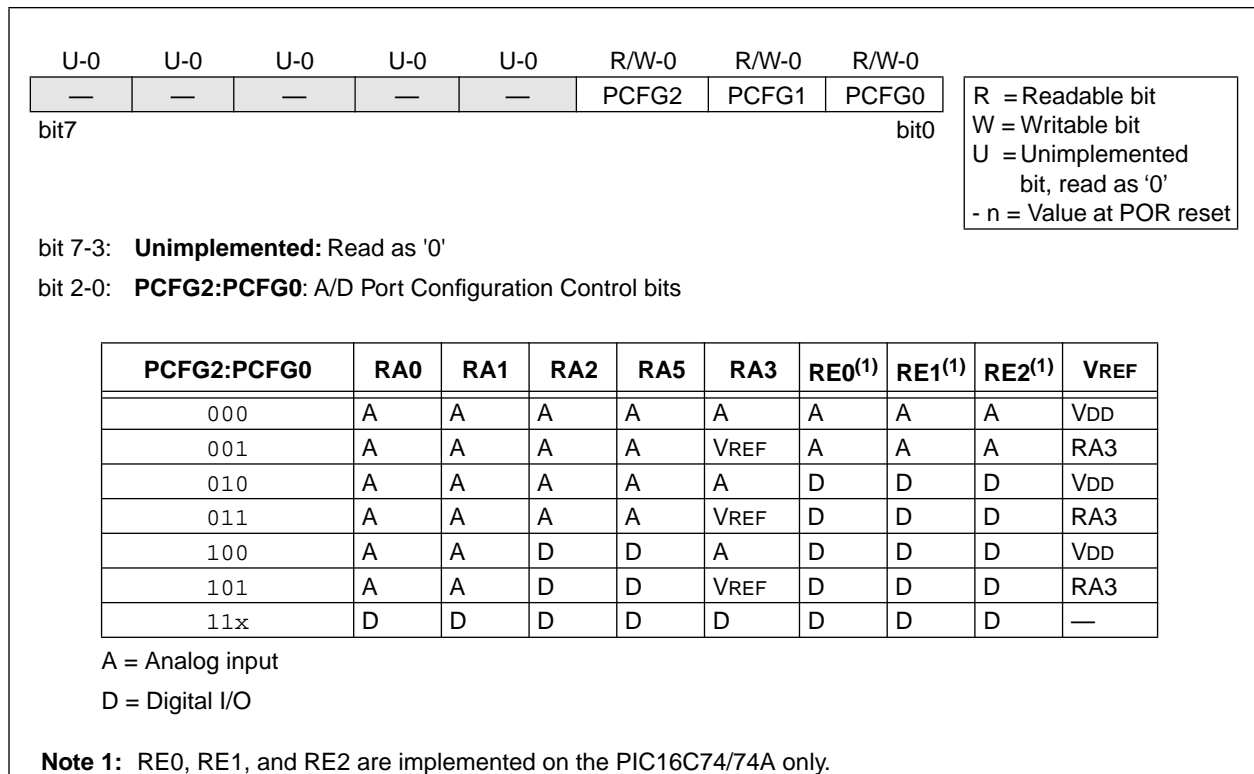
**FIGURE 13-2: ADCON0 REGISTER, PIC16C72/73/73A/74/74A (ADDRESS 1Fh)**



**FIGURE 13-3: ADCON1 REGISTER FOR PIC16C710/71/711 (ADDRESS 88h)**



**FIGURE 13-4: ADCON1 REGISTER, PIC16C72/73/73A/74/74A (ADDRESS 9Fh)**



# PIC16C7X

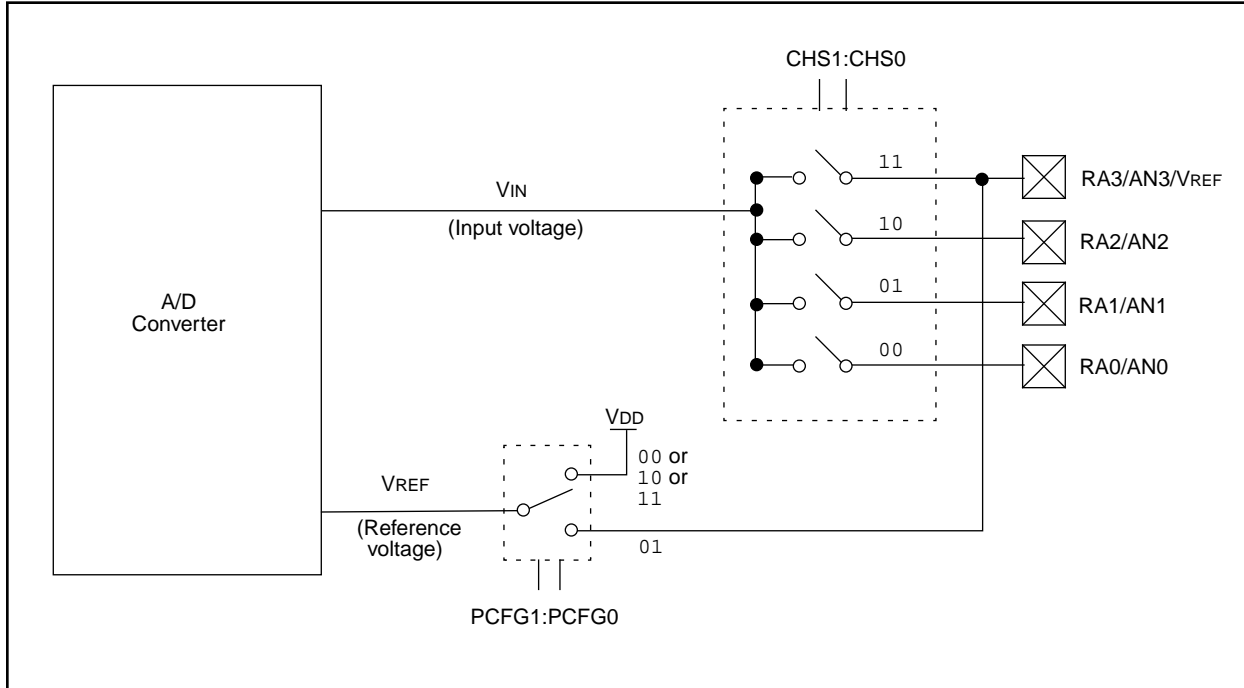
The ADRES register contains the result of the A/D conversion. When the A/D conversion is complete, the result is loaded into the ADRES register, the GO/DONE bit (ADCON0<2>) is cleared, and A/D interrupt flag bit ADIF is set. The block diagrams of the A/D module are shown in Figure 13-5 and Figure 13-6.

After the A/D module has been configured as desired, the selected channel must be acquired before the conversion is started. The analog input channels must have their corresponding TRIS bits selected as an input. To determine sample time, see Section 13.1. After this acquisition time has elapsed the A/D conversion can be started. The following steps should be followed for doing an A/D conversion:

1. Configure the A/D module:
  - Configure analog pins / voltage reference / and digital I/O (ADCON1)
  - Select A/D input channel (ADCON0)
  - Select A/D conversion clock (ADCON0)
  - Turn on A/D module (ADCON0)
2. Configure A/D interrupt (if desired):
  - Clear ADIF bit
  - Set ADIE bit
  - Set GIE bit

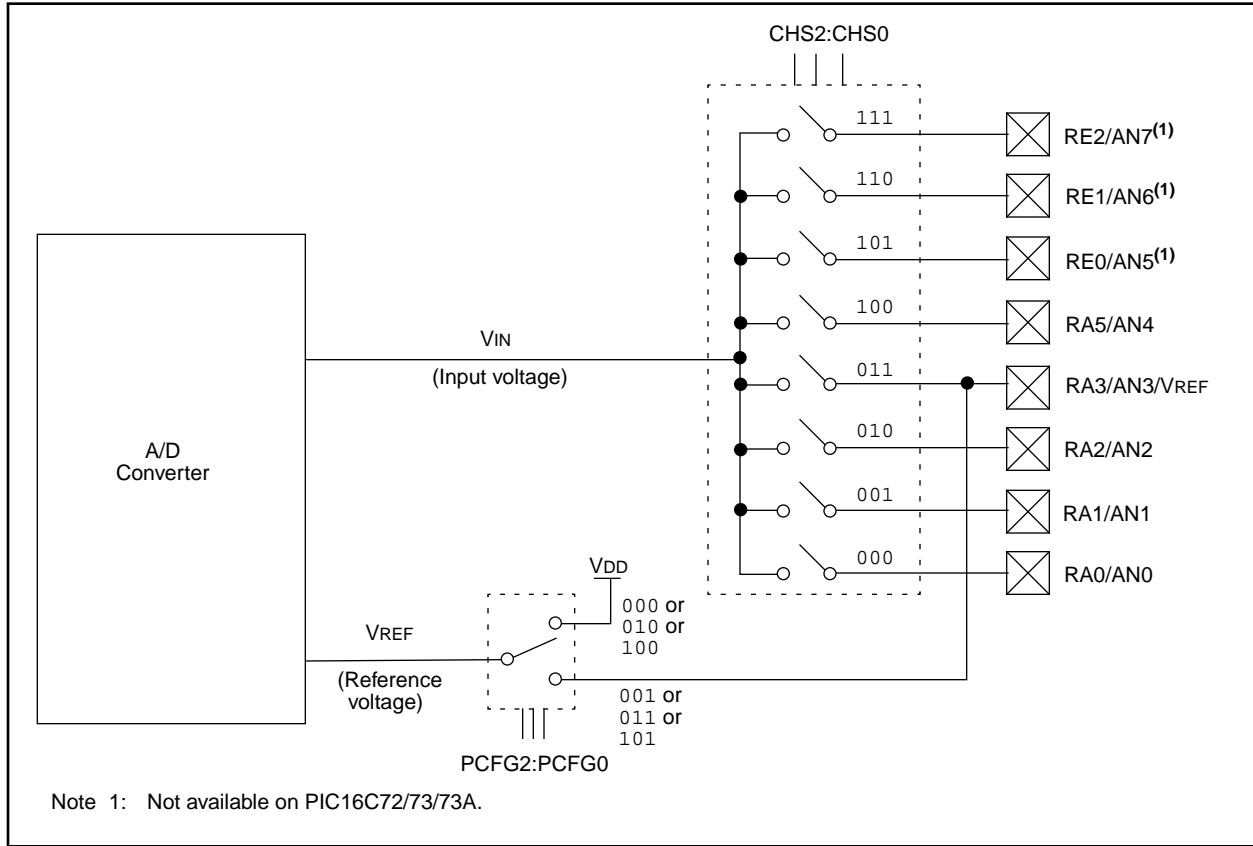
3. Wait the required acquisition time.
4. Start conversion:
  - Set GO/DONE bit (ADCON0)
5. Wait for A/D conversion to complete, by either:
  - Polling for the GO/DONE bit to be clearedOR
  - Waiting for the A/D interrupt
6. Read A/D Result register (ADRES), clear bit ADIF if required.
7. For next conversion, go to step 1 or step 2 as required. The A/D conversion time per bit is defined as TAD. A minimum wait of 2TAD is required before next acquisition starts.

FIGURE 13-5: A/D BLOCK DIAGRAM, PIC16C710/71/711





**FIGURE 13-6: A/D BLOCK DIAGRAM, PIC16C72/73/73A/74/74A**



# PIC16C7X

## 13.1 A/D Sampling Requirements

Applicable Devices							
710	711	712	713	73A	74	74A	

For the A/D converter to meet its specified accuracy, the charge holding capacitor (CHOLD) must be allowed to fully charge to the input channel voltage level. The analog input model is shown in Figure 13-7. The source impedance (RS) and the internal sampling switch (RSS) impedance directly affect the time required to charge the capacitor CHOLD. The sampling switch (RSS) impedance varies over the device voltage (VDD), see Figure 13-7. **The maximum recommended impedance for analog sources is 10 kΩ.** After the analog input channel is selected (changed) this acquisition must be done before the conversion can be started.

To calculate the minimum acquisition time, Equation 13-1 may be used. This equation assumes that 1/2 LSB error is used (512 steps for the A/D). The 1/2 LSB error is the maximum error allowed for the A/D to meet its specified resolution.

### EQUATION 13-1: A/D MINIMUM CHARGING TIME

$$V_{HOLD} = (V_{REF} - (V_{REF}/512)) \cdot (1 - e^{-(T_c/CHOLD)(R_{IC} + R_{SS} + R_S)})$$

or

$$T_c = -(51.2 \text{ pF})(1 \text{ k}\Omega + R_{SS} + R_S) \ln(1/511)$$

Example 13-1 shows the calculation of the minimum required acquisition time TACQ. This calculation is based on the following system assumptions.

RS = 10 kΩ

1/2 LSB error

VDD = 5V → RSS = 7 kΩ

Temp (system max.) = 50°C

VHOLD = 0 @ t = 0

**Note 1:** The reference voltage (VREF) has no effect on the equation, since it cancels itself out.

**Note 2:** The charge holding capacitor (CHOLD) is not discharged after each conversion.

**Note 3:** The maximum recommended impedance for analog sources is 10 kΩ. This is required to meet the pin leakage specification.

**Note 4:** After a conversion has completed, a 2.0 TAD delay must complete before acquisition can begin again. During this time the holding capacitor is not connected to the selected A/D input channel.

### EXAMPLE 13-1: CALCULATING THE MINIMUM REQUIRED SAMPLE TIME

TACQ = Amplifier Settling Time +  
Holding Capacitor Charging Time +  
Temperature Coefficient

$$TACQ = 5 \mu\text{s} + T_c + [(Temp - 25^\circ\text{C})(0.05 \mu\text{s}/^\circ\text{C})]$$

$$T_c = -CHOLD (R_{IC} + R_{SS} + R_S) \ln(1/512)$$

$$= -51.2 \text{ pF} (1 \text{ k}\Omega + 7 \text{ k}\Omega + 10 \text{ k}\Omega) \ln(0.0020)$$

$$= -51.2 \text{ pF} (18 \text{ k}\Omega) \ln(0.0020)$$

$$= -0.921 \mu\text{s} (-6.2146)$$

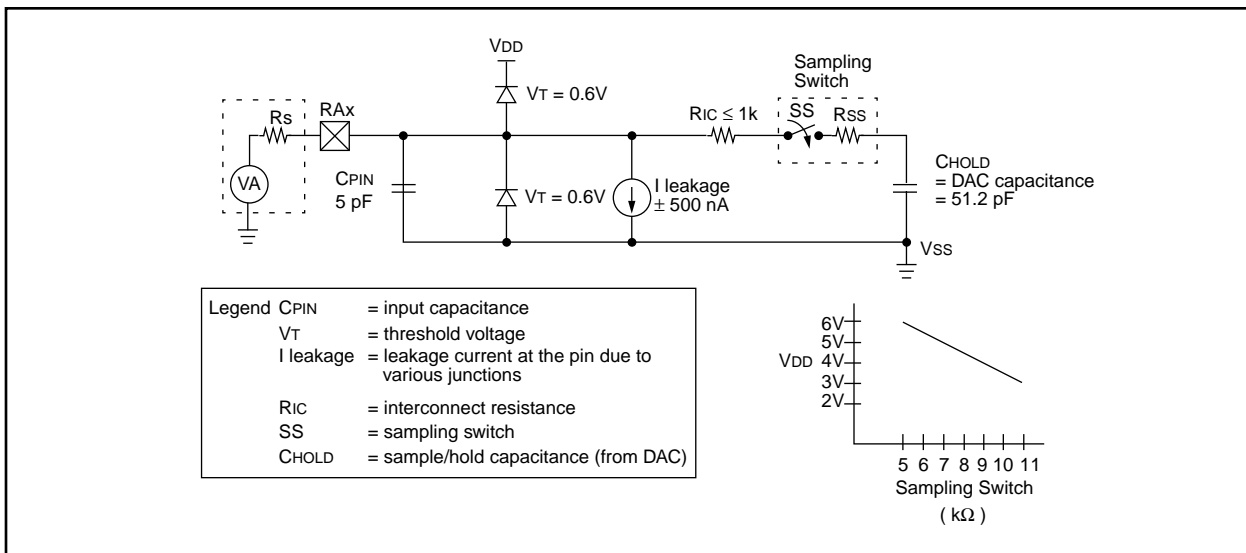
$$5.724 \mu\text{s}$$

$$TACQ = 5 \mu\text{s} + 5.724 \mu\text{s} + [(50^\circ\text{C} - 25^\circ\text{C})(0.05 \mu\text{s}/^\circ\text{C})]$$

$$10.724 \mu\text{s} + 1.25 \mu\text{s}$$

$$11.974 \mu\text{s}$$

FIGURE 13-7: ANALOG INPUT MODEL



## 13.2 Selecting the A/D Conversion Clock

Applicable Devices							
710	71	711	72	73	73A	74	74A

The A/D conversion time per bit is defined as TAD. The A/D conversion requires 9.5 TAD per 8-bit conversion. The source of the A/D conversion clock is software selected. The four possible options for TAD are:

- 2Tosc
- 8TOSC
- 32TOSC
- Internal RC oscillator

For correct A/D conversions, the A/D conversion clock (TAD) must be selected to ensure a minimum TAD time of:

2.0  $\mu$ s for the PIC16C71

1.6  $\mu$ s for all other PIC16C7X devices

Table 13-2 and Table 13-1 show the resultant TAD times derived from the device operating frequencies and the A/D clock source selected.

## 13.3 Configuring Analog Port Pins

Applicable Devices							
710	71	711	72	73	73A	74	74A

The ADCON1, TRISA, and TRISE registers control the operation of the A/D port pins. The port pins that are desired as analog inputs must have their corresponding TRIS bits set (input). If the TRIS bit is cleared (output), the digital output level (VOH or VOL) will be converted.

The A/D operation is independent of the state of the CHS2:CHS0 bits and the TRIS bits.

**Note 1:** When reading the port register, all pins configured as analog input channel will read as cleared (a low level). Pins configured as digital inputs, will convert an analog input. Analog levels on a digitally configured input will not affect the conversion accuracy.

**Note 2:** Analog levels on any pin that is defined as a digital input (including the AN7:AN0 pins), may cause the input buffer to consume current that is out of the devices specification.

**TABLE 13-1: TAD vs. DEVICE OPERATING FREQUENCIES, PIC16C71**

AD Clock Source (TAD)		Device Frequency				
Operation	ADCS1:ADCS0	20 MHz	16 MHz	4 MHz	1 MHz	333.33 kHz
2Tosc	00	100 ns <sup>(2)</sup>	125 ns <sup>(2)</sup>	500 ns <sup>(2)</sup>	2.0 $\mu$ s	6 $\mu$ s
8TOSC	01	400 ns <sup>(2)</sup>	500 ns <sup>(2)</sup>	2.0 $\mu$ s	8.0 $\mu$ s	24 $\mu$ s <sup>(3)</sup>
32TOSC	10	1.6 $\mu$ s <sup>(2)</sup>	2.0 $\mu$ s	8.0 $\mu$ s	32.0 $\mu$ s <sup>(3)</sup>	96 $\mu$ s <sup>(3)</sup>
RC <sup>(5)</sup>	11	2 - 6 $\mu$ s <sup>(1,4)</sup>	2 - 6 $\mu$ s <sup>(1,4)</sup>	2 - 6 $\mu$ s <sup>(1,4)</sup>	2 - 6 $\mu$ s <sup>(1)</sup>	2 - 6 $\mu$ s <sup>(1)</sup>

Note 1: The RC source has a typical TAD time of 4  $\mu$ s.

2: These values violate the minimum required TAD time.

3: For faster conversion times, the selection of another clock source is recommended.

4: While in RC mode, with device frequency above 1 MHz, conversion accuracy is out of specification.

5: For extended voltage devices (LC), please refer to Electrical Specifications section.

**TABLE 13-2: TAD vs. DEVICE OPERATING FREQUENCIES, PIC16C710/711/72/73/73A/74/74A**

AD Clock Source (TAD)		Device Frequency			
Operation	ADCS1:ADCS0	20 MHz	5 MHz	1.25 MHz	333.33 kHz
2TOSC	00	100 ns <sup>(2)</sup>	400 ns <sup>(2)</sup>	1.6 $\mu$ s	6 $\mu$ s
8TOSC	01	400 ns <sup>(2)</sup>	1.6 $\mu$ s	6.4 $\mu$ s	24 $\mu$ s <sup>(3)</sup>
32TOSC	10	1.6 $\mu$ s	6.4 $\mu$ s	25.6 $\mu$ s <sup>(3)</sup>	96 $\mu$ s <sup>(3)</sup>
RC <sup>(5)</sup>	11	2 - 6 $\mu$ s <sup>(1,4)</sup>	2 - 6 $\mu$ s <sup>(1,4)</sup>	2 - 6 $\mu$ s <sup>(1,4)</sup>	2 - 6 $\mu$ s <sup>(1)</sup>

Note 1: The RC source has a typical TAD time of 4  $\mu$ s.

2: These values violate the minimum required TAD time.

3: For faster conversion times, the selection of another clock source is recommended.

4: While in RC mode, with device frequency above 1 MHz, conversion accuracy is out of specification.

5: For extended voltage devices (LC), please refer to Electrical Specifications section.

# PIC16C7X

## 13.4 A/D Conversions

Applicable Devices							
710	71	711	72	73	73A	74	74A

Example 13-2 and Example 13-3 show how to perform an A/D conversion. The RA pins are configured as analog inputs. The analog reference (VREF) is the device VDD. The A/D interrupt is enabled, and the A/D conversion clock is FRC. The conversion is performed on the RA0 channel.

**Note:** The GO/DONE bit should **NOT** be set in the same instruction that turns on the A/D.

Clearing the GO/DONE bit during a conversion will abort the current conversion. The ADRES register will NOT be updated with the partially completed A/D conversion sample. That is, the ADRES register will continue to contain the value of the last completed conversion (or the last value written to the ADRES register). After the A/D conversion is aborted, a 2TAD wait is required before the next acquisition is started. After this 2TAD wait, an acquisition is automatically started on the selected channel.

### EXAMPLE 13-2: DOING AN A/D CONVERSION (PIC16C710/71/711)

```
BSF    STATUS, RP0           ; Select Page 1
CLRF   ADCON1                ; Configure A/D inputs
BCF    STATUS, RP0           ; Select Page 0
MOVLW  0xC1                  ; RC Clock, A/D is on, Channel 0 is selected
MOVWF  ADCON0                ;
BSF    INTCON, ADIE          ; Enable A/D Interrupt
BSF    INTCON, GIE           ; Enable all interrupts
;
; Ensure that the required sampling time for the selected input channel has elapsed.
; Then the conversion may be started.
;
BSF    ADCON0, GO             ; Start A/D Conversion
:                                           ; The ADIF bit will be set and the GO/DONE bit
:                                           ; is cleared upon completion of the A/D Conversion.
```

### EXAMPLE 13-3: DOING AN A/D CONVERSION (PIC16C72/73/73A/74/74A)

```
BSF    STATUS, RP0           ; Select Page 1
CLRF   ADCON1                ; Configure A/D inputs
BSF    PIE1, ADIE            ; Enable A/D interrupts
BCF    STATUS, RP0           ; Select Page 0
MOVLW  0xC1                  ; RC Clock, A/D is on, Channel 0 is selected
MOVWF  ADCON0                ;
BCF    PIR1, ADIF            ; Clear A/D interrupt flag bit
BSF    INTCON, PEIE          ; Enable peripheral interrupts
BSF    INTCON, GIE           ; Enable all interrupts
;
; Ensure that the required sampling time for the selected input channel has elapsed.
; Then the conversion may be started.
;
BSF    ADCON0, GO             ; Start A/D Conversion
:                                           ; The ADIF bit will be set and the GO/DONE bit
:                                           ; is cleared upon completion of the A/D Conversion.
```

## 13.4.1 FASTER CONVERSION - LOWER RESOLUTION TRADE-OFF

Not all applications require a result with 8-bits of resolution, but may instead require a faster conversion time. The A/D module allows users to make the trade-off of conversion speed to resolution. Regardless of the resolution required, the acquisition time is the same. To speed up the conversion, the clock source of the A/D module may be switched so that the TAD time violates the minimum specified time (see the applicable electrical specification). Once the TAD time violates the minimum specified time, all the following A/D result bits are not valid (see A/D Conversion Timing in the Electrical Specifications section.) The clock sources may only be switched between the three oscillator versions (cannot be switched from/to RC). The equation to determine the time before the oscillator can be switched is as follows:

$$\text{Conversion time} = 2T_{AD} + N \cdot T_{AD} + (8 - N)(2T_{OSC})$$

Where: N = number of bits of resolution required.

Since the TAD is based from the device oscillator, the user must use some method (a timer, software loop, etc.) to determine when the A/D oscillator may be changed. Example 13-4 shows a comparison of time required for a conversion with 4-bits of resolution, versus the 8-bit resolution conversion. The example is for devices operating at 20 MHz and 16 MHz (The A/D clock is programmed for 32TOSC), and assumes that immediately after 6TAD, the A/D clock is programmed for 2TOSC.

The 2TOSC violates the minimum TAD time since the last 4-bits will not be converted to correct values.

### EXAMPLE 13-4: 4-BIT vs. 8-BIT CONVERSION TIMES

	Freq. (MHz) <sup>(1)</sup>	Resolution	
		4-bit	8-bit
TAD	20	1.6 μs	1.6 μs
	16	2.0 μs	2.0 μs
TOSC	20	50 ns	50 ns
	16	62.5 ns	62.5 ns
2TAD + N • TAD + (8 - N)(2TOSC)	20	10 μs	16 μs
	16	12.5 μs	20 μs

Note 1: The PIC16C71 has a minimum TAD time of 2.0 μs.  
All other PIC16C7X devices have a minimum TAD time of 1.6 μs.

# PIC16C7X

## 13.5 A/D Operation During Sleep

Applicable Devices							
710	71	711	72	73	73A	74	74A

The A/D module can operate during SLEEP mode. This requires that the A/D clock source be set to RC (ADCS1:ADCS0 = 11). When the RC clock source is selected, the A/D module waits one instruction cycle before starting the conversion. This allows the SLEEP instruction to be executed, which eliminates all digital switching noise from the conversion. When the conversion is completed the GO/DONE bit will be cleared, and the result loaded into the ADRES register. If the A/D interrupt is enabled, the device will wake-up from SLEEP. If the A/D interrupt is not enabled, the A/D module will then be turned off, although the ADON bit will remain set.

When the A/D clock source is another clock option (not RC), a SLEEP instruction will cause the present conversion to be aborted and the A/D module to be turned off, though the ADON bit will remain set.

Turning off the A/D places the A/D module in its lowest current consumption state.

**Note:** For the A/D module to operate in SLEEP, the A/D clock source must be set to RC (ADCS1:ADCS0 = 11). To perform an A/D conversion in SLEEP, the GO/DONE bit must be set, followed by the SLEEP instruction.

## 13.6 A/D Accuracy/Error

Applicable Devices							
710	71	711	72	73	73A	74	74A

The overall accuracy of the A/D is less than  $\pm 1$  LSB for  $V_{DD} = 5V \pm 10\%$  and the analog  $V_{REF} = V_{DD}$ . This overall accuracy includes offset error, full scale error, and integral error. The A/D converter is guaranteed to be monotonic. The resolution and accuracy may be less when either the analog reference ( $V_{DD}$ ) is less than 5.0V or when the analog reference ( $V_{REF}$ ) is less than  $V_{DD}$ .

The maximum pin leakage current is  $\pm 5 \mu A$ .

In systems where the device frequency is low, use of the A/D RC clock is preferred. At moderate to high frequencies, TAD should be derived from the device oscillator. TAD must not violate the minimum and should be  $\leq 8 \mu s$  for preferred operation. This is because TAD, when derived from TOSC, is kept away from on-chip phase clock transitions. This reduces, to a large extent, the effects of digital switching noise. This is not possible with the RC derived clock. The loss of accuracy due to digital switching noise can be significant if many I/O pins are active.

In systems where the device will enter SLEEP mode after the start of the A/D conversion, the RC clock source selection is required. In this mode, the digital noise from the modules in SLEEP are stopped. This method gives high accuracy.

## 13.7 Effects of a RESET

Applicable Devices							
710	71	711	72	73	73A	74	74A

A device reset forces all registers to their reset state. This forces the A/D module to be turned off, and any conversion is aborted. The value that is in the ADRES register is not modified for a Power-on Reset. The ADRES register will contain unknown data after a Power-on Reset.

## 13.8 Use of the CCP Trigger

Applicable Devices							
710	71	711	72	73	73A	74	74A

**Note:** In the PIC16C72 the "special event trigger" is implemented in the CCP1 module.

An A/D conversion can be started by the "special event trigger" of the CCP2 module (CCP1 on the PIC16C72 only). This requires that the CCP2M3:CCP2M0 bits (CCP2CON<3:0>) be programmed as 1011 and that the A/D module is enabled (ADON bit is set). When the trigger occurs, the GO/DONE bit will be set, starting the A/D conversion, and the Timer1 counter will be reset to zero. Timer1 is reset to automatically repeat the A/D acquisition period with minimal software overhead (moving the ADRES to the desired location). The appropriate analog input channel must be selected and the minimum acquisition done before the "special event trigger" sets the GO/DONE bit (starts a conversion).

If the A/D module is not enabled (ADON is cleared), then the "special event trigger" will be ignored by the A/D module, but will still reset the Timer1 counter.

## 13.9 Connection Considerations

### Applicable Devices

710	71	711	72	73	73A	74	74A
-----	----	-----	----	----	-----	----	-----

If the input voltage exceeds the rail values ( $V_{SS}$  or  $V_{DD}$ ) by greater than 0.2V, then the accuracy of the conversion is out of specification.

**Note:** For the PIC16C710/71/711, care must be taken when using the RA0 pin in A/D conversions due to its proximity to the OSC1 pin.

An external RC filter is sometimes added for anti-aliasing of the input signal. The R component should be selected to ensure that the total source impedance is kept under the 10 k $\Omega$  recommended specification. Any external components connected (via hi-impedance) to an analog input pin (capacitor, zener diode, etc.) should have very little leakage current at the pin.

## 13.10 Transfer Function

### Applicable Devices

710	71	711	72	73	73A	74	74A
-----	----	-----	----	----	-----	----	-----

The ideal transfer function of the A/D converter is as follows: the first transition occurs when the analog input voltage ( $V_{AIN}$ ) is 1 LSb (or Analog  $V_{REF} / 256$ ) (Figure 13-8).

FIGURE 13-8: A/D TRANSFER FUNCTION

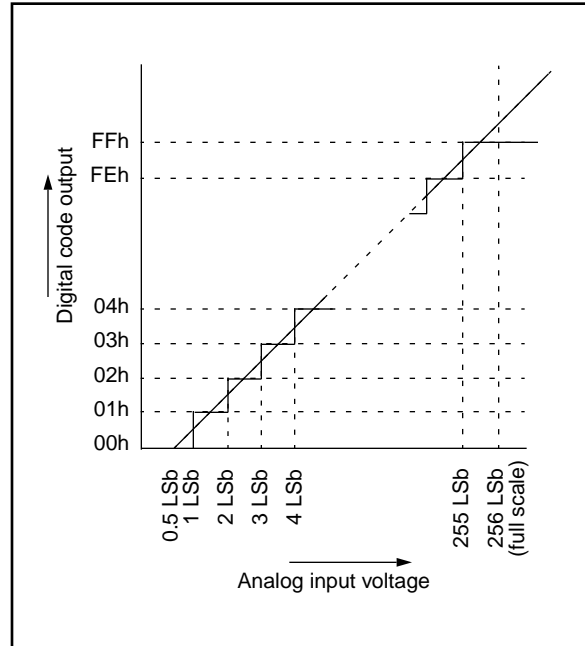
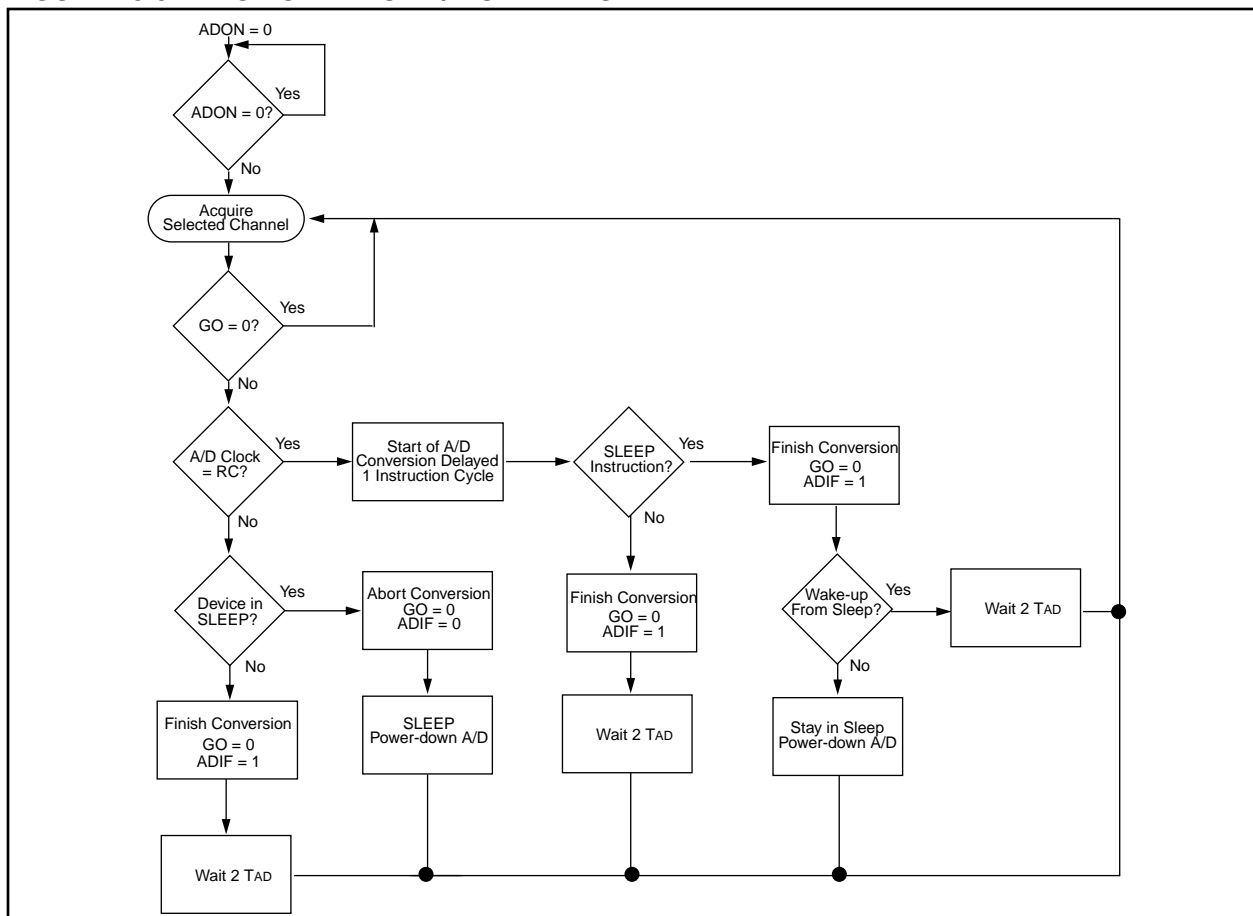


FIGURE 13-9: FLOWCHART OF A/D OPERATION



# PIC16C7X

**TABLE 13-3: SUMMARY OF A/D REGISTERS, PIC16C710/71/711**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other Resets
0Bh/8Bh	INTCON	GIE	ADIE	TOIE	INTE	RBIE	TOIF	INTF	RBIF	0000 000x	0000 000u
89h	ADRES	A/D Result Register								xxxx xxxx	uuuu uuuu
08h	ADCON0	ADCS1	ADCS0	—	CHS1	CHS0	GO/DONE	ADIF	ADON	00-0 0000	00-0 0000
88h	ADCON1	—	—	—	—	—	—	PCFG1	PCFG0	---- --00	---- --00
05h	PORTA	—	—	—	RA4	RA3	RA2	RA1	RA0	---x 0000	---u 0000
85h	TRISA	—	—	—	TRISA4	TRISA3	TRISA2	TRISA1	TRISA0	---1 1111	---1 1111

Legend: x = unknown, u = unchanged, - = unimplemented read as '0'. Shaded cells are not used for A/D conversion.

**TABLE 13-4: SUMMARY OF A/D REGISTERS, PIC16C72**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other Resets
0Bh/8Bh	INTCON	GIE	PEIE	TOIE	INTE	RBIE	TOIF	INTF	RBIF	0000 000x	0000 000u
0Ch	PIR1	—	ADIF	—	—	SSPIF	CCP1IF	TMR2IF	TMR1IF	-0-- 0000	-0-- 0000
8Ch	PIE1	—	ADIE	—	—	SSPIE	CCP1IE	TMR2IE	TMR1IE	-0-- 0000	-0-- 0000
1Eh	ADRES	A/D Result Register								xxxx xxxx	uuuu uuuu
1Fh	ADCON0	ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/DONE	—	ADON	0000 00-0	0000 00-0
9Fh	ADCON1	—	—	—	—	—	PCFG2	PCFG1	PCFG0	---- -000	---- -000
05h	PORTA	—	—	RA5	RA4	RA3	RA2	RA1	RA0	--0x 0000	--0u 0000
85h	TRISA	—	—	TRISA5	TRISA4	TRISA3	TRISA2	TRISA1	TRISA0	--11 1111	--11 1111

Legend: x = unknown, u = unchanged, - = unimplemented read as '0'. Shaded cells are not used for A/D conversion.

**TABLE 13-5: SUMMARY OF A/D REGISTERS, PIC16C73/73A/74/74A**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other Resets
0Bh/8Bh	INTCON	GIE	PEIE	TOIE	INTE	RBIE	TOIF	INTF	RBIF	0000 000x	0000 000u
0Ch	PIR1	PSPIF <sup>(1)</sup>	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
8Ch	PIE1	PSPIE <sup>(1)</sup>	ADIE	RCIE	TXIE	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
0Dh	PIR2	—	—	—	—	—	—	—	CCP2IF	---- --0	---- --0
8Dh	PIE2	—	—	—	—	—	—	—	CCP2IE	---- --0	---- --0
1Eh	ADRES	A/D Result Register								xxxx xxxx	uuuu uuuu
1Fh	ADCON0	ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/DONE	—	ADON	0000 00-0	0000 00-0
9Fh	ADCON1	—	—	—	—	—	PCFG2	PCFG1	PCFG0	---- -000	---- -000
05h	PORTA	—	—	RA5	RA4	RA3	RA2	RA1	RA0	--0x 0000	--0u 0000
85h	TRISA	—	—	TRISA5	TRISA4	TRISA3	TRISA2	TRISA1	TRISA0	--11 1111	--11 1111
09h	PORTE	—	—	—	—	—	RE2	RE1	RE0	---- -xxx	---- -uuu
89h	TRISE	IBF	OBF	IBOV	PSPMODE	—	TRISE2	TRISE1	TRISE0	0000 -111	0000 -111

Legend: x = unknown, u = unchanged, - = unimplemented read as '0'. Shaded cells are not used for A/D conversion.

Note 1: Bits PSPIE and PSPIF are reserved on the PIC16C73/73A, always maintain these bits clear.



## 14.0 SPECIAL FEATURES OF THE CPU

Applicable Devices							
710	71	711	72	73	73A	74	74A

What sets a microcontroller apart from other processors are special circuits to deal with the needs of real-time applications. The PIC16CXX family has a host of such features intended to maximize system reliability, minimize cost through elimination of external components, provide power saving operating modes and offer code protection. These are:

- Oscillator selection
- Reset
  - Power-on Reset (POR)
  - Power-up Timer (PWRT)
  - Oscillator Start-up Timer (OST)
  - Brown-out Reset (BOR)
- Interrupts
- Watchdog Timer (WDT)
- SLEEP
- Code protection
- ID locations
- In-circuit serial programming

The PIC16CXX has a Watchdog Timer which can be shut off only through configuration bits. It runs off its own RC oscillator for added reliability. There are two timers that offer necessary delays on power-up. One is the Oscillator Start-up Timer (OST), intended to keep the chip in reset until the crystal oscillator is stable. The other is the Power-up Timer (PWRT), which provides a fixed delay of 72 ms (nominal) on power-up only,

designed to keep the part in reset while the power supply stabilizes. With these two timers on-chip, most applications need no external reset circuitry.

SLEEP mode is designed to offer a very low current power-down mode. The user can wake-up from SLEEP through external reset, Watchdog Timer Wake-up, or through an interrupt. Several oscillator options are also made available to allow the part to fit the application. The RC oscillator option saves system cost while the LP crystal option saves power. A set of configuration bits are used to select various options.

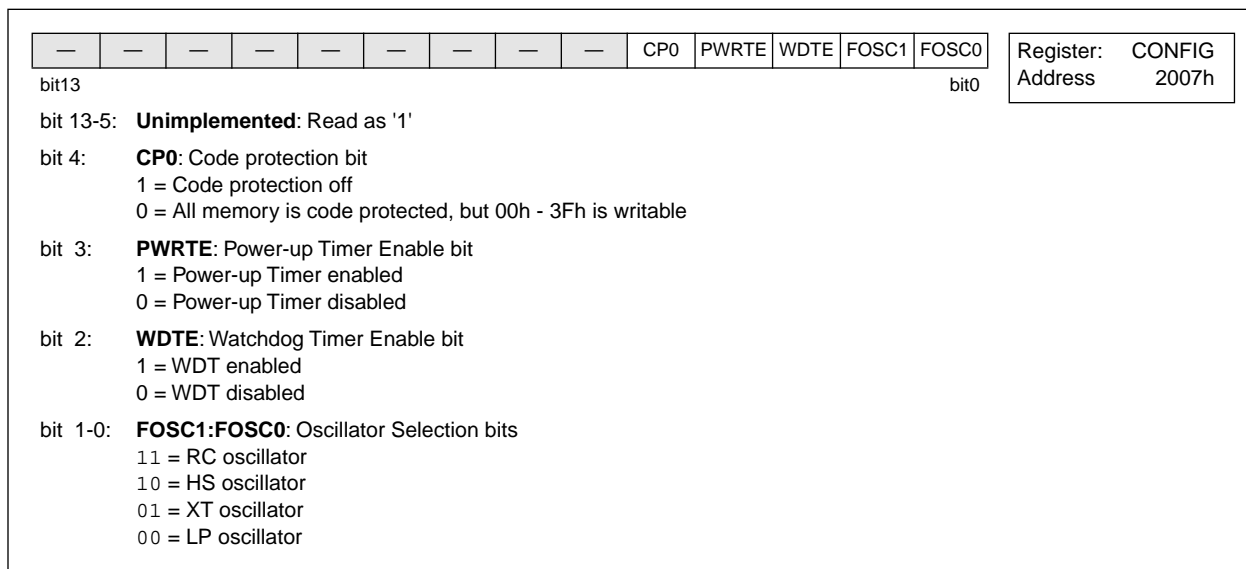
### 14.1 Configuration Bits

Applicable Devices							
710	71	711	72	73	73A	74	74A

The configuration bits can be programmed (read as '0') or left unprogrammed (read as '1') to select various device configurations. These bits are mapped in program memory location 2007h.

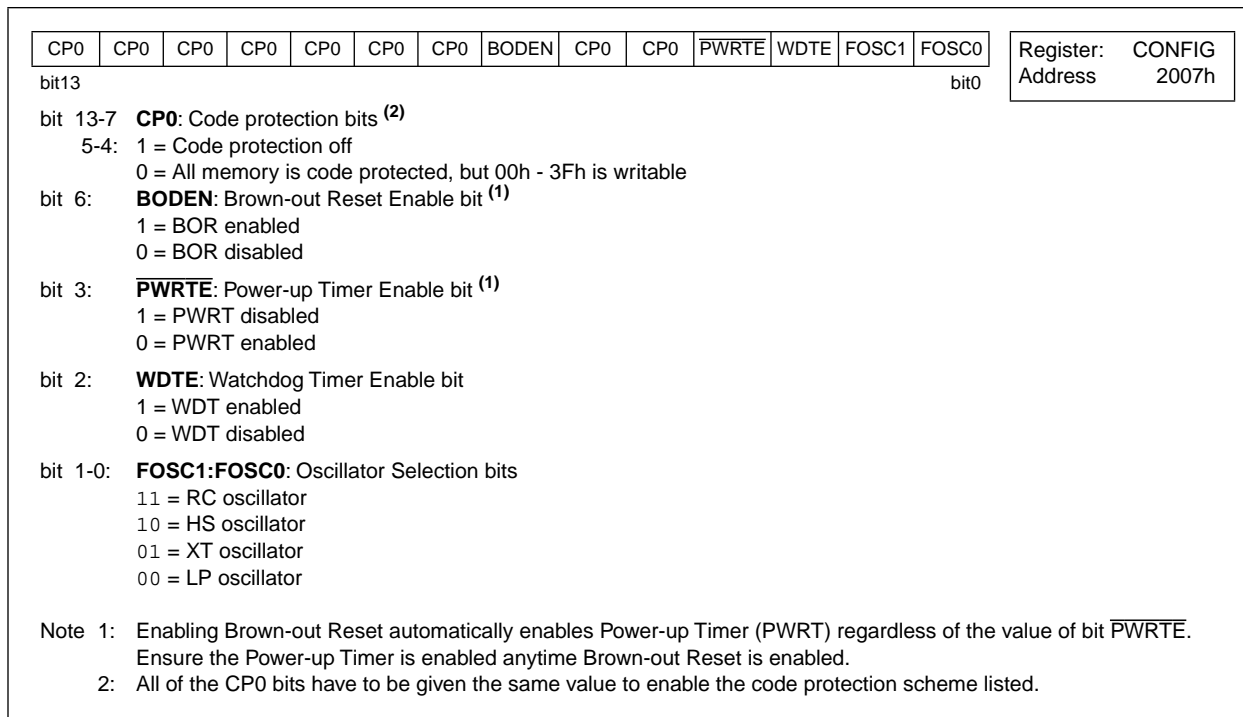
The user will note that address 2007h is beyond the user program memory space. In fact, it belongs to the special test/configuration memory space (2000h - 3FFFh), which can be accessed only during programming.

FIGURE 14-1: CONFIGURATION WORD FOR PIC16C71

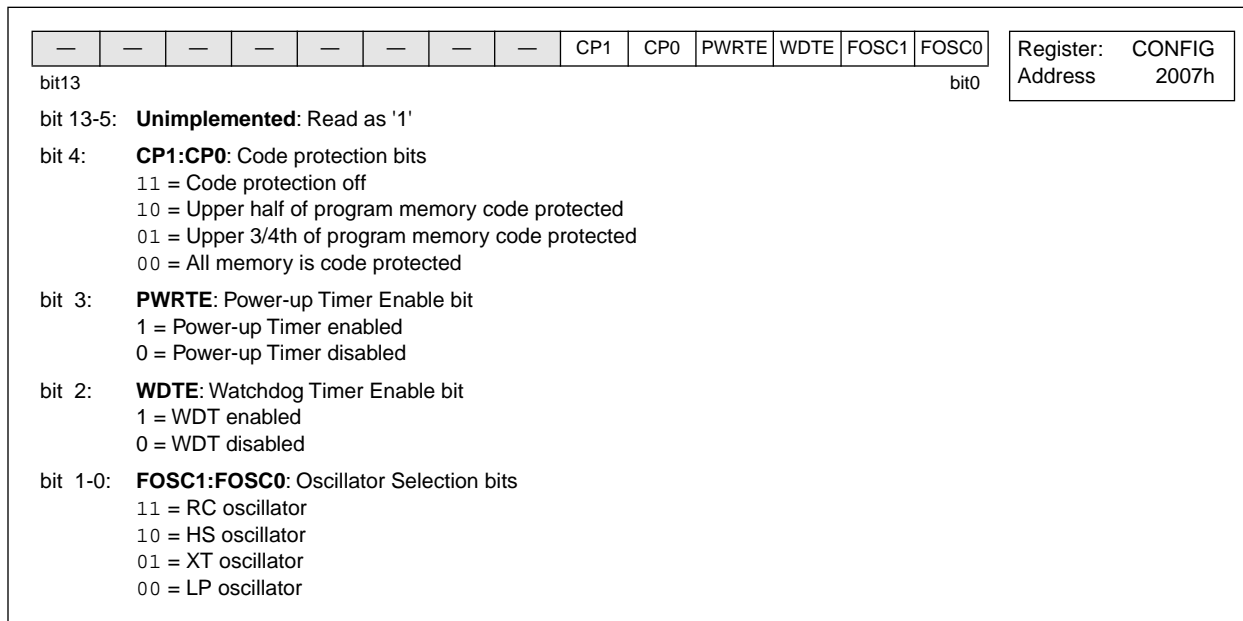


# PIC16C7X

**FIGURE 14-2: CONFIGURATION WORD FOR PIC16C710/711**



**FIGURE 14-3: CONFIGURATION WORD FOR PIC16C73/74**



**FIGURE 14-4: CONFIGURATION WORD FOR PIC16C72/73A/74A**

CP1	CP0	CP1	CP0	CP1	CP0	—	BODEN	CP1	CP0	PWRT $\overline{E}$	WDTE	FOSC1	FOSC0	Register: CONFIG Address: 2007h
bit13													bit0	
bit 13-8: <b>CP1:CP0:</b> Code Protection bits <sup>(2)</sup>														
5-4: 11 = Code protection off														
10 = Upper half of program memory code protected														
01 = Upper 3/4th of program memory code protected														
00 = All memory is code protected														
bit 7: <b>Unimplemented:</b> Read as '1'														
bit 6: <b>BODEN:</b> Brown-out Reset Enable bit <sup>(1)</sup>														
1 = BOR enabled														
0 = BOR disabled														
bit 3: <b>PWRT<math>\overline{E}</math>:</b> Power-up Timer Enable bit <sup>(1)</sup>														
1 = PWRT disabled														
0 = PWRT enabled														
bit 2: <b>WDTE:</b> Watchdog Timer Enable bit														
1 = WDT enabled														
0 = WDT disabled														
bit 1-0: <b>FOSC1:FOSC0:</b> Oscillator Selection bits														
11 = RC oscillator														
10 = HS oscillator														
01 = XT oscillator														
00 = LP oscillator														
Note 1: Enabling Brown-out Reset automatically enables Power-up Timer (PWRT) regardless of the value of bit $\overline{PWRT\overline{E}}$ . Ensure the Power-up Timer is enabled anytime Brown-out Reset is enabled.														
2: All of the CP1:CP0 pairs have to be given the same value to enable the code protection scheme listed.														

## 14.2 Oscillator Configurations

### Applicable Devices

710	71	711	72	73	73A	74	74A
-----	----	-----	----	----	-----	----	-----

### 14.2.1 OSCILLATOR TYPES

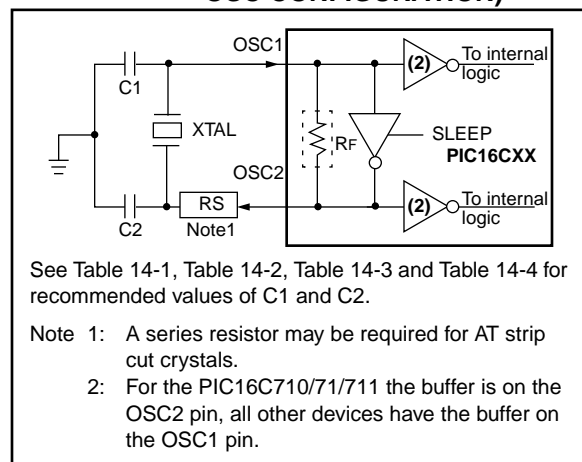
The PIC16CXX can be operated in four different oscillator modes. The user can program two configuration bits (FOSC1 and FOSC0) to select one of these four modes:

- LP Low Power Crystal
- XT Crystal/Resonator
- HS High Speed Crystal/Resonator
- RC Resistor/Capacitor

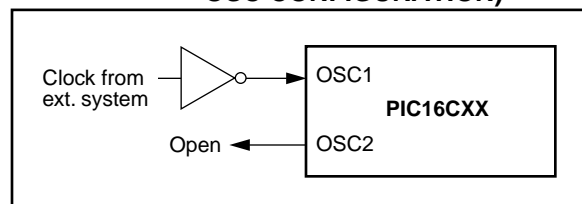
### 14.2.2 CRYSTAL OSCILLATOR/CERAMIC RESONATORS

In XT, LP or HS modes a crystal or ceramic resonator is connected to the OSC1/CLKIN and OSC2/CLKOUT pins to establish oscillation (Figure 14-5). The PIC16CXX Oscillator design requires the use of a parallel cut crystal. Use of a series cut crystal may give a frequency out of the crystal manufacturers specifications. When in XT, LP or HS modes, the device can have an external clock source to drive the OSC1/CLKIN pin (Figure 14-6).

**FIGURE 14-5: CRYSTAL/CERAMIC RESONATOR OPERATION (HS, XT OR LP OSC CONFIGURATION)**



**FIGURE 14-6: EXTERNAL CLOCK INPUT OPERATION (HS, XT OR LP OSC CONFIGURATION)**



# PIC16C7X

**TABLE 14-1: CERAMIC RESONATORS  
PIC16C71**

Ranges Tested:			
Mode	Freq	OSC1	OSC2
XT	455 kHz	47 - 100 pF	47 - 100 pF
	2.0 MHz	15 - 68 pF	15 - 68 pF
	4.0 MHz	15 - 68 pF	15 - 68 pF
HS	8.0 MHz	15 - 68 pF	15 - 68 pF
	16.0 MHz	10 - 47 pF	10 - 47 pF
<p>Note: Recommended values of C1 and C2 are identical to the ranges tested table. Higher capacitance increases the stability of oscillator but also increases the start-up time. These values are for design guidance only. Since each resonator has its own characteristics, the user should consult the resonator manufacturer for appropriate values of external components.</p>			
Resonators Used:			
455 kHz	Panasonic EFO-A455K04B	± 0.3%	
2.0 MHz	Murata Erie CSA2.00MG	± 0.5%	
4.0 MHz	Murata Erie CSA4.00MG	± 0.5%	
8.0 MHz	Murata Erie CSA8.00MT	± 0.5%	
16.0 MHz	Murata Erie CSA16.00MX	± 0.5%	
All resonators used did not have built-in capacitors.			

**TABLE 14-2: CAPACITOR SELECTION  
FOR CRYSTAL OSCILLATOR  
FOR PIC16C71**

Mode	Freq	OSC1	OSC2
LP	32 kHz	33 - 68 pF	33 - 68 pF
	200 kHz	15 - 47 pF	15 - 47 pF
XT	100 kHz	47 - 100 pF	47 - 100 pF
	500 kHz	20 - 68 pF	20 - 68 pF
	1 MHz	15 - 68 pF	15 - 68 pF
	2 MHz	15 - 47 pF	15 - 47 pF
	4 MHz	15 - 33 pF	15 - 33 pF
HS	8 MHz	15 - 47 pF	15 - 47 pF
	20 MHz	15 - 47 pF	15 - 47 pF
<p>Note: Higher capacitance increases the stability of oscillator but also increases the start-up time. These values are for design guidance only. Rs may be required in HS mode as well as XT mode to avoid overdriving crystals with low drive level specification. Since each crystal has its own characteristics, the user should consult the crystal manufacturer for appropriate values of external components.</p>			

**TABLE 14-3: CERAMIC RESONATORS  
PIC16C710/711/72/73/73A/74/  
74A**

Ranges Tested:			
Mode	Freq	OSC1	OSC2
XT	455 kHz	68 - 100 pF	68 - 100 pF
	2.0 MHz	15 - 68 pF	15 - 68 pF
	4.0 MHz	15 - 68 pF	15 - 68 pF
HS	8.0 MHz	10 - 68 pF	10 - 68 pF
	16.0 MHz	10 - 22 pF	10 - 22 pF
<p>Note: Recommended values of C1 and C2 are identical to the ranges tested table. Higher capacitance increases the stability of oscillator but also increases the start-up time. These values are for design guidance only. Since each resonator has its own characteristics, the user should consult the resonator manufacturer for appropriate values of external components.</p>			
Resonators Used:			
455 kHz	Panasonic EFO-A455K04B	± 0.3%	
2.0 MHz	Murata Erie CSA2.00MG	± 0.5%	
4.0 MHz	Murata Erie CSA4.00MG	± 0.5%	
8.0 MHz	Murata Erie CSA8.00MT	± 0.5%	
16.0 MHz	Murata Erie CSA16.00MX	± 0.5%	
All resonators used did not have built-in capacitors.			

**TABLE 14-4: CAPACITOR SELECTION  
FOR CRYSTAL OSCILLATOR  
FOR PIC16C710/711/72/73/  
73A/74/74A**

Mode	Freq	OSC1	OSC2
LP	32 kHz <sup>(1)</sup>	15 - 47 pF	15 - 47 pF
	200 kHz	15 - 33 pF	15 - 33 pF
XT	100 kHz	47 - 100 pF	47 - 100 pF
	500 kHz	20 - 68 pF	20 - 68 pF
	1 MHz	15 - 68 pF	15 - 68 pF
	2 MHz	15 - 47 pF	15 - 47 pF
	4 MHz	15 - 33 pF	15 - 33 pF
HS	8 MHz	15 - 47 pF	15 - 47 pF
	20 MHz	15 - 47 pF	15 - 47 pF
<p>Note: Higher capacitance increases the stability of oscillator but also increases the start-up time. These values are for design guidance only. Rs may be required in HS mode as well as XT mode to avoid overdriving crystals with low drive level specification. Since each crystal has its own characteristics, the user should consult the crystal manufacturer for appropriate values of external components.</p>			
<p>Note 1: For VDD &gt; 4.5V, C1 = C2 ≈ 30 pF is recommended.</p>			

## 14.2.3 EXTERNAL CRYSTAL OSCILLATOR CIRCUIT

Either a prepackaged oscillator can be used or a simple oscillator circuit with TTL gates can be built. Prepackaged oscillators provide a wide operating range and better stability. A well-designed crystal oscillator will provide good performance with TTL gates. Two types of crystal oscillator circuits can be used; one with series resonance, or one with parallel resonance.

Figure 14-7 shows implementation of a parallel resonant oscillator circuit. The circuit is designed to use the fundamental frequency of the crystal. The 74AS04 inverter performs the 180-degree phase shift that a parallel oscillator requires. The 4.7 k $\Omega$  resistor provides the negative feedback for stability. The 10 k $\Omega$  potentiometer biases the 74AS04 in the linear region. This could be used for external oscillator designs.

**FIGURE 14-7: EXTERNAL PARALLEL RESONANT CRYSTAL OSCILLATOR CIRCUIT**

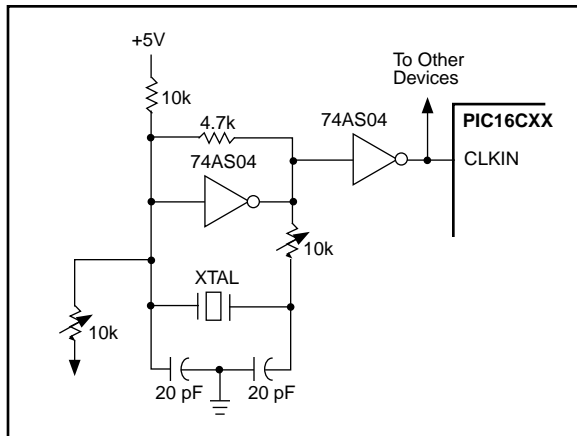
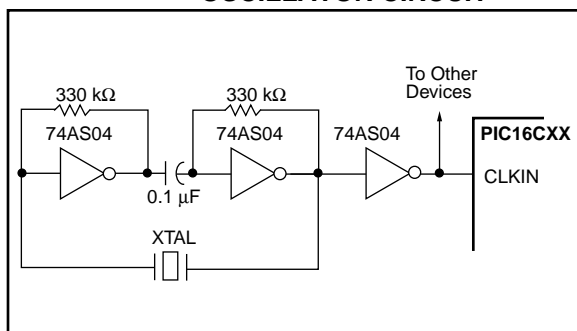


Figure 14-8 shows a series resonant oscillator circuit. This circuit is also designed to use the fundamental frequency of the crystal. The inverter performs a 180-degree phase shift in a series resonant oscillator circuit. The 330 k $\Omega$  resistors provide the negative feedback to bias the inverters in their linear region.

**FIGURE 14-8: EXTERNAL SERIES RESONANT CRYSTAL OSCILLATOR CIRCUIT**



## 14.2.4 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 14-9 shows how the R/C combination is connected to the PIC16CXX. For  $R_{ext}$  values below 2.2 k $\Omega$ , the oscillator operation may become unstable, or stop completely. For very high  $R_{ext}$  values (e.g. 1 M $\Omega$ ), the oscillator becomes sensitive to noise, humidity and leakage. Thus, we recommend to keep  $R_{ext}$  between 3 k $\Omega$  and 100 k $\Omega$ .

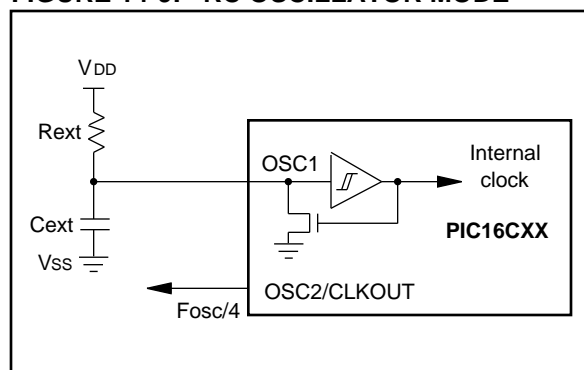
Although the oscillator will operate with no external capacitor ( $C_{ext} = 0$  pF), we recommend using values above 20 pF for noise and stability reasons. With no or small external capacitance, the oscillation frequency can vary dramatically due to changes in external capacitances, such as PCB trace capacitance or package lead frame capacitance.

See characterization data for desired device for RC frequency variation from part to part due to normal process variation. The variation is larger for larger R (since leakage current variation will affect RC frequency more for large R) and for smaller C (since variation of input capacitance will affect RC frequency more).

See characterization data for desired device for variation of oscillator frequency due to  $V_{DD}$  for given  $R_{ext}/C_{ext}$  values as well as frequency variation due to operating temperature for given R, C, and  $V_{DD}$  values.

The oscillator frequency, divided by 4, is available on the OSC2/CLKOUT pin, and can be used for test purposes or to synchronize other logic (see Figure 3-5 for waveform).

**FIGURE 14-9: RC OSCILLATOR MODE**



# PIC16C7X

## 14.3 Reset

Applicable Devices							
710	711	711	72	73	73A	74	74A

The PIC16CXX differentiates between various kinds of reset:

- Power-on Reset (POR)
- $\overline{\text{MCLR}}$  reset during normal operation
- $\overline{\text{MCLR}}$  reset during SLEEP
- WDT Reset (normal operation)
- Brown-out Reset (BOR) (PIC16C710/711/72/73A/74A)

Some registers are not affected in any reset condition; their status is unknown on POR and unchanged in any other reset. Most other registers are reset to a "reset state" on Power-on Reset (POR), on the  $\overline{\text{MCLR}}$  and WDT Reset, on  $\overline{\text{MCLR}}$  reset during SLEEP, and Brown-out Reset (BOR). They are not affected by a WDT Wake-up, which is viewed as the resumption of normal operation. The  $\overline{\text{TO}}$  and  $\overline{\text{PD}}$  bits are set or cleared differently in different reset situations as indicated in

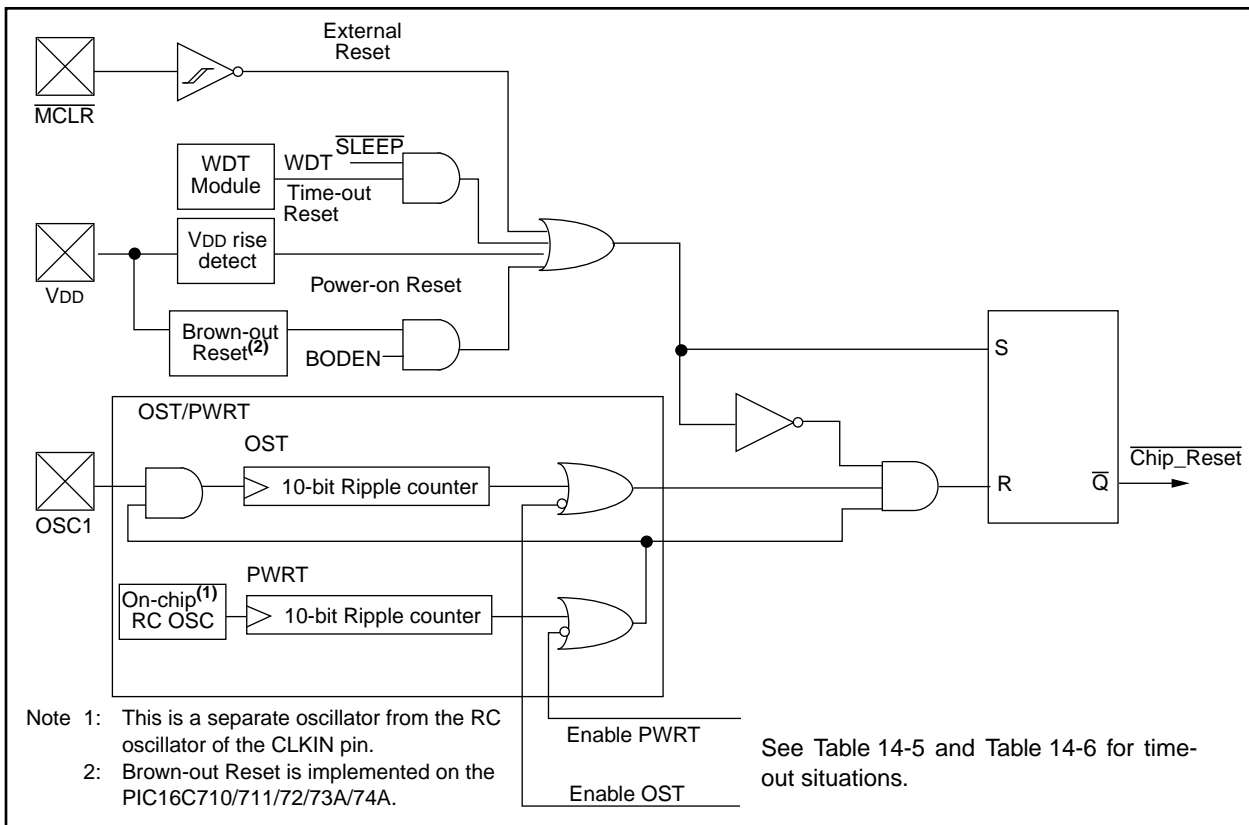
Table 14-7 and Table 14-8. These bits are used in software to determine the nature of the reset. See Table 14-10 for a full description of reset states of all registers.

A simplified block diagram of the on-chip reset circuit is shown in Figure 14-10.

The PIC16C710/711/72/73A/74A have a  $\overline{\text{MCLR}}$  noise filter in the  $\overline{\text{MCLR}}$  reset path. The filter will detect and ignore small pulses.

It should be noted that a WDT Reset does not drive  $\overline{\text{MCLR}}$  pin low.

**FIGURE 14-10: SIMPLIFIED BLOCK DIAGRAM OF ON-CHIP RESET CIRCUIT**



## 14.4 Power-on Reset (POR), Power-up Timer (PWRT) and Oscillator Start-up Timer (OST), Brown-out Reset (BOR)

Applicable Devices							
710	71	711	72	73	73A	74	74A

### 14.4.1 POWER-ON RESET (POR)

A Power-on Reset pulse is generated on-chip when VDD rise is detected (in the range of 1.5V - 2.1V). To take advantage of the POR, just tie the MCLR pin directly (or through a resistor) to VDD. This will eliminate external RC components usually needed to create a Power-on Reset. A maximum rise time for VDD is specified. See Electrical Specifications for details.

When the device starts normal operation (exits the reset condition), device operating parameters (voltage, frequency, temperature, ...) must be met to ensure operation. If these conditions are not met, the device must be held in reset until the operating conditions are met.

For additional information, refer to Application Note AN607, "Power-up Trouble Shooting."

### 14.4.2 POWER-UP TIMER (PWRT)

The Power-up Timer provides a fixed 72 ms nominal time-out on power-up only, from the POR. The Power-up Timer operates on an internal RC oscillator. The chip is kept in reset as long as the PWRT is active. The PWRT's time delay allows VDD to rise to an acceptable level. A configuration bit is provided to enable/disable the PWRT.

The power-up time delay will vary from chip to chip due to VDD, temperature, and process variation. See DC parameters for details.

### 14.4.3 OSCILLATOR START-UP TIMER (OST)

The Oscillator Start-up Timer (OST) provides 1024 oscillator cycle (from OSC1 input) delay after the PWRT delay is over. This ensures that the crystal oscillator or resonator has started and stabilized.

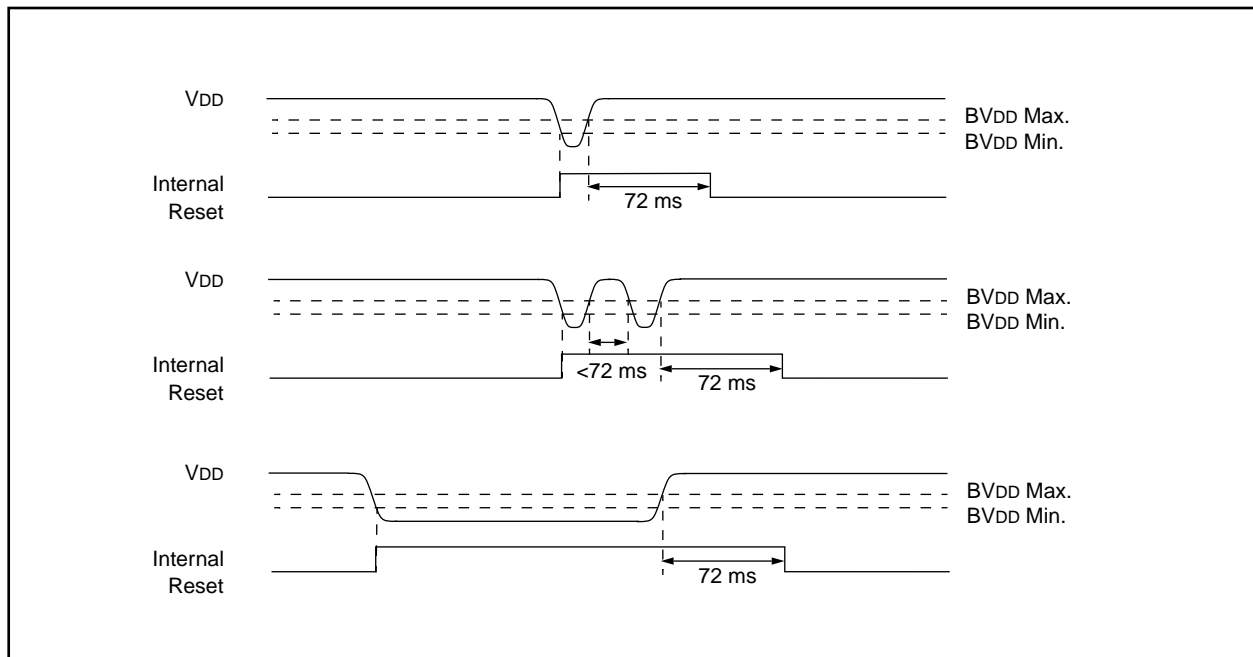
The OST time-out is invoked only for XT, LP and HS modes and only on Power-on Reset or wake-up from SLEEP.

### 14.4.4 BROWN-OUT RESET (BOR)

Applicable Devices							
710	71	711	72	73	73A	74	74A

A configuration bit, BODEN, can disable (if clear/programmed) or enable (if set) the Brown-out Reset circuitry. If VDD falls below 4.0V (3.8V - 4.2V range) for greater than parameter #35, the brown-out situation will reset the chip. A reset may not occur if VDD falls below 4.0V for less than parameter #35. The chip will remain in Brown-out Reset until VDD rises above BVDD. The Power-up Timer will now be invoked and will keep the chip in RESET an additional 72 ms. If VDD drops below BVDD while the Power-up Timer is running, the chip will go back into a Brown-out Reset and the Power-up Timer will be initialized. Once VDD rises above BVDD, the Power-up Timer will execute a 72 ms time delay. The Power-up Timer should always be enabled when Brown-out Reset is enabled. Figure 14-11 shows typical brown-out situations.

**FIGURE 14-11: BROWN-OUT SITUATIONS**



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## 14.4.5 TIME-OUT SEQUENCE

On power-up the time-out sequence is as follows: First PWRT time-out is invoked after the POR time delay has expired. Then OST is activated. The total time-out will vary based on oscillator configuration and the status of the PWRT. For example, in RC mode with the PWRT disabled, there will be no time-out at all. Figure 14-12, Figure 14-13, and Figure 14-14 depict time-out sequences on power-up.

Since the time-outs occur from the POR pulse, if  $\overline{\text{MCLR}}$  is kept low long enough, the time-outs will expire. Then bringing  $\overline{\text{MCLR}}$  high will begin execution immediately (Figure 14-13). This is useful for testing purposes or to synchronize more than one PIC16CXX device operating in parallel.

Table 14-9 shows the reset conditions for some special function registers, while Table 14-10 shows the reset conditions for all the registers.

## 14.4.6 POWER CONTROL/STATUS REGISTER (PCON)

Applicable Devices							
710	711	712	713	73A	74	74A	

The Power Control/Status Register, PCON has up to 8 bits, depending upon the device. Bit0 is not implemented on the PIC16C73 or PIC16C74.

Bit0 is Brown-out Reset Status bit,  $\overline{\text{BOR}}$ . Bit  $\overline{\text{BOR}}$  is unknown on a Power-on Reset. It must then be set by the user and checked on subsequent resets to see if bit  $\overline{\text{BOR}}$  cleared, indicating a BOR occurred. The  $\overline{\text{BOR}}$  bit is a "Don't Care" bit and is not necessarily predictable if the Brown-out Reset circuitry is disabled (by clearing bit BODEN in the Configuration Word).

Bit1 is Power-on Reset Status bit  $\overline{\text{POR}}$ . It is cleared on a Power-on Reset and unaffected otherwise. The user must set this bit following a Power-on Reset.

**TABLE 14-5: TIME-OUT IN VARIOUS SITUATIONS, PIC16C71/73/74**

Oscillator Configuration	Power-up		Wake-up from SLEEP
	PWRTE = 1	PWRTE = 0	
XT, HS, LP	72 ms + 1024Tosc	1024Tosc	1024 Tosc
RC	72 ms	—	—

**TABLE 14-6: TIME-OUT IN VARIOUS SITUATIONS, PIC16C710/711/72/73A/74A**

Oscillator Configuration	Power-up		Brown-out	Wake-up from SLEEP
	PWRTE = 0	PWRTE = 1		
XT, HS, LP	72 ms + 1024Tosc	1024Tosc	72 ms + 1024Tosc	1024Tosc
RC	72 ms	—	72 ms	—

**TABLE 14-7: STATUS BITS AND THEIR SIGNIFICANCE, PIC16C71/73/74**

POR <sup>(1)</sup>	$\overline{\text{TO}}$	$\overline{\text{PD}}$	
0	1	1	Power-on Reset
0	0	x	Illegal, $\overline{\text{TO}}$ is set on $\overline{\text{POR}}$
0	x	0	Illegal, $\overline{\text{PD}}$ is set on $\overline{\text{POR}}$
1	0	1	WDT Reset
1	0	0	WDT Wake-up
1	u	u	$\overline{\text{MCLR}}$ Reset during normal operation
1	1	0	$\overline{\text{MCLR}}$ Reset during SLEEP or interrupt wake-up from SLEEP

Legend: u = unchanged, x = unknown

Note 1: Bit  $\overline{\text{POR}}$  is not implemented on the PIC16C71.

**TABLE 14-8: STATUS BITS AND THEIR SIGNIFICANCE, PIC16C710/711/72/73A/74A**

POR	BOR	$\overline{\text{TO}}$	$\overline{\text{PD}}$	
0	x	1	1	Power-on Reset
0	x	0	x	Illegal, $\overline{\text{TO}}$ is set on $\overline{\text{POR}}$
0	x	x	0	Illegal, $\overline{\text{PD}}$ is set on $\overline{\text{POR}}$
1	0	x	x	Brown-out Reset
1	1	0	1	WDT Reset
1	1	0	0	WDT Wake-up
1	1	u	u	$\overline{\text{MCLR}}$ Reset during normal operation
1	1	1	0	$\overline{\text{MCLR}}$ Reset during SLEEP or interrupt wake-up from SLEEP



**TABLE 14-9: RESET CONDITION FOR SPECIAL REGISTERS**

Condition	Program Counter	STATUS Register	PCON Register PIC16C710/711	PCON Register PIC16C73/74	PCON Register PIC16C72/73A/74A
Power-on Reset	000h	0001 1xxx	---- --0x	---- --0-	---- --0x
MCLR Reset during normal operation	000h	000u uuuu	---- --uu	---- --u-	---- --uu
MCLR Reset during SLEEP	000h	0001 0uuu	---- --uu	---- --u-	---- --uu
WDT Reset	000h	0000 1uuu	---- --uu	---- --u-	---- --uu
WDT Wake-up	PC + 1	uuu0 0uuu	---- --uu	---- --u-	---- --uu
Brown-out Reset	000h	0001 1uuu	---- --u0	N/A	---- --u0
Interrupt wake-up from SLEEP	PC + 1 <sup>(1)</sup>	uuu1 0uuu	---- --uu	---- --u-	---- --uu

Legend: u = unchanged, x = unknown, - = unimplemented bit read as '0'.

Note 1: When the wake-up is due to an interrupt and the GIE bit is set, the PC is loaded with the interrupt vector (0004h).

**TABLE 14-10: INITIALIZATION CONDITIONS FOR ALL REGISTERS**

Register	Applicable Devices								Power-on Reset, Brown-out Reset	MCLR Resets WDT Reset	Wake-up via WDT or Interrupt
W	710	71	711	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
INDF	710	71	711	72	73	73A	74	74A	N/A	N/A	N/A
TMR0	710	71	711	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
PCL	710	71	711	72	73	73A	74	74A	0000h	0000h	PC + 1 <sup>(2)</sup>
STATUS	710	71	711	72	73	73A	74	74A	0001 1xxx	000q quuu <sup>(3)</sup>	uuuq quuu <sup>(3)</sup>
FSR	710	71	711	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
PORTA	710	71	711	72	73	73A	74	74A	---x 0000	---u 0000	---u uuuu
	710	71	711	72	73	73A	74	74A	--0x 0000	--0u 0000	--uu uuuu
PORTB	710	71	711	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
PORTC	710	71	711	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
PORTD	710	71	711	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
PORTE	710	71	711	72	73	73A	74	74A	---- -xxx	---- -uuu	---- -uuu
PCLATH	710	71	711	72	73	73A	74	74A	---0 0000	---0 0000	---u uuuu
INTCON	710	71	711	72	73	73A	74	74A	0000 000x	0000 000u	uuuu uuuu <sup>(1)</sup>
PIR1	710	71	711	72	73	73A	74	74A	-0-- 0000	-0-- 0000	-u-- uuuu <sup>(1)</sup>
	710	71	711	72	73	73A	74	74A	-000 0000	-000 0000	-uuu uuuu <sup>(1)</sup>
	710	71	711	72	73	73A	74	74A	0000 0000	0000 0000	uuuu uuuu <sup>(1)</sup>
PIR2	710	71	711	72	73	73A	74	74A	---- ---0	---- ---0	---- ---u <sup>(1)</sup>
TMR1L	710	71	711	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
TMR1H	710	71	711	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
T1CON	710	71	711	72	73	73A	74	74A	--00 0000	--uu uuuu	--uu uuuu

Legend: u = unchanged, x = unknown, - = unimplemented bit, read as '0', q = value depends on condition

Note 1: One or more bits in INTCON, PIR1 and/or PIR2 will be affected (to cause wake-up).

2: When the wake-up is due to an interrupt and the GIE bit is set, the PC is loaded with the interrupt vector (0004h).

3: See Table 14-9 for reset value for specific condition.

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**TABLE 14-10: INITIALIZATION CONDITIONS FOR ALL REGISTERS (Cont'd)**

Register	Applicable Devices								Power-on Reset, Brown-out Reset	MCLR Resets WDT Reset	Wake-up via WDT or Interrupt
TMR2	710	71	711	72	73	73A	74	74A	0000 0000	0000 0000	uuuu uuuu
T2CON	710	71	711	72	73	73A	74	74A	-000 0000	-000 0000	-uuu uuuu
SSPBUF	710	71	711	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
SSPCON	710	71	711	72	73	73A	74	74A	0000 0000	0000 0000	uuuu uuuu
CCPR1L	710	71	711	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
CCPR1H	710	71	711	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
CCP1CON	710	71	711	72	73	73A	74	74A	--00 0000	--00 0000	--uu uuuu
RCSTA	710	71	711	72	73	73A	74	74A	0000 -00x	0000 -00x	uuuu -uuu
TXREG	710	71	711	72	73	73A	74	74A	0000 0000	0000 0000	uuuu uuuu
RCREG	710	71	711	72	73	73A	74	74A	0000 0000	0000 0000	uuuu uuuu
CCPR2L	710	71	711	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
CCPR2H	710	71	711	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
CCP2CON	710	71	711	72	73	73A	74	74A	0000 0000	0000 0000	uuuu uuuu
ADRES	710	71	711	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
ADCON0	710	71	711	72	73	73A	74	74A	00-0 0000	00-0 0000	uu-u uuuu
	710	71	711	72	73	73A	74	74A	0000 00-0	0000 00-0	uuuu uu-u
OPTION	710	71	711	72	73	73A	74	74A	1111 1111	1111 1111	uuuu uuuu
TRISA	710	71	711	72	73	73A	74	74A	---1 1111	---1 1111	---u uuuu
	710	71	711	72	73	73A	74	74A	--11 1111	--11 1111	--uu uuuu
TRISB	710	71	711	72	73	73A	74	74A	1111 1111	1111 1111	uuuu uuuu
TRISC	710	71	711	72	73	73A	74	74A	1111 1111	1111 1111	uuuu uuuu
TRISD	710	71	711	72	73	73A	74	74A	1111 1111	1111 1111	uuuu uuuu
TRISE	710	71	711	72	73	73A	74	74A	0000 -111	0000 -111	uuuu -uuu
PIE1	710	71	711	72	73	73A	74	74A	-0-- 0000	-0-- 0000	-u-- uuuu
	710	71	711	72	73	73A	74	74A	-000 0000	-000 0000	-uuu uuuu
	710	71	711	72	73	73A	74	74A	0000 0000	0000 0000	uuuu uuuu
PIE2	710	71	711	72	73	73A	74	74A	---- ---0	---- ---0	---- ---u
PCON	710	71	711	72	73	73A	74	74A	---- --0-	---- --u-	---- --u-
	710	71	711	72	73	73A	74	74A	---- --0u	---- --uu	---- --uu
PR2	710	71	711	72	73	73A	74	74A	1111 1111	1111 1111	1111 1111
SSPADD	710	71	711	72	73	73A	74	74A	0000 0000	0000 0000	uuuu uuuu
SSPSTAT	710	71	711	72	73	73A	74	74A	--00 0000	--00 0000	--uu uuuu
TXSTA	710	71	711	72	73	73A	74	74A	0000 -010	0000 -010	uuuu -uuu
SPBRG	710	71	711	72	73	73A	74	74A	0000 0000	0000 0000	uuuu uuuu
ADCON1	710	71	711	72	73	73A	74	74A	---- --00	---- --00	---- --uu
	710	71	711	72	73	73A	74	74A	---- -000	---- -000	---- -uuu

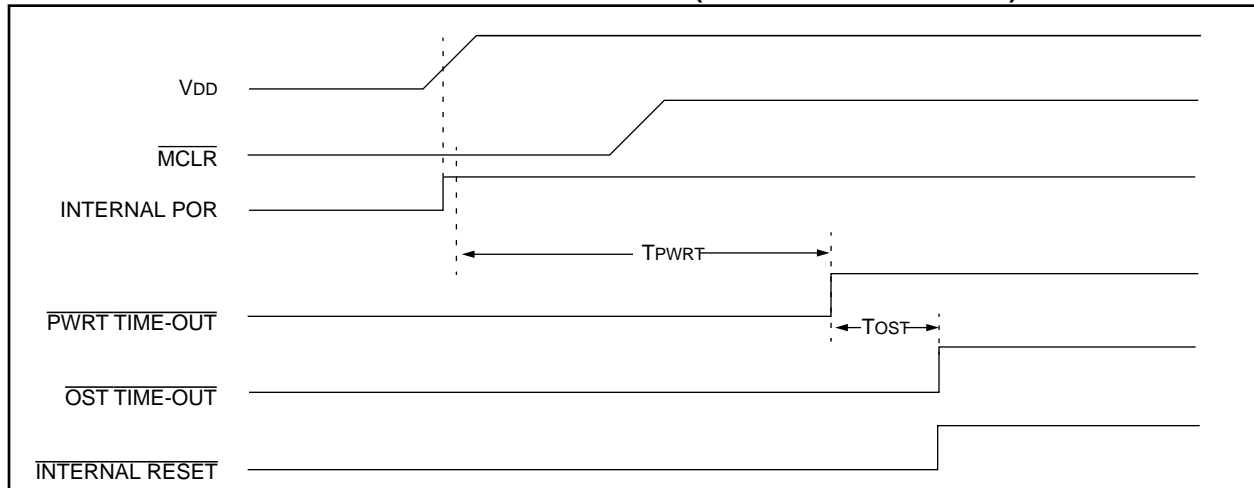
Legend: u = unchanged, x = unknown, - = unimplemented bit, read as '0', q = value depends on condition

Note 1: One or more bits in INTCON, PIR1 and/or PIR2 will be affected (to cause wake-up).

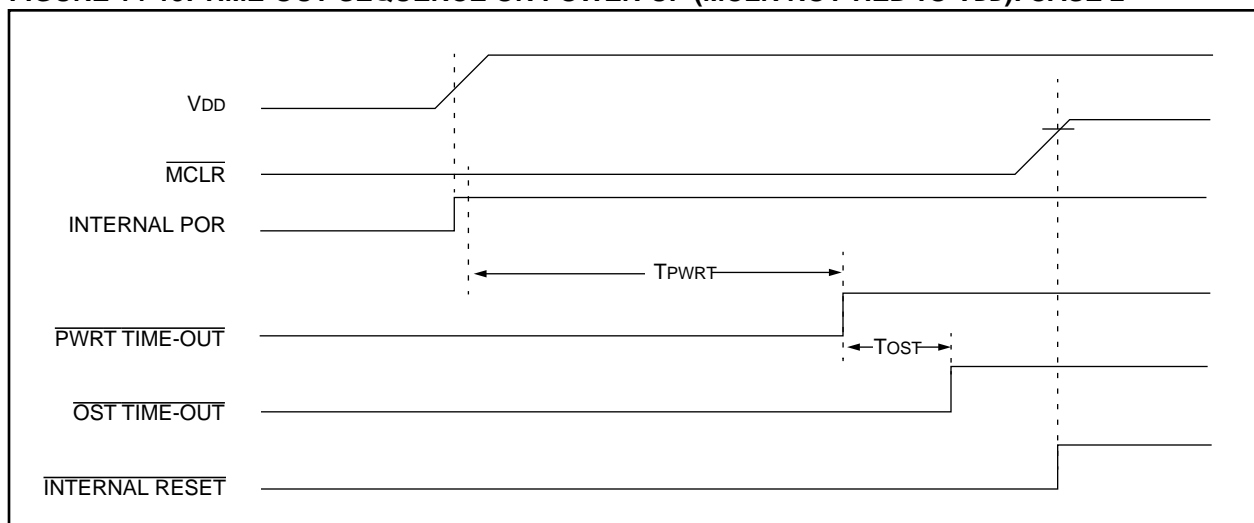
2: When the wake-up is due to an interrupt and the GIE bit is set, the PC is loaded with the interrupt vector (0004h).

3: See Table 14-9 for reset value for specific condition.

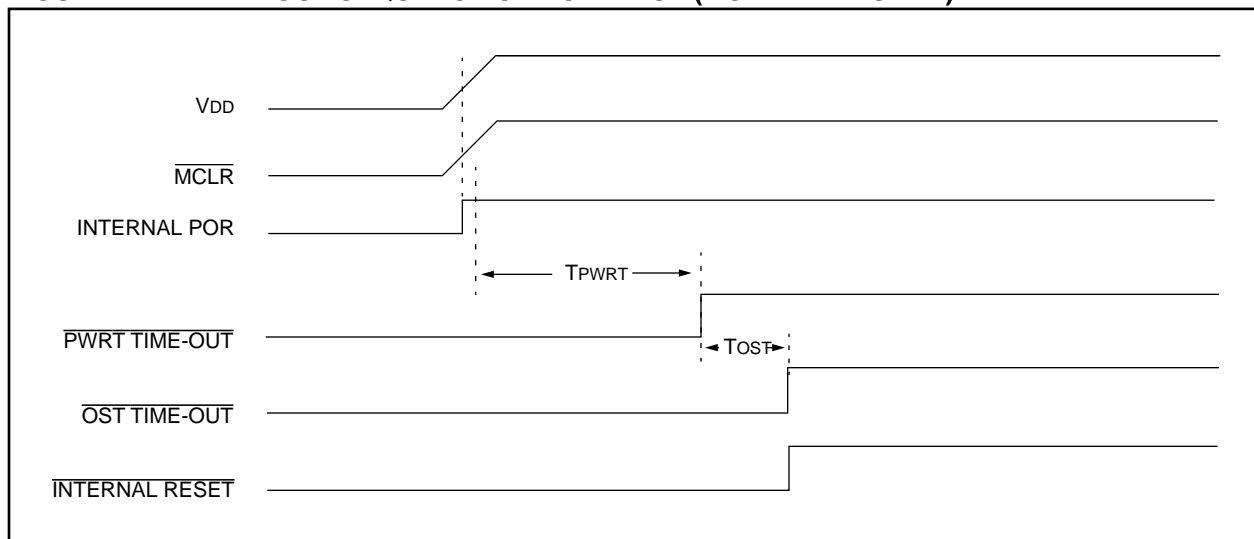
**FIGURE 14-12: TIME-OUT SEQUENCE ON POWER-UP ( $\overline{\text{MCLR}}$  NOT TIED TO  $V_{\text{DD}}$ ): CASE 1**



**FIGURE 14-13: TIME-OUT SEQUENCE ON POWER-UP ( $\overline{\text{MCLR}}$  NOT TIED TO  $V_{\text{DD}}$ ): CASE 2**

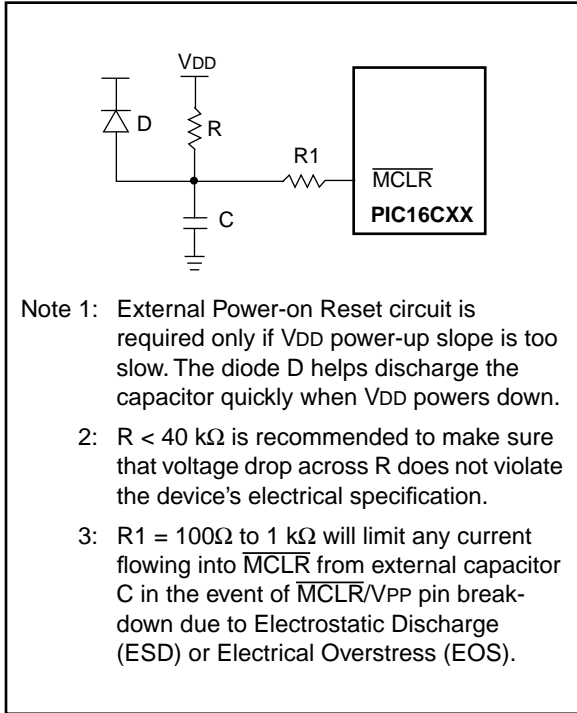


**FIGURE 14-14: TIME-OUT SEQUENCE ON POWER-UP ( $\overline{\text{MCLR}}$  TIED TO  $V_{\text{DD}}$ )**

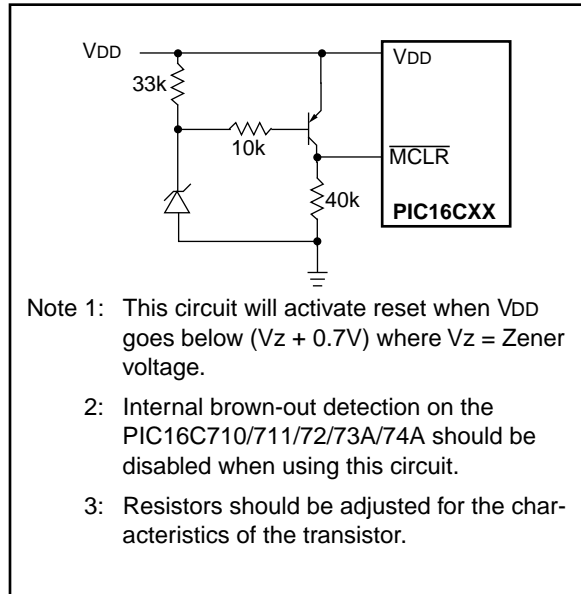


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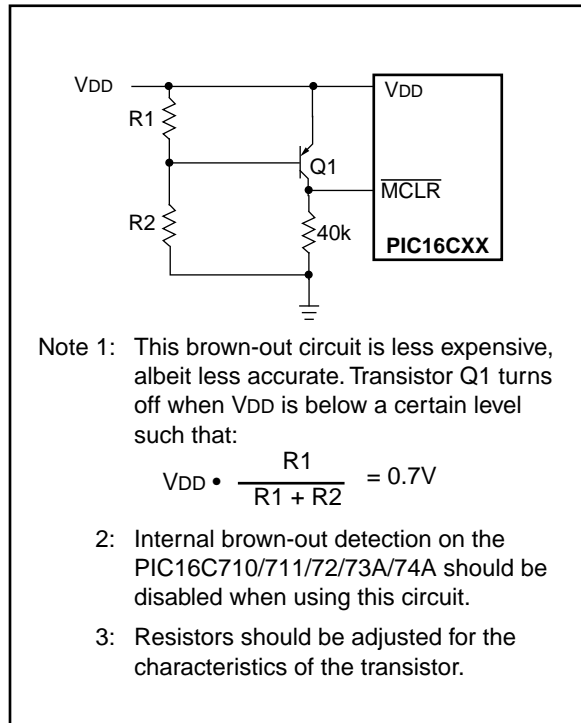
**FIGURE 14-15: EXTERNAL POWER-ON RESET CIRCUIT (FOR SLOW VDD POWER-UP)**



**FIGURE 14-16: EXTERNAL BROWN-OUT PROTECTION CIRCUIT 1**



**FIGURE 14-17: EXTERNAL BROWN-OUT PROTECTION CIRCUIT 2**



## 14.5 Interrupts

Applicable Devices								
710	71	711	72	73	73A	74	74A	

The PIC16C7X family has up to 12 sources of interrupt:

Interrupt Sources	Applicable Devices								
External interrupt RB0/INT	710	71	711	72	73	73A	74	74A	
TMR0 overflow interrupt	710	71	711	72	73	73A	74	74A	
PORTB change interrupts (pins RB7:RB4)	710	71	711	72	73	73A	74	74A	
A/D Interrupt	710	71	711	72	73	73A	74	74A	
TMR1 overflow interrupt	710	71	711	72	73	73A	74	74A	
TMR2 matches period interrupt	710	71	711	72	73	73A	74	74A	
CCP1 interrupt	710	71	711	72	73	73A	74	74A	
CCP2 interrupt	710	71	711	72	73	73A	74	74A	
USART Receive	710	71	711	72	73	73A	74	74A	
USART Transmit	710	71	711	72	73	73A	74	74A	
Synchronous serial port interrupt	710	71	711	72	73	73A	74	74A	
Parallel slave port read/write interrupt	710	71	711	72	73	73A	74	74A	

The interrupt control register (INTCON) records individual interrupt requests in flag bits. It also has individual and global interrupt enable bits.

**Note:** Individual interrupt flag bits are set regardless of the status of their corresponding mask bit or the GIE bit.

A global interrupt enable bit, GIE (INTCON<7>) enables (if set) all un-masked interrupts or disables (if cleared) all interrupts. When bit GIE is enabled, and an interrupt's flag bit and mask bit are set, the interrupt will vector immediately. Individual interrupts can be disabled through their corresponding enable bits in various registers. Individual interrupt bits are set regardless of the status of the GIE bit. The GIE bit is cleared on reset.

The "return from interrupt" instruction, `RETFIE`, exits the interrupt routine as well as sets the GIE bit, which re-enables interrupts.

The RB0/INT pin interrupt, the RB port change interrupt and the TMR0 overflow interrupt flags are contained in the INTCON register.

The peripheral interrupt flags are contained in the special function registers PIR1 and PIR2. The corresponding interrupt enable bits are contained in special function registers PIE1 and PIE2, and the peripheral interrupt enable bit is contained in special function register INTCON.

When an interrupt is responded to, the GIE bit is cleared to disable any further interrupt, the return address is pushed onto the stack and the PC is loaded with 0004h. Once in the interrupt service routine the source(s) of the interrupt can be determined by polling the interrupt flag bits. The interrupt flag bit(s) must be cleared in software before re-enabling interrupts to avoid recursive interrupts.

For external interrupt events, such as the INT pin or PORTB change interrupt, the interrupt latency will be three or four instruction cycles. The exact latency depends when the interrupt event occurs (Figure 14-22). The latency is the same for one or two cycle instructions. Individual interrupt flag bits are set regardless of the status of their corresponding mask bit or the GIE bit.

**Note:** For the PIC16C71/73/74

If an interrupt occurs while the Global Interrupt Enable (GIE) bit is being cleared, the GIE bit may unintentionally be re-enabled by the user's Interrupt Service Routine (the `RETFIE` instruction). The events that would cause this to occur are:

1. An instruction clears the GIE bit while an interrupt is acknowledged.
2. The program branches to the Interrupt vector and executes the Interrupt Service Routine.
3. The Interrupt Service Routine completes with the execution of the `RETFIE` instruction. This causes the GIE bit to be set (enables interrupts), and the program returns to the instruction after the one which was meant to disable interrupts.

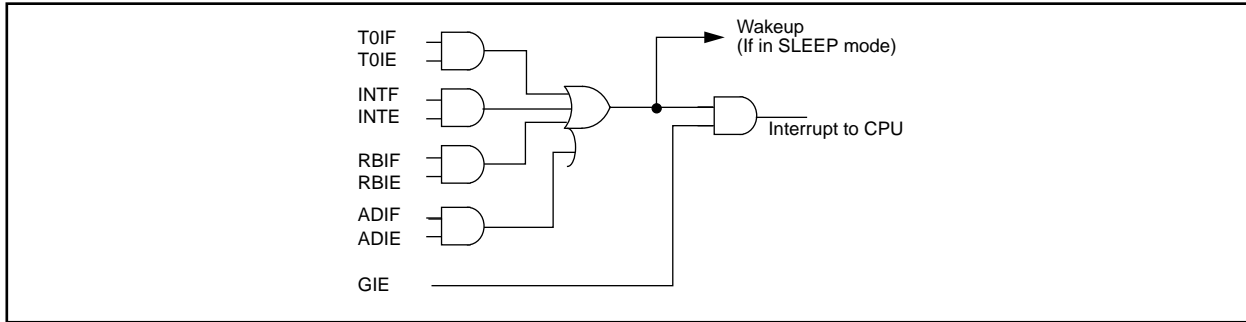
Perform the following to ensure that interrupts are globally disabled:

```

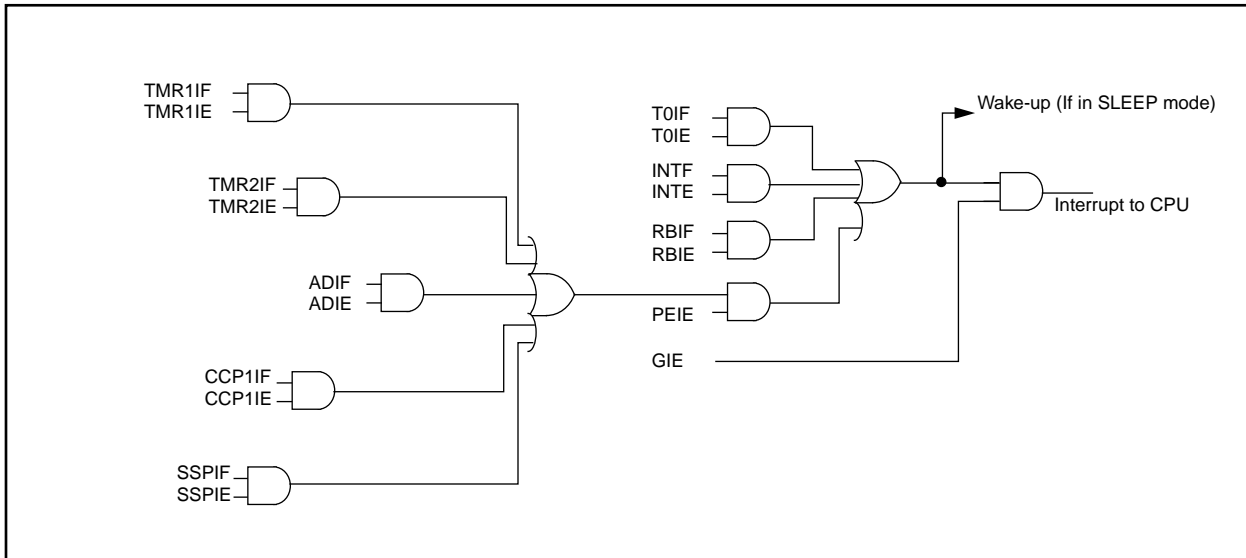
LOOP BCF    INTCON, GIE    ; Disable global
                          ; interrupt bit
      BTFSC INTCON, GIE    ; Global interrupt
                          ; disabled?
      GOTO  LOOP          ; NO, try again
      :                  ; Yes, continue
                          ; with program
                          ; flow
    
```

# PIC16C7X

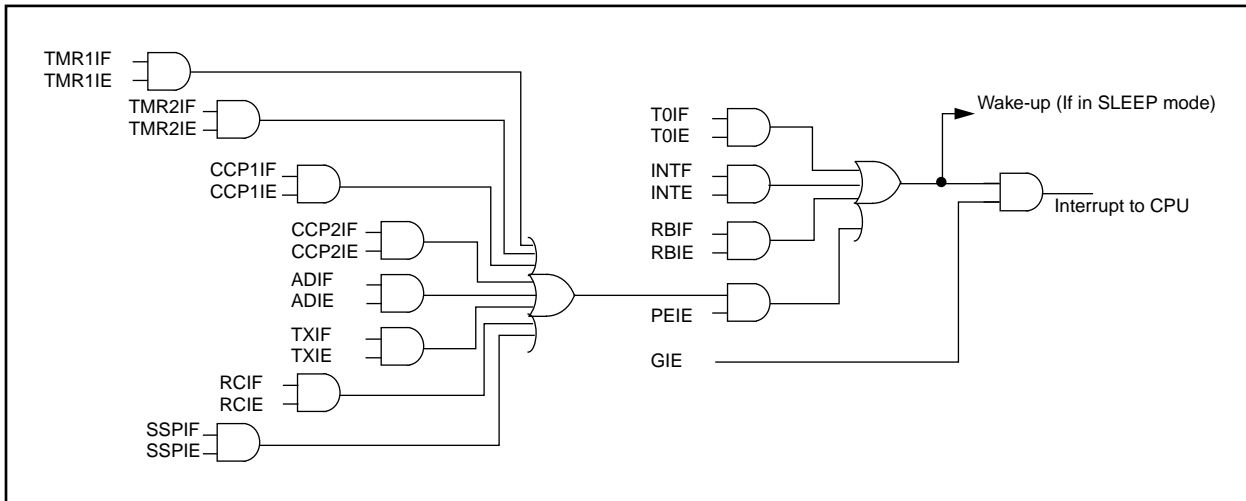
**FIGURE 14-18: INTERRUPT LOGIC FOR PIC16C710/711/711**



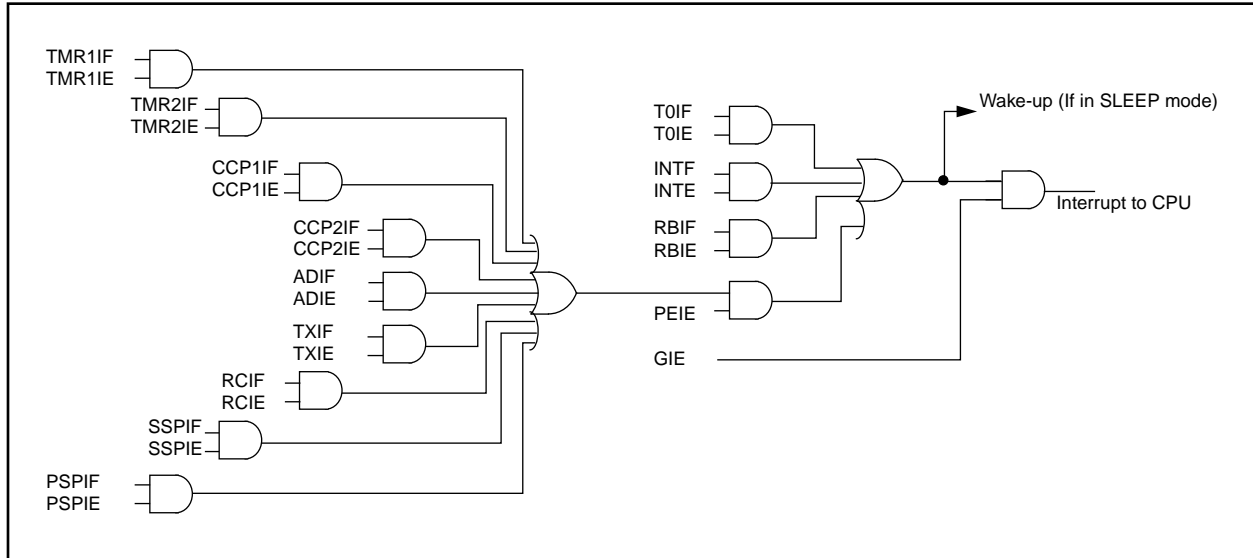
**FIGURE 14-19: INTERRUPT LOGIC FOR PIC16C72**



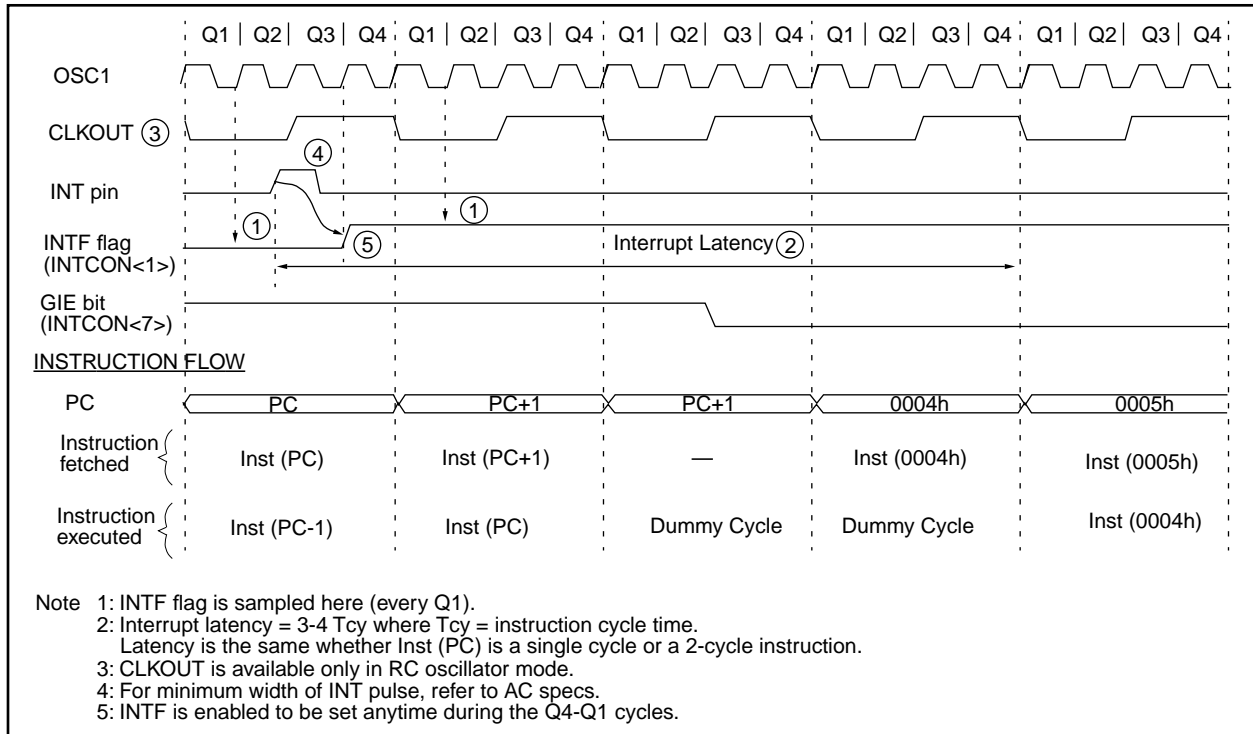
**FIGURE 14-20: INTERRUPT LOGIC FOR PIC16C73/73A**



**FIGURE 14-21: INTERRUPT LOGIC FOR PIC16C74/74A**



**FIGURE 14-22: INT PIN INTERRUPT TIMING**



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## 14.5.1 INT INTERRUPT

External interrupt on RB0/INT pin is edge triggered: either rising if bit INTEDG (OPTION<6>) is set, or falling, if the INTEDG bit is clear. When a valid edge appears on the RB0/INT pin, flag bit INTF (INTCON<1>) is set. This interrupt can be disabled by clearing enable bit INTE (INTCON<4>). Flag bit INTF must be cleared in software in the interrupt service routine before re-enabling this interrupt. The INT interrupt can wake-up the processor from SLEEP, if bit INTE was set prior to going into SLEEP. The status of global interrupt enable bit GIE decides whether or not the processor branches to the interrupt vector following wake-up. See Section 14.8 for details on SLEEP mode.

## 14.5.2 TMR0 INTERRUPT

An overflow (FFh → 00h) in the TMR0 register will set flag bit TOIF (INTCON<2>). The interrupt can be enabled/disabled by setting/clearing enable bit TOIE (INTCON<5>). (Section 7.0)

## 14.5.3 PORTB INTCON CHANGE

An input change on PORTB<7:4> sets flag bit RBIF (INTCON<0>). The interrupt can be enabled/disabled by setting/clearing enable bit RBIE (INTCON<4>). (Section 5.2)

**Note:** For the PIC16C71/73/74 if a change on the I/O pin should occur when the read operation is being executed (start of the Q2 cycle), then the RBIF interrupt flag may not get set.

## 14.6 Context Saving During Interrupts

### Applicable Devices

710	71	711	72	73	73A	74	74A
-----	----	-----	----	----	-----	----	-----

During an interrupt, only the return PC value is saved on the stack. Typically, users may wish to save key registers during an interrupt i.e., W register and STATUS register. This will have to be implemented in software.

Example 14-1 and Example 14-2 store and restore the STATUS and W registers. For PIC16C72/73/73A/74/74A, the register, W\_TEMP, must be defined in both banks and must be defined at the same offset from the bank base address (i.e., if W\_TEMP is defined at 0x20 in bank 0, it must also be defined at 0xA0 in bank 1). For PIC16C710/71/711, the user register, STATUS\_TEMP, must be defined in bank 0.

The example:

- Stores the W register.
- Stores the STATUS register in bank 0.
- Executes the ISR code.
- Restores the STATUS register (and bank select bit).
- Restores the W register.

### EXAMPLE 14-1: SAVING STATUS AND W REGISTERS IN RAM (PIC16C710/71/711)

```
MOVWF    W_TEMP          ;Copy W to TEMP register, could be bank one or zero
SWAPF    STATUS,W        ;Swap status to be saved into W
MOVWF    STATUS_TEMP     ;Save status to bank zero STATUS_TEMP register
:
:(ISR)
:
SWAPF    STATUS_TEMP,W   ;Swap STATUS_TEMP register into W
                        ;(sets bank to original state)
MOVWF    STATUS          ;Move W into STATUS register
SWAPF    W_TEMP,F        ;Swap W_TEMP
SWAPF    W_TEMP,W        ;Swap W_TEMP into W
```

### EXAMPLE 14-2: SAVING STATUS AND W REGISTERS IN RAM (PIC16C72/73/73A/74/74A)

```
MOVWF    W_TEMP          ;Copy W to TEMP register, could be bank one or zero
SWAPF    STATUS,W        ;Swap status to be saved into W
BCF      STATUS,RP0     ;Change to bank zero, regardless of current bank
MOVWF    STATUS_TEMP     ;Save status to bank zero STATUS_TEMP register
:
:(ISR)
:
SWAPF    STATUS_TEMP,W   ;Swap STATUS_TEMP register into W
                        ;(sets bank to original state)
MOVWF    STATUS          ;Move W into STATUS register
SWAPF    W_TEMP,F        ;Swap W_TEMP
SWAPF    W_TEMP,W        ;Swap W_TEMP into W
```



## 14.7 Watchdog Timer (WDT)

Applicable Devices							
710	71	711	72	73	73A	74	74A

The Watchdog Timer is as a free running on-chip RC oscillator which does not require any external components. This RC oscillator is separate from the RC oscillator of the OSC1/CLKIN pin. That means that the WDT will run, even if the clock on the OSC1/CLKIN and OSC2/CLKOUT pins of the device has been stopped, for example, by execution of a SLEEP instruction. During normal operation, a WDT time-out generates a device RESET (Watchdog Timer Reset). If the device is in SLEEP mode, a WDT time-out causes the device to wake-up and continue with normal operation (Watchdog Timer Wake-up). The WDT can be permanently disabled by clearing configuration bit WDTE (Section 14.1).

### 14.7.1 WDT PERIOD

The WDT has a nominal time-out period of 18 ms, (with no prescaler). The time-out periods vary with temperature, VDD and process variations from part to part (see DC specs). If longer time-out periods are desired, a

prescaler with a division ratio of up to 1:128 can be assigned to the WDT under software control by writing to the OPTION register. Thus, time-out periods up to 2.3 seconds can be realized.

The CLRWDT and SLEEP instructions clear the WDT and the postscaler, if assigned to the WDT, and prevent it from timing out and generating a device RESET condition.

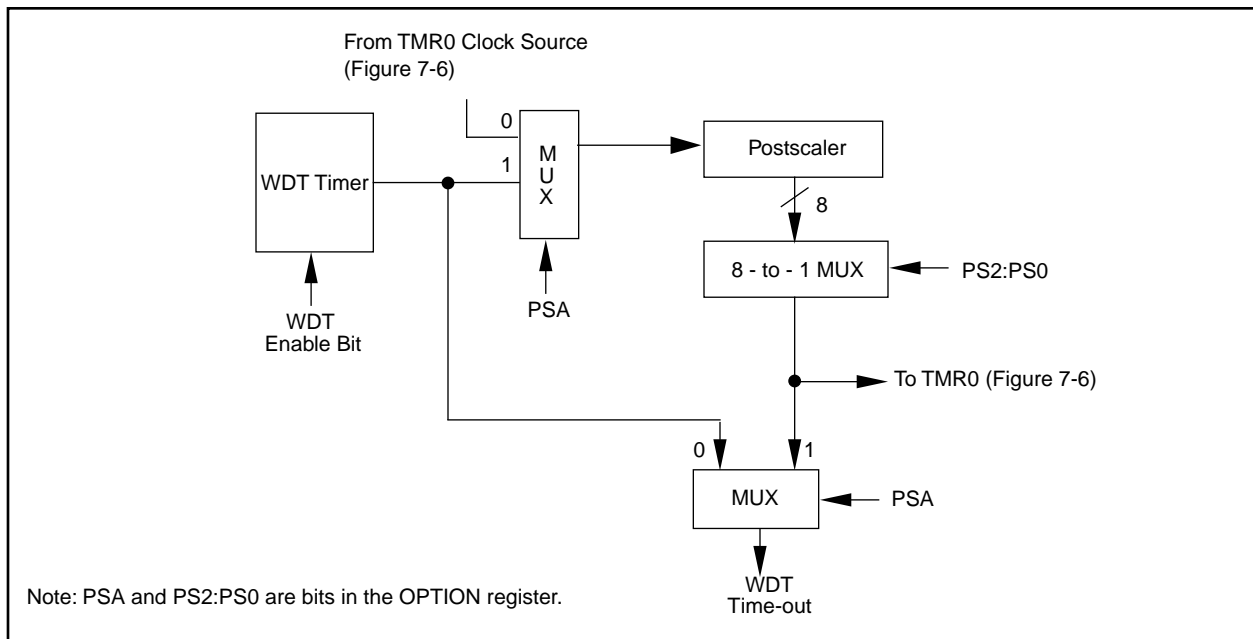
The  $\overline{TO}$  bit in the STATUS register will be cleared upon a Watchdog Timer time-out.

### 14.7.2 WDT PROGRAMMING CONSIDERATIONS

It should also be taken into account that under worst case conditions (VDD = Min., Temperature = Max., and max. WDT prescaler) it may take several seconds before a WDT time-out occurs.

**Note:** When the prescaler is assigned to the WDT, always execute a CLRWDT instruction before changing the prescale value, otherwise a WDT reset may occur.

**FIGURE 14-23: WATCHDOG TIMER BLOCK DIAGRAM**



**FIGURE 14-24: SUMMARY OF WATCHDOG TIMER REGISTERS**

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
2007h	Config. bits	(1)	BODEN <sup>(1)</sup>	CP1	CP0	PWRTE <sup>(1)</sup>	WDTE	FOSC1	FOSC0
81h	OPTION	$\overline{RBPU}$	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0

Legend: Shaded cells are not used by the Watchdog Timer.

Note 1: See Figure 14-1, Figure 14-2, Figure 14-3, and Figure 14-4 for operation of these bits.

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## 14.8 Power-down Mode (SLEEP)

Applicable Devices							
710	71	711	72	73	73A	74	74A

Power-down mode is entered by executing a SLEEP instruction.

If enabled, the Watchdog Timer will be cleared but keeps running, the  $\overline{PD}$  bit (STATUS<3>) is cleared, the  $\overline{TO}$  (STATUS<4>) bit is set, and the oscillator driver is turned off. The I/O ports maintain the status they had, before the SLEEP instruction was executed (driving high, low, or hi-impedance).

For lowest current consumption in this mode, place all I/O pins at either VDD, or VSS, ensure no external circuitry is drawing current from the I/O pin, power-down the A/D, disable external clocks. Pull all I/O pins, that are hi-impedance inputs, high or low externally to avoid switching currents caused by floating inputs. The T0CKI input should also be at VDD or VSS for lowest current consumption. The contribution from on-chip pull-ups on PORTB should be considered.

The  $\overline{MCLR}$  pin must be at a logic high level (VIHMC).

### 14.8.1 WAKE-UP FROM SLEEP

The device can wake up from SLEEP through one of the following events:

1. External reset input on  $\overline{MCLR}$  pin.
2. Watchdog Timer Wake-up (if WDT was enabled).
3. Interrupt from INT pin, RB port change, or some Peripheral Interrupts.

External  $\overline{MCLR}$  Reset will cause a device reset. All other events are considered a continuation of program execution and cause a "wake-up". The  $\overline{TO}$  and  $\overline{PD}$  bits in the STATUS register can be used to determine the cause of device reset. The  $\overline{PD}$  bit, which is set on power-up, is cleared when SLEEP is invoked. The  $\overline{TO}$  bit is cleared if a WDT time-out occurred (and caused wake-up).

The following peripheral interrupts can wake the device from SLEEP:

1. TMR1 interrupt. Timer1 must be operating as an asynchronous counter.
2. SSP (Start/Stop) bit detect interrupt.
3. SSP transmit or receive in slave mode (SPI/I<sup>2</sup>C).
4. CCP capture mode interrupt.
5. Parallel Slave Port read or write.
6. A/D conversion (when A/D clock source is RC).
7. Special event trigger (Timer1 in asynchronous mode using an external clock).
8. USART TX or RX (synchronous slave mode).

Other peripherals can not generate interrupts since during SLEEP, no on-chip Q clocks are present.

When the SLEEP instruction is being executed, the next instruction (PC + 1) is pre-fetched. For the device to wake-up through an interrupt event, the corresponding interrupt enable bit must be set (enabled). Wake-up is regardless of the state of the GIE bit. If the GIE bit is clear (disabled), the device continues execution at the instruction after the SLEEP instruction. If the GIE bit is set (enabled), the device executes the instruction after the SLEEP instruction and then branches to the interrupt address (0004h). In cases where the execution of the instruction following SLEEP is not desirable, the user should have a NOP after the SLEEP instruction.

### 14.8.2 WAKE-UP USING INTERRUPTS

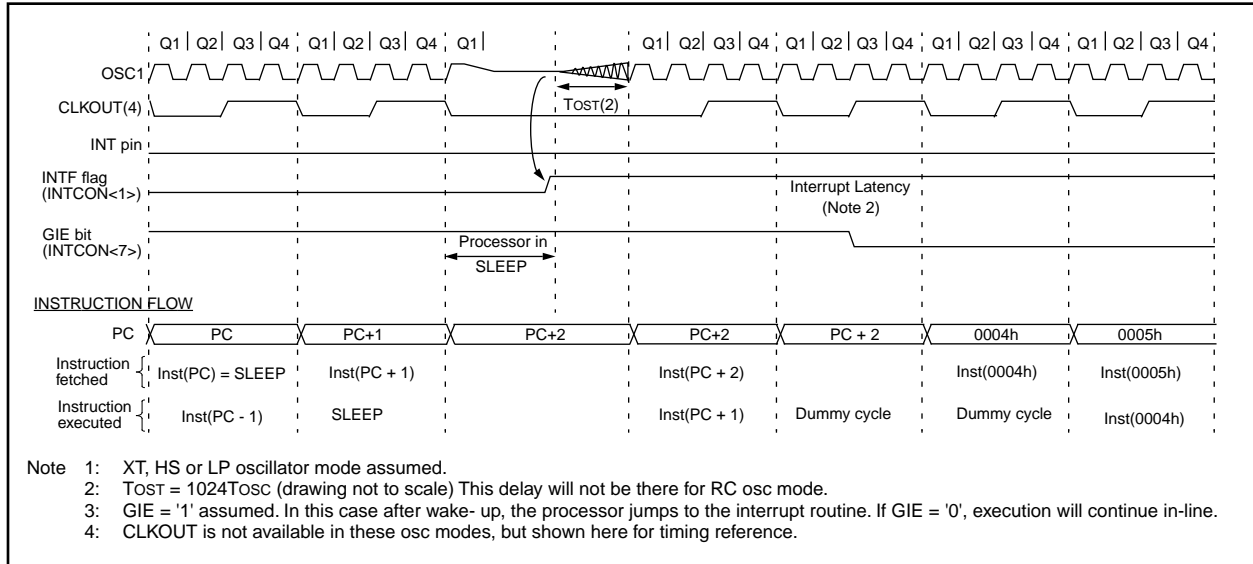
When global interrupts are disabled (GIE cleared) and any interrupt source has both its interrupt enable bit and interrupt flag bit set, one of the following will occur:

- If the interrupt occurs **before** the the execution of a SLEEP instruction, the SLEEP instruction will complete as a NOP. Therefore, the WDT and WDT postscaler will not be cleared, the  $\overline{TO}$  bit will not be set and  $\overline{PD}$  bits will not be cleared.
- If the interrupt occurs **during or after** the execution of a SLEEP instruction, the device will immediately wake up from sleep. The SLEEP instruction will be completely executed before the wake-up. Therefore, the WDT and WDT postscaler will be cleared, the  $\overline{TO}$  bit will be set and the  $\overline{PD}$  bit will be cleared.

Even if the flag bits were checked before executing a SLEEP instruction, it may be possible for flag bits to become set before the SLEEP instruction completes. To determine whether a SLEEP instruction executed, test the  $\overline{PD}$  bit. If the  $\overline{PD}$  bit is set, the SLEEP instruction was executed as a NOP.

To ensure that the WDT is cleared, a CLRWDT instruction should be executed before a SLEEP instruction.

**FIGURE 14-25: WAKE-UP FROM SLEEP THROUGH INTERRUPT**



## 14.9 Program Verification/Code Protection

Applicable Devices							
710	71	711	72	73	73A	74	74A

If the code protection bit(s) have not been programmed, the on-chip program memory can be read out for verification purposes.

**Note:** Microchip does not recommend code protecting windowed devices.

## 14.10 ID Locations

Applicable Devices							
710	71	711	72	73	73A	74	74A

Four memory locations (2000h - 2003h) are designated as ID locations where the user can store checksum or other code-identification numbers. These locations are not accessible during normal execution but are readable and writable during program/verify. It is recommended that only the 4 least significant bits of the ID location are used.

## 14.11 In-Circuit Serial Programming

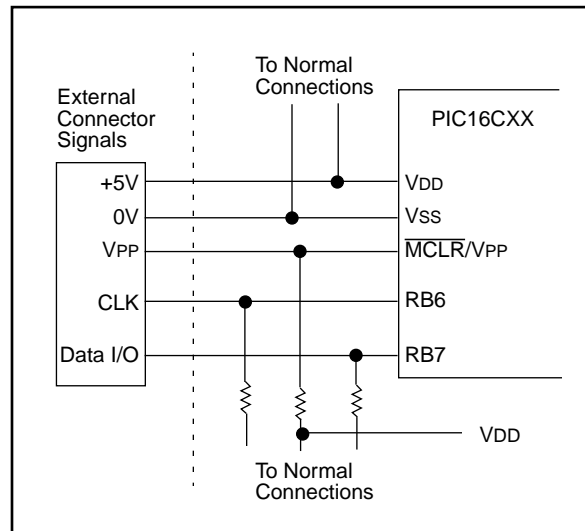
Applicable Devices							
710	71	711	72	73	73A	74	74A

PIC16CXX microcontrollers can be serially programmed while in the end application circuit. This is simply done with two lines for clock and data, and three other lines for power, ground, and the programming voltage. This allows customers to manufacture boards with unprogrammed devices, and then program the microcontroller just before shipping the product. This also allows the most recent firmware or a custom firmware to be programmed.

The device is placed into a program/verify mode by holding the RB6 and RB7 pins low while raising the MCLR (VPP) pin from  $V_{IL}$  to  $V_{IH}$  (see programming specification). RB6 becomes the programming clock and RB7 becomes the programming data. Both RB6 and RB7 are Schmitt Trigger inputs in this mode.

After reset, to place the device into programming/verify mode, the program counter (PC) is at location 00h. A 6-bit command is then supplied to the device. Depending on the command, 14-bits of program data are then supplied to or from the device, depending if the command was a load or a read. For complete details of serial programming, please refer to the PIC16C6X/7X Programming Specifications (Literature #DS30228).

**FIGURE 14-26: TYPICAL IN-CIRCUIT SERIAL PROGRAMMING CONNECTION**



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NOTES:

## 15.0 INSTRUCTION SET SUMMARY

Applicable Devices							
710	71	711	72	73	73A	74	74A

Each PIC16CXX instruction is a 14-bit word divided into an OPCODE which specifies the instruction type and one or more operands which further specify the operation of the instruction. The PIC16CXX instruction set summary in Table 15-2 lists **byte-oriented**, **bit-oriented**, and **literal and control** operations. Table 15-1 shows the opcode field descriptions.

For **byte-oriented** instructions, 'f' represents a file register designator and 'd' represents a destination designator. The file register designator specifies which file register is to be used by the instruction.

The destination designator specifies where the result of the operation is to be placed. If 'd' is zero, the result is placed in the W register. If 'd' is one, the result is placed in the file register specified in the instruction.

For **bit-oriented** instructions, 'b' represents a bit field designator which selects the number of the bit affected by the operation, while 'f' represents the number of the file in which the bit is located.

For **literal and control** operations, 'k' represents an eight or eleven bit constant or literal value.

**TABLE 15-1: OPCODE FIELD DESCRIPTIONS**

Field	Description
f	Register file address (0x00 to 0x7F)
w	Working register (accumulator)
b	Bit address within an 8-bit file register
k	Literal field, constant data or label
x	Don't care location (= 0 or 1) The assembler will generate code with x = 0. It is the recommended form of use for compatibility with all Microchip software tools.
d	Destination select; d = 0: store result in W, d = 1: store result in file register f. Default is d = 1
label	Label name
TOS	Top of Stack
PC	Program Counter
PCLATH	Program Counter High Latch
GIE	Global Interrupt Enable bit
WDT	Watchdog Timer/Counter
$\overline{TO}$	Time-out bit
$\overline{PD}$	Power-down bit
dest	Destination either the W register or the specified register file location
[ ]	Options
( )	Contents
→	Assigned to
< >	Register bit field
∈	In the set of
<i>italics</i>	User defined term (font is courier)

# PIC16C7X

The instruction set is highly orthogonal and is grouped into three basic categories:

- **Byte-oriented** operations
- **Bit-oriented** operations
- **Literal and control** operations

All instructions are executed within one single instruction cycle, unless a conditional test is true or the program counter is changed as a result of an instruction. In this case, the execution takes two instruction cycles with the second cycle executed as a NOP. One instruction cycle consists of four oscillator periods. Thus, for an oscillator frequency of 4 MHz, the normal instruction execution time is 1  $\mu$ s. If a conditional test is true or the program counter is changed as a result of an instruction, the instruction execution time is 2  $\mu$ s.

Table 15-2 lists the instructions recognized by the MPASM assembler.

Figure 15-1 shows the three general formats that the instructions can have.

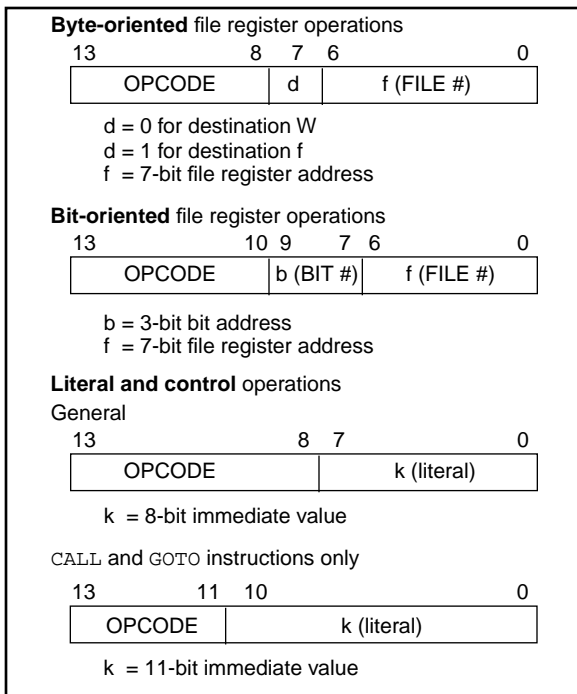
**Note:** To maintain upward compatibility with future PIC16CXX products, do not use the `OPTION` and `TRIS` instructions.

All examples use the following format to represent a hexadecimal number:

0xhh

where h signifies a hexadecimal digit.

**FIGURE 15-1: GENERAL FORMAT FOR INSTRUCTIONS**



## 15.1 Special Function Registers as Source/Destination

The PIC16C7X's orthogonal instruction set allows read and write of all file registers, including special function registers. There are some special situations the user should be aware of:

### 15.1.1 STATUS AS DESTINATION

If an instruction writes to STATUS, the Z, C and DC bits may be set or cleared as a result of the instruction and overwrite the original data bits written. For example, executing `CLRF STATUS` will clear register STATUS, and then set the Z bit leaving 0000 0100b in the register.

### 15.1.2 PCL AS SOURCE OR DESTINATION

Read, write or read-modify-write on PCL may have the following results:

Read PC: PCL → dest  
 Write PCL: PCLATH → PCH;  
 8-bit destination value → PCL  
 Read-Modify-Write: PCL → ALU operand  
 PCLATH → PCH;  
 8-bit result → PCL

Where PCH = program counter high byte (not an addressable register), PCLATH = Program counter high holding latch, dest = destination, WREG or f.

### 15.1.3 BIT MANIPULATION

All bit manipulation instructions are done by first reading the entire register, operating on the selected bit and writing the result back (read-modify-write). The user should keep this in mind when operating on special function registers, such as ports.

**TABLE 15-2: PIC16CXX INSTRUCTION SET**

Mnemonic, Operands	Description	Cycles	14-Bit Opcode			Status Affected	Notes		
			MSb	LSb					
<b>BYTE-ORIENTED FILE REGISTER OPERATIONS</b>									
<b>ADDWF</b>	<b>f, d</b>	Add W and f	1	00	0111	dfff	ffff	C,DC,Z	1,2
<b>ANDWF</b>	<b>f, d</b>	AND W with f	1	00	0101	dfff	ffff	Z	1,2
<b>CLRF</b>	<b>f</b>	Clear f	1	00	0001	1fff	ffff	Z	2
<b>CLRWF</b>	<b>-</b>	Clear W	1	00	0001	0xxx	xxxx	Z	
<b>COMF</b>	<b>f, d</b>	Complement f	1	00	1001	dfff	ffff	Z	1,2
<b>DECF</b>	<b>f, d</b>	Decrement f	1	00	0011	dfff	ffff	Z	1,2
<b>DECFSZ</b>	<b>f, d</b>	Decrement f, Skip if 0	1(2)	00	1011	dfff	ffff		1,2,3
<b>INCF</b>	<b>f, d</b>	Increment f	1	00	1010	dfff	ffff	Z	1,2
<b>INCFSZ</b>	<b>f, d</b>	Increment f, Skip if 0	1(2)	00	1111	dfff	ffff		1,2,3
<b>IORWF</b>	<b>f, d</b>	Inclusive OR W with f	1	00	0100	dfff	ffff	Z	1,2
<b>MOVF</b>	<b>f, d</b>	Move f	1	00	1000	dfff	ffff	Z	1,2
<b>MOVWF</b>	<b>f</b>	Move W to f	1	00	0000	1fff	ffff		
<b>NOP</b>	<b>-</b>	No Operation	1	00	0000	0xx0	0000		
<b>RLF</b>	<b>f, d</b>	Rotate Left f through Carry	1	00	1101	dfff	ffff	C	1,2
<b>RRF</b>	<b>f, d</b>	Rotate Right f through Carry	1	00	1100	dfff	ffff	C	1,2
<b>SUBWF</b>	<b>f, d</b>	Subtract W from f	1	00	0010	dfff	ffff	C,DC,Z	1,2
<b>SWAPF</b>	<b>f, d</b>	Swap nibbles in f	1	00	1110	dfff	ffff		1,2
<b>XORWF</b>	<b>f, d</b>	Exclusive OR W with f	1	00	0110	dfff	ffff	Z	1,2
<b>BIT-ORIENTED FILE REGISTER OPERATIONS</b>									
<b>BCF</b>	<b>f, b</b>	Bit Clear f	1	01	00bb	bfff	ffff		1,2
<b>BSF</b>	<b>f, b</b>	Bit Set f	1	01	01bb	bfff	ffff		1,2
<b>BTFSC</b>	<b>f, b</b>	Bit Test f, Skip if Clear	1 (2)	01	10bb	bfff	ffff		3
<b>BTFSS</b>	<b>f, b</b>	Bit Test f, Skip if Set	1 (2)	01	11bb	bfff	ffff		3
<b>LITERAL AND CONTROL OPERATIONS</b>									
<b>ADDLW</b>	<b>k</b>	Add literal and W	1	11	111x	kkkk	kkkk	C,DC,Z	
<b>ANDLW</b>	<b>k</b>	AND literal with W	1	11	1001	kkkk	kkkk	Z	
<b>CALL</b>	<b>k</b>	Call subroutine	2	10	0kkk	kkkk	kkkk		
<b>CLRWDT</b>	<b>-</b>	Clear Watchdog Timer	1	00	0000	0110	0100	$\overline{TO}, \overline{PD}$	
<b>GOTO</b>	<b>k</b>	Go to address	2	10	1kkk	kkkk	kkkk		
<b>IORLW</b>	<b>k</b>	Inclusive OR literal with W	1	11	1000	kkkk	kkkk	Z	
<b>MOVLW</b>	<b>k</b>	Move literal to W	1	11	00xx	kkkk	kkkk		
<b>RETFIE</b>	<b>-</b>	Return from interrupt	2	00	0000	0000	1001		
<b>RETLW</b>	<b>k</b>	Return with literal in W	2	11	01xx	kkkk	kkkk		
<b>RETURN</b>	<b>-</b>	Return from Subroutine	2	00	0000	0000	1000		
<b>SLEEP</b>	<b>-</b>	Go into standby mode	1	00	0000	0110	0011	$\overline{TO}, \overline{PD}$	
<b>SUBLW</b>	<b>k</b>	Subtract W from literal	1	11	110x	kkkk	kkkk	C,DC,Z	
<b>XORLW</b>	<b>k</b>	Exclusive OR literal with W	1	11	1010	kkkk	kkkk	Z	

- Note 1: When an I/O register is modified as a function of itself ( e.g., `MOVF PORTB, 1`), the value used will be that value present on the pins themselves. For example, if the data latch is '1' for a pin configured as input and is driven low by an external device, the data will be written back with a '0'.
- 2: If this instruction is executed on the TMR0 register (and, where applicable, d = 1), the prescaler will be cleared if assigned to the Timer0 Module.
- 3: If Program Counter (PC) is modified or a conditional test is true, the instruction requires two cycles. The second cycle is executed as a NOP.

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## 15.2 Instruction Descriptions

<b>ADDLW</b>	<b>Add Literal and W</b>				
Syntax:	[ <i>label</i> ] ADDLW k				
Operands:	$0 \leq k \leq 255$				
Operation:	(W) + k → (W)				
Status Affected:	C, DC, Z				
Encoding:	<table border="1"><tr><td>11</td><td>111x</td><td>kkkk</td><td>kkkk</td></tr></table>	11	111x	kkkk	kkkk
11	111x	kkkk	kkkk		
Description:	The contents of the W register are added to the eight bit literal 'k' and the result is placed in the W register.				
Words:	1				
Cycles:	1				
Example	ADDLW 0x15 Before Instruction W = 0x10 After Instruction W = 0x25				

<b>ANDLW</b>	<b>And Literal with W</b>				
Syntax:	[ <i>label</i> ] ANDLW k				
Operands:	$0 \leq k \leq 255$				
Operation:	(W) .AND. (k) → (W)				
Status Affected:	Z				
Encoding:	<table border="1"><tr><td>11</td><td>1001</td><td>kkkk</td><td>kkkk</td></tr></table>	11	1001	kkkk	kkkk
11	1001	kkkk	kkkk		
Description:	The contents of W register are AND'ed with the eight bit literal 'k'. The result is placed in the W register.				
Words:	1				
Cycles:	1				
Example	ANDLW 0x5F Before Instruction W = 0xA3 After Instruction W = 0x03				

<b>ADDWF</b>	<b>Add W and f</b>				
Syntax:	[ <i>label</i> ] ADDWF f,d				
Operands:	$0 \leq f \leq 127$ $d \in [0,1]$				
Operation:	(W) + (f) → (dest)				
Status Affected:	C, DC, Z				
Encoding:	<table border="1"><tr><td>00</td><td>0111</td><td>dfff</td><td>ffff</td></tr></table>	00	0111	dfff	ffff
00	0111	dfff	ffff		
Description:	Add the contents of the W register with register 'f'. If 'd' is 0 the result is stored in the W register. If 'd' is 1 the result is stored back in register 'f'.				
Words:	1				
Cycles:	1				
Example	ADDWF FSR, 0 Before Instruction W = 0x17 FSR = 0xC2 After Instruction W = 0xD9 FSR = 0xC2				

<b>ANDWF</b>	<b>AND W with f</b>				
Syntax:	[ <i>label</i> ] ANDWF f,d				
Operands:	$0 \leq f \leq 127$ $d \in [0,1]$				
Operation:	(W) .AND. (f) → (dest)				
Status Affected:	Z				
Encoding:	<table border="1"><tr><td>00</td><td>0101</td><td>dfff</td><td>ffff</td></tr></table>	00	0101	dfff	ffff
00	0101	dfff	ffff		
Description:	AND the W register with register 'f'. If 'd' is 0 the result is stored in the W register. If 'd' is 1 the result is stored back in register 'f'.				
Words:	1				
Cycles:	1				
Example	ANDWF FSR, 1 Before Instruction W = 0x17 FSR = 0xC2 After Instruction W = 0x17 FSR = 0x02				



**BCF**                    **Bit Clear f**

---

Syntax:                `[ label ] BCF f,b`

Operands:             $0 \leq f \leq 127$   
 $0 \leq b \leq 7$

Operation:             $0 \rightarrow (f<b>)$

Status Affected:    None

Encoding:            

01	00bb	bfff	ffff
----	------	------	------

Description:         Bit 'b' in register 'f' is cleared.

Words:                1

Cycles:               1

Example               `BCF        FLAG_REG, 7`

                         Before Instruction  
   FLAG\_REG = 0xC7

                         After Instruction  
   FLAG\_REG = 0x47

**BTFSC**                **Bit Test, Skip if Clear**

---

Syntax:                `[ label ] BTFSC f,b`

Operands:             $0 \leq f \leq 127$   
 $0 \leq b \leq 7$

Operation:            skip if (f<b>) = 0

Status Affected:    None

Encoding:            

01	10bb	bfff	ffff
----	------	------	------

Description:         If bit 'b' in register 'f' is '0' then the next instruction is skipped.  
                         If bit 'b' is '0' then the next instruction fetched during the current instruction execution is discarded, and a NOP is executed instead, making this a 2 cycle instruction.

Words:                1

Cycles:               1(2)

Example               `HERE     BTFSC   FLAG, 1`  
                         `FALSE    GOTO     PROCESS_CODE`  
                         `TRUE     .`  
                         `.`

Before Instruction  
                         PC = address HERE

After Instruction  
                         if FLAG<1> = 0,  
                         PC = address TRUE  
                         if FLAG<1> = 1,  
                         PC = address FALSE

**BSF**                    **Bit Set f**

---

Syntax:                `[ label ] BSF f,b`

Operands:             $0 \leq f \leq 127$   
 $0 \leq b \leq 7$

Operation:             $1 \rightarrow (f<b>)$

Status Affected:    None

Encoding:            

01	01bb	bfff	ffff
----	------	------	------

Description:         Bit 'b' in register 'f' is set.

Words:                1

Cycles:               1

Example               `BSF        FLAG_REG, 7`

                         Before Instruction  
   FLAG\_REG = 0x0A

                         After Instruction  
   FLAG\_REG = 0x8A

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## **BTFS** Bit Test f, Skip if Set

Syntax: [ *label* ] BTFS f,b

Operands:  $0 \leq f \leq 127$   
 $0 \leq b < 7$

Operation: skip if (f<b>) = 1

Status Affected: None

Encoding: 

01	11bb	bfff	ffff
----	------	------	------

Description: If bit 'b' in register 'f' is '1' then the next instruction is skipped.  
 If bit 'b' is '1', then the next instruction fetched during the current instruction execution, is discarded and a NOP is executed instead, making this a 2 cycle instruction.

Words: 1

Cycles: 1(2)

Example

```

HERE    BTFS    FLAG,1
FALSE   GOTO   PROCESS_CODE
TRUE    .
        .
        .
    
```

Before Instruction  
 PC = address HERE

After Instruction  
 if FLAG<1> = 0,  
 PC = address FALSE  
 if FLAG<1> = 1,  
 PC = address TRUE

## **CALL** Call Subroutine

Syntax: [ *label* ] CALL k

Operands:  $0 \leq k \leq 2047$

Operation: (PC)+ 1 → TOS,  
 k → PC<10:0>,  
 (PCLATH<4:3>) → PC<12:11>

Status Affected: None

Encoding: 

10	0kkk	kkkk	kkkk
----	------	------	------

Description: Call Subroutine. First, return address (PC+1) is pushed onto the stack. The eleven bit immediate address is loaded into PC bits <10:0>. The upper bits of the PC are loaded from PCLATH. CALL is a two cycle instruction.

Words: 1

Cycles: 2

Example

```

HERE    CALL   THERE
    
```

Before Instruction  
 PC = Address HERE

After Instruction  
 PC = Address THERE  
 TOS = Address HERE+1

## **CLRF** Clear f

Syntax: [ *label* ] CLRF f

Operands:  $0 \leq f \leq 127$

Operation: 00h → (f)  
 1 → Z

Status Affected: Z

Encoding: 

00	0001	1fff	ffff
----	------	------	------

Description: The contents of register 'f' are cleared and the Z bit is set.

Words: 1

Cycles: 1

Example

```

CLRF    FLAG_REG
    
```

Before Instruction  
 FLAG\_REG = 0x5A

After Instruction  
 FLAG\_REG = 0x00  
 Z = 1

## **CLRW** Clear W

Syntax: [ *label* ] CLRW

Operands: None

Operation: 00h → (W)  
 1 → Z

Status Affected: Z

Encoding: 

00	0001	0xxx	xxxx
----	------	------	------

Description: W register is cleared. Zero bit (Z) is set.

Words: 1

Cycles: 1

Example

```

CLRW
    
```

Before Instruction  
 W = 0x5A

After Instruction  
 W = 0x00  
 Z = 1

**CLRWDT**      **Clear Watchdog Timer**

Syntax:      `[label] CLRWDT`

Operands:      None

Operation:      `00h → WDT`  
`0 → WDT prescaler,`  
`1 →  $\overline{TO}$`   
`1 →  $\overline{PD}$`

Status Affected:       $\overline{TO}$ ,  $\overline{PD}$

Encoding:      

00	0000	0110	0100
----	------	------	------

Description:      CLRWDT instruction resets the Watchdog Timer. It also resets the prescaler of the WDT. Status bits  $\overline{TO}$  and  $\overline{PD}$  are set.

Words:      1

Cycles:      1

Example      `CLRWDT`

Before Instruction  
WDT counter = ?

After Instruction  
WDT counter = 0x00  
WDT prescaler = 0  
 $\overline{TO}$  = 1  
 $\overline{PD}$  = 1

**COMF**      **Complement f**

Syntax:      `[label] COMF f,d`

Operands:       $0 \leq f \leq 127$   
 $d \in [0,1]$

Operation:       $(\overline{f}) \rightarrow (\text{dest})$

Status Affected:      Z

Encoding:      

00	1001	dfff	ffff
----	------	------	------

Description:      The contents of register 'f' are complemented. If 'd' is 0 the result is stored in W. If 'd' is 1 the result is stored back in register 'f'.

Words:      1

Cycles:      1

Example      `COMF      REG1, 0`

Before Instruction  
REG1 = 0x13

After Instruction  
REG1 = 0x13  
W = 0xEC

**DECF**      **Decrement f**

Syntax:      `[label] DECF f,d`

Operands:       $0 \leq f \leq 127$   
 $d \in [0,1]$

Operation:       $(f) - 1 \rightarrow (\text{dest})$

Status Affected:      Z

Encoding:      

00	0011	dfff	ffff
----	------	------	------

Description:      Decrement register 'f'. If 'd' is 0 the result is stored in the W register. If 'd' is 1 the result is stored back in register 'f'.

Words:      1

Cycles:      1

Example      `DECF      CNT, 1`

Before Instruction  
CNT = 0x01  
Z = 0

After Instruction  
CNT = 0x00  
Z = 1

**DECFSZ**      **Decrement f, Skip if 0**

Syntax:      `[label] DECFSZ f,d`

Operands:       $0 \leq f \leq 127$   
 $d \in [0,1]$

Operation:       $(f) - 1 \rightarrow (\text{dest});$  skip if result = 0

Status Affected:      None

Encoding:      

00	1011	dfff	ffff
----	------	------	------

Description:      The contents of register 'f' are decremented. If 'd' is 0 the result is placed in the W register. If 'd' is 1 the result is placed back in register 'f'. If the result is 0, the next instruction, which is already fetched, is discarded. A NOP is executed instead making it a two cycle instruction.

Words:      1

Cycles:      1(2)

Example      `HERE      DECFSZ      CNT, 1`  
`GOTO      LOOP`  
`CONTINUE    •`  
`•`  
`•`

Before Instruction  
PC = address HERE

After Instruction  
CNT = CNT - 1  
if CNT = 0,  
PC = address CONTINUE  
if CNT  $\neq$  0,  
PC = address HERE+1

# PIC16C7X

**GOTO**                    **Unconditional Branch**

Syntax:                    [*label*] GOTO *k*

Operands:                  $0 \leq k \leq 2047$

Operation:                 $k \rightarrow PC<10:0>$   
                                $PCLATH<4:3> \rightarrow PC<12:11>$

Status Affected:        None

Encoding:                 

10	1kkk	kkkk	kkkk
----	------	------	------

Description:             GOTO is an unconditional branch. The eleven bit immediate value is loaded into PC bits <10:0>. The upper bits of PC are loaded from PCLATH<4:3>. GOTO is a two cycle instruction.

Words:                    1

Cycles:                    2

Example                    GOTO THERE

                              After Instruction

                                      PC = Address THERE

**INCFSZ**                    **Increment f, Skip if 0**

Syntax:                    [*label*] INCFSZ *f,d*

Operands:                  $0 \leq f \leq 127$   
                                $d \in [0,1]$

Operation:                 $(f) + 1 \rightarrow (\text{dest})$ , skip if result = 0

Status Affected:        None

Encoding:                 

00	1111	dfff	ffff
----	------	------	------

Description:             The contents of register 'f' are incremented. If 'd' is 0 the result is placed in the W register. If 'd' is 1 the result is placed back in register 'f'. If the result is 0, the next instruction, which is already fetched, is discarded. A NOP is executed instead making it a two cycle instruction.

Words:                    1

Cycles:                    1(2)

Example                    HERE            INCFSZ            CNT, 1  
                                       GOTO            LOOP  
                                       CONTINUE    •  
     •  
     •

Before Instruction  
                               PC = address HERE

After Instruction  
                               CNT = CNT + 1  
                               if CNT= 0,  
                               PC = address CONTINUE  
                               if CNT≠ 0,  
                               PC = address HERE + 1

**INCF**                    **Increment f**

Syntax:                    [*label*] INCF *f,d*

Operands:                  $0 \leq f \leq 127$   
                                $d \in [0,1]$

Operation:                 $(f) + 1 \rightarrow (\text{dest})$

Status Affected:        Z

Encoding:                 

00	1010	dfff	ffff
----	------	------	------

Description:             The contents of register 'f' are incremented. If 'd' is 0 the result is placed in the W register. If 'd' is 1 the result is placed back in register 'f'.

Words:                    1

Cycles:                    1

Example                    INCF    CNT, 1

                              Before Instruction

                                      CNT = 0xFF  
                                       Z = 0

                              After Instruction

                                      CNT = 0x00  
                                       Z = 1

**IORLW**                    **Inclusive OR Literal with W**

Syntax:                    [*label*] IORLW *k*

Operands:                  $0 \leq k \leq 255$

Operation:                 $(W) .OR. k \rightarrow (W)$

Status Affected:        Z

Encoding:                 

11	1000	kkkk	kkkk
----	------	------	------

Description:             The contents of the W register is OR'ed with the eight bit literal 'k'. The result is placed in the W register.

Words:                    1

Cycles:                    1

Example                    IORLW    0x35

                              Before Instruction

                                      W = 0x9A

                              After Instruction

                                      W = 0xBF  
                                       Z = 1

**IORWF**                    **Inclusive OR W with f**

---

Syntax:                    `[label] IORWF f,d`

Operands:                 $0 \leq f \leq 127$   
 $d \in [0,1]$

Operation:                 $(W) .OR. (f) \rightarrow (dest)$

Status Affected:        Z

Encoding:                

00	0100	dfff	ffff
----	------	------	------

Description:             Inclusive OR the W register with register 'f'. If 'd' is 0 the result is placed in the W register. If 'd' is 1 the result is placed back in register 'f'.

Words:                    1

Cycles:                   1

Example                    `IORWF                RESULT, 0`

Before Instruction

RESULT = 0x13

W        = 0x91

After Instruction

RESULT = 0x13

W        = 0x93

Z        = 1

**MOVF**                    **Move f**

---

Syntax:                    `[label] MOVF f,d`

Operands:                 $0 \leq f \leq 127$   
 $d \in [0,1]$

Operation:                 $(f) \rightarrow (dest)$

Status Affected:        Z

Encoding:                

00	1000	dfff	ffff
----	------	------	------

Description:             The contents of register f is moved to a destination dependent upon the status of d. If d = 0, destination is W register. If d = 1, the destination is file register f itself. d = 1 is useful to test a file register since status flag Z is affected.

Words:                    1

Cycles:                   1

Example                    `MOVF                FSR, 0`

After Instruction

W = value in FSR register

Z = 1

**MOVLW**                  **Move Literal to W**

---

Syntax:                    `[label] MOVLW k`

Operands:                 $0 \leq k \leq 255$

Operation:                 $k \rightarrow (W)$

Status Affected:        None

Encoding:                

11	00xx	kkkk	kkkk
----	------	------	------

Description:             The eight bit literal 'k' is loaded into W register. The don't cares will assemble as 0's.

Words:                    1

Cycles:                   1

Example                    `MOVLW               0x5A`

After Instruction

W = 0x5A

**MOVWF**                  **Move W to f**

---

Syntax:                    `[label] MOVWF f`

Operands:                 $0 \leq f \leq 127$

Operation:                 $(W) \rightarrow (f)$

Status Affected:        None

Encoding:                

00	0000	1fff	ffff
----	------	------	------

Description:             Move data from W register to register 'f'.

Words:                    1

Cycles:                   1

Example                    `MOVWF               OPTION`

Before Instruction

OPTION = 0xFF

W        = 0x4F

After Instruction

OPTION = 0x4F

W        = 0x4F

# PIC16C7X

## NOP No Operation

Syntax:	[ <i>label</i> ] NOP				
Operands:	None				
Operation:	No operation				
Status Affected:	None				
Encoding:	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 20px; text-align: center;">00</td> <td style="width: 20px; text-align: center;">0000</td> <td style="width: 20px; text-align: center;">0xx0</td> <td style="width: 20px; text-align: center;">0000</td> </tr> </table>	00	0000	0xx0	0000
00	0000	0xx0	0000		
Description:	No operation.				
Words:	1				
Cycles:	1				
Example	NOP				

## RETFIE Return from Interrupt

Syntax:	[ <i>label</i> ] RETFIE				
Operands:	None				
Operation:	TOS → PC, 1 → GIE				
Status Affected:	None				
Encoding:	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 20px; text-align: center;">00</td> <td style="width: 20px; text-align: center;">0000</td> <td style="width: 20px; text-align: center;">0000</td> <td style="width: 20px; text-align: center;">1001</td> </tr> </table>	00	0000	0000	1001
00	0000	0000	1001		
Description:	Return from Interrupt. Stack is POPed and Top of Stack (TOS) is loaded in the PC. Interrupts are enabled by setting Global Interrupt Enable bit, GIE (INTCON<7>). This is a two cycle instruction.				
Words:	1				
Cycles:	2				
Example	<pre>RETFIE  After Interrupt PC = TOS GIE = 1</pre>				

OPTION	Load Option Register				
Syntax:	[ <i>label</i> ] OPTION				
Operands:	None				
Operation:	(W) → OPTION				
Status Affected:	None				
Encoding:	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 20px; text-align: center;">00</td> <td style="width: 20px; text-align: center;">0000</td> <td style="width: 20px; text-align: center;">0110</td> <td style="width: 20px; text-align: center;">0010</td> </tr> </table>	00	0000	0110	0010
00	0000	0110	0010		
Description:	The contents of the W register are loaded in the OPTION register. This instruction is supported for code compatibility with PIC16C5X products. Since OPTION is a readable/writable register, the user can directly address it.				
Words:	1				
Cycles:	1				
Example	<div style="border: 1px solid black; padding: 5px; margin: 5px 0;"> <p><b>To maintain upward compatibility with future PIC16CXX products, do not use this instruction.</b></p> </div>				

## RETLW Return with Literal in W

Syntax:	[ <i>label</i> ] RETLW k				
Operands:	0 ≤ k ≤ 255				
Operation:	k → (W); TOS → PC				
Status Affected:	None				
Encoding:	<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 20px; text-align: center;">11</td> <td style="width: 20px; text-align: center;">01xx</td> <td style="width: 20px; text-align: center;">kkkk</td> <td style="width: 20px; text-align: center;">kkkk</td> </tr> </table>	11	01xx	kkkk	kkkk
11	01xx	kkkk	kkkk		
Description:	The W register is loaded with the eight bit literal 'k'. The program counter is loaded from the top of the stack (the return address). This is a two cycle instruction.				
Words:	1				
Cycles:	2				
Example	<pre>CALL TABLE      ;W contains table                   ;offset value                   ;W now has table value . . . TABLE ADDWF PC    ;W = offset       RETLW k1    ;Begin table       RETLW k2    ;       .       .       RETLW kn    ; End of table  Before Instruction W = 0x07 After Instruction W = value of k8</pre>				

**RETURN**      **Return from Subroutine**

---

Syntax:      `[label] RETURN`

Operands:    None

Operation:    `TOS → PC`

Status Affected: None

Encoding:    

00	0000	0000	1000
----	------	------	------

Description: Return from subroutine. The stack is POPed and the top of the stack (TOS) is loaded into the program counter. This is a two cycle instruction.

Words:      1

Cycles:      2

Example      `RETURN`

After Interrupt  
PC = TOS

**RRF**      **Rotate Right f through Carry**

---

Syntax:      `[label] RRF f,d`

Operands:     $0 \leq f \leq 127$   
 $d \in [0,1]$

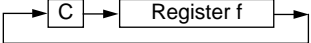
Operation:    See description below

Status Affected: C

Encoding:    

00	1100	dfff	ffff
----	------	------	------

Description: The contents of register 'f' are rotated one bit to the right through the Carry Flag. If 'd' is 0 the result is placed in the W register. If 'd' is 1 the result is placed back in register 'f'.



Words:      1

Cycles:      1

Example      `RRF                  REG1,0`

Before Instruction

REG1 = 1110 0110  
C = 0

After Instruction

REG1 = 1110 0110  
W = 0111 0011  
C = 0

**RLF**      **Rotate Left f through Carry**

---

Syntax:      `[label] RLF f,d`

Operands:     $0 \leq f \leq 127$   
 $d \in [0,1]$

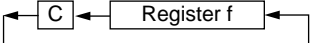
Operation:    See description below

Status Affected: C

Encoding:    

00	1101	dfff	ffff
----	------	------	------

Description: The contents of register 'f' are rotated one bit to the left through the Carry Flag. If 'd' is 0 the result is placed in the W register. If 'd' is 1 the result is stored back in register 'f'.



Words:      1

Cycles:      1

Example      `RLF                  REG1,0`

Before Instruction

REG1 = 1110 0110  
C = 0

After Instruction

REG1 = 1110 0110  
W = 1100 1100  
C = 1

**SLEEP**

---

Syntax:      `[label] SLEEP`

Operands:    None

Operation:    `00h → WDT,`  
`0 → WDT prescaler,`  
`1 →  $\overline{TO}$ ,`  
`0 →  $\overline{PD}$`

Status Affected:  $\overline{TO}$ ,  $\overline{PD}$

Encoding:    

00	0000	0110	0011
----	------	------	------

Description: The power-down status bit,  $\overline{PD}$  is cleared. Time-out status bit,  $\overline{TO}$  is set. Watchdog Timer and its prescaler are cleared. The processor is put into SLEEP mode with the oscillator stopped. See Section 14.8 for more details.

Words:      1

Cycles:      1

Example      `SLEEP`

# PIC16C7X

## SUBLW Subtract W from Literal

Syntax: [ *label*] SUBLW *k*

Operands:  $0 \leq k \leq 255$

Operation:  $k - (W) \rightarrow (W)$

Status: C, DC, Z

Affected:

Encoding: 

11	110x	kkkk	kkkk
----	------	------	------

Description: The W register is subtracted (2's complement method) from the eight bit literal 'k'. The result is placed in the W register.

Words: 1

Cycles: 1

Example 1: SUBLW 0x02

Before Instruction

W = 1  
C = ?

After Instruction

W = 1  
C = 1; result is positive

Example 2: Before Instruction

W = 2  
C = ?

After Instruction

W = 0  
C = 1; result is zero

Example 3: Before Instruction

W = 3  
C = ?

After Instruction

W = 0xFF  
C = 0; result is negative

## SUBWF Subtract W from f

Syntax: [ *label*] SUBWF *f,d*

Operands:  $0 \leq f \leq 127$

$d \in [0,1]$

Operation:  $(f) - (W) \rightarrow (\text{dest})$

Status: C, DC, Z

Affected:

Encoding: 

00	0010	dfff	ffff
----	------	------	------

Description: Subtract (2's complement method) W register from register 'f'. If 'd' is 0 the result is stored in the W register. If 'd' is 1 the result is stored back in register 'f'.

Words: 1

Cycles: 1

Example 1: SUBWF REG1, 1

Before Instruction

REG1 = 3  
W = 2  
C = ?

After Instruction

REG1 = 1  
W = 2  
C = 1; result is positive

Example 2: Before Instruction

REG1 = 2  
W = 2  
C = ?

After Instruction

REG1 = 0  
W = 2  
C = 1; result is zero

Example 3: Before Instruction

REG1 = 1  
W = 2  
C = ?

After Instruction

REG1 = 0xFF  
W = 2  
C = 0; result is negative



SWAPF	Swap Nibbles in f				
Syntax:	[ <i>label</i> ] SWAPF f,d				
Operands:	0 ≤ f ≤ 127 d ∈ [0,1]				
Operation:	(f<3:0>) → (dest<7:4>), (f<7:4>) → (dest<3:0>)				
Status Affected:	None				
Encoding:	<table border="1"> <tr> <td>00</td> <td>1110</td> <td>dfff</td> <td>ffff</td> </tr> </table>	00	1110	dfff	ffff
00	1110	dfff	ffff		
Description:	The upper and lower nibbles of register 'f' are exchanged. If 'd' is 0 the result is placed in W register. If 'd' is 1 the result is placed in register 'f'.				
Words:	1				
Cycles:	1				
Example	<pre>SWAPF REG, 0</pre> <p>Before Instruction</p> <pre>REG1 = 0xA5</pre> <p>After Instruction</p> <pre>REG1 = 0xA5 W     = 0x5A</pre>				

XORLW	Exclusive OR Literal with W				
Syntax:	[ <i>label</i> ] XORLW k				
Operands:	0 ≤ k ≤ 255				
Operation:	(W) .XOR. k → (W)				
Status Affected:	Z				
Encoding:	<table border="1"> <tr> <td>11</td> <td>1010</td> <td>kkkk</td> <td>kkkk</td> </tr> </table>	11	1010	kkkk	kkkk
11	1010	kkkk	kkkk		
Description:	The contents of the W register are XOR'ed with the eight bit literal 'k'. The result is placed in the W register.				
Words:	1				
Cycles:	1				
Example:	<pre>XORLW 0xAF</pre> <p>Before Instruction</p> <pre>W = 0xB5</pre> <p>After Instruction</p> <pre>W = 0x1A</pre>				

TRIS	Load TRIS Register				
Syntax:	[ <i>label</i> ] TRIS f				
Operands:	5 ≤ f ≤ 7				
Operation:	(W) → TRIS register f;				
Status Affected:	None				
Encoding:	<table border="1"> <tr> <td>00</td> <td>0000</td> <td>0110</td> <td>0fff</td> </tr> </table>	00	0000	0110	0fff
00	0000	0110	0fff		
Description:	The instruction is supported for code compatibility with the PIC16C5X products. Since TRIS registers are readable and writable, the user can directly address them.				
Words:	1				
Cycles:	1				
Example	<p><b>To maintain upward compatibility with future PIC16CXX products, do not use this instruction.</b></p>				

XORWF	Exclusive OR W with f				
Syntax:	[ <i>label</i> ] XORWF f,d				
Operands:	0 ≤ f ≤ 127 d ∈ [0,1]				
Operation:	(W) .XOR. (f) → (dest)				
Status Affected:	Z				
Encoding:	<table border="1"> <tr> <td>00</td> <td>0110</td> <td>dfff</td> <td>ffff</td> </tr> </table>	00	0110	dfff	ffff
00	0110	dfff	ffff		
Description:	Exclusive OR the contents of the W register with register 'f'. If 'd' is 0 the result is stored in the W register. If 'd' is 1 the result is stored back in register 'f'.				
Words:	1				
Cycles:	1				
Example	<pre>XORWF REG 1</pre> <p>Before Instruction</p> <pre>REG = 0xAF W   = 0xB5</pre> <p>After Instruction</p> <pre>REG = 0x1A W   = 0xB5</pre>				



## 16.0 DEVELOPMENT SUPPORT

### 16.1 Development Tools

The PIC16/17 microcontrollers are supported with a full range of hardware and software development tools:

- PICMASTER/PICMASTER CE Real-Time In-Circuit Emulator
- ICEPIC Low-Cost PIC16C5X and PIC16CXXX In-Circuit Emulator
- PRO MATE® II Universal Programmer
- PICSTART® Plus Entry-Level Prototype Programmer
- PICDEM-1 Low-Cost Demonstration Board
- PICDEM-2 Low-Cost Demonstration Board
- PICDEM-3 Low-Cost Demonstration Board
- MPASM Assembler
- MPLAB-SIM Software Simulator
- MPLAB-C (C Compiler)
- Fuzzy logic development system (fuzzyTECH®-MP)

### 16.2 PICMASTER: High Performance Universal In-Circuit Emulator with MPLAB IDE

The PICMASTER Universal In-Circuit Emulator is intended to provide the product development engineer with a complete microcontroller design tool set for all microcontrollers in the PIC12C5XX, PIC14000, PIC16C5X, PIC16CXXX and PIC17CXX families. PICMASTER is supplied with the MPLAB™ Integrated Development Environment (IDE), which allows editing, “make” and download, and source debugging from a single environment.

Interchangeable target probes allow the system to be easily reconfigured for emulation of different processors. The universal architecture of the PICMASTER allows expansion to support all new Microchip microcontrollers.

The PICMASTER Emulator System has been designed as a real-time emulation system with advanced features that are generally found on more expensive development tools. The PC compatible 386 (and higher) machine platform and Microsoft Windows® 3.x environment were chosen to best make these features available to you, the end user.

A CE compliant version of PICMASTER is available for European Union (EU) countries.

### 16.3 ICEPIC: Low-cost PIC16CXXX In-Circuit Emulator

ICEPIC is a low-cost in-circuit emulator solution for the Microchip PIC16C5X and PIC16CXXX families of 8-bit OTP microcontrollers.

ICEPIC is designed to operate on PC-compatible machines ranging from 286-AT® through Pentium™ based machines under Windows 3.x environment. ICEPIC features real time, non-intrusive emulation.

### 16.4 PRO MATE II: Universal Programmer

The PRO MATE II Universal Programmer is a full-featured programmer capable of operating in stand-alone mode as well as PC-hosted mode.

The PRO MATE II has programmable VDD and VPP supplies which allows it to verify programmed memory at VDD min and VDD max for maximum reliability. It has an LCD display for displaying error messages, keys to enter commands and a modular detachable socket assembly to support various package types. In stand-alone mode the PRO MATE II can read, verify or program PIC16C5X, PIC16CXXX, PIC17CXX and PIC14000 devices. It can also set configuration and code-protect bits in this mode.

### 16.5 PICSTART Plus Entry Level Development System

The PICSTART programmer is an easy-to-use, low-cost prototype programmer. It connects to the PC via one of the COM (RS-232) ports. MPLAB Integrated Development Environment software makes using the programmer simple and efficient. PICSTART Plus is not recommended for production programming.

PICSTART Plus supports all PIC12C5XX, PIC14000, PIC16C5X, PIC16CXXX and PIC17CXX devices with up to 40 pins. Larger pin count devices such as the PIC16C923 and PIC16C924 may be supported with an adapter socket.

## **16.6 PICDEM-1 Low-Cost PIC16/17 Demonstration Board**

The PICDEM-1 is a simple board which demonstrates the capabilities of several of Microchip's microcontrollers. The microcontrollers supported are: PIC16C5X (PIC16C54 to PIC16C58A), PIC16C61, PIC16C62X, PIC16C71, PIC16C8X, PIC17C42, PIC17C43 and PIC17C44. All necessary hardware and software is included to run basic demo programs. The users can program the sample microcontrollers provided with the PICDEM-1 board, on a PRO MATE II or PICSTART-16B programmer, and easily test firmware. The user can also connect the PICDEM-1 board to the PICMASTER emulator and download the firmware to the emulator for testing. Additional prototype area is available for the user to build some additional hardware and connect it to the microcontroller socket(s). Some of the features include an RS-232 interface, a potentiometer for simulated analog input, push-button switches and eight LEDs connected to PORTB.

## **16.7 PICDEM-2 Low-Cost PIC16CXX Demonstration Board**

The PICDEM-2 is a simple demonstration board that supports the PIC16C62, PIC16C64, PIC16C65, PIC16C73 and PIC16C74 microcontrollers. All the necessary hardware and software is included to run the basic demonstration programs. The user can program the sample microcontrollers provided with the PICDEM-2 board, on a PRO MATE II programmer or PICSTART-16C, and easily test firmware. The PICMASTER emulator may also be used with the PICDEM-2 board to test firmware. Additional prototype area has been provided to the user for adding additional hardware and connecting it to the microcontroller socket(s). Some of the features include a RS-232 interface, push-button switches, a potentiometer for simulated analog input, a Serial EEPROM to demonstrate usage of the I<sup>2</sup>C bus and separate headers for connection to an LCD module and a keypad.

## **16.8 PICDEM-3 Low-Cost PIC16CXXX Demonstration Board**

The PICDEM-3 is a simple demonstration board that supports the PIC16C923 and PIC16C924 in the PLCC package. It will also support future 44-pin PLCC microcontrollers with a LCD Module. All the necessary hardware and software is included to run the basic demonstration programs. The user can program the sample microcontrollers provided with the PICDEM-3 board, on a PRO MATE II programmer or PICSTART Plus with an adapter socket, and easily test firmware. The PICMASTER emulator may also be used with the PICDEM-3 board to test firmware. Additional prototype area has been provided to the user for adding hardware and connecting it to the microcontroller socket(s). Some of the features

include an RS-232 interface, push-button switches, a potentiometer for simulated analog input, a thermistor and separate headers for connection to an external LCD module and a keypad. Also provided on the PICDEM-3 board is an LCD panel, with 4 commons and 12 segments, that is capable of displaying time, temperature and day of the week. The PICDEM-3 provides an additional RS-232 interface and Windows 3.1 software for showing the demultiplexed LCD signals on a PC. A simple serial interface allows the user to construct a hardware demultiplexer for the LCD signals. PICDEM-3 will be available in the 3rd quarter of 1996.

## **16.9 MPLAB Integrated Development Environment Software**

The MPLAB IDE Software brings an ease of software development previously unseen in the 8-bit microcontroller market. MPLAB is a windows based application which contains:

- A full featured editor
- Three operating modes
  - editor
  - emulator
  - simulator
- A project manager
- Customizable tool bar and key mapping
- A status bar with project information
- Extensive on-line help

MPLAB allows you to:

- Edit your source files (either assembly or 'C')
- One touch assemble (or compile) and download to PIC16/17 tools (automatically updates all project information)
- Debug using:
  - source files
  - absolute listing file
- Transfer data dynamically via DDE (soon to be replaced by OLE)
- Run up to four emulators on the same PC

The ability to use MPLAB with Microchip's simulator allows a consistent platform and the ability to easily switch from the low cost simulator to the full featured emulator with minimal retraining due to development tools.

## **16.10 Assembler (MPASM)**

The MPASM Universal Macro Assembler is a PC-hosted symbolic assembler. It supports all microcontroller series including the PIC12C5XX, PIC14000, PIC16C5X, PIC16CXXX, and PIC17CXX families.

MPASM offers full featured Macro capabilities, conditional assembly, and several source and listing formats. It generates various object code formats to support Microchip's development tools as well as third party programmers.

MPASM allow full symbolic debugging from the Microchip Universal Emulator System (PICMASTER).

MPASM has the following features to assist in developing software for specific use applications.

- Provides translation of Assembler source code to object code for all Microchip microcontrollers.
- Macro assembly capability.
- Produces all the files (Object, Listing, Symbol, and special) required for symbolic debug with Microchip's emulator systems.
- Supports Hex (default), Decimal and Octal source and listing formats.

MPASM provides a rich directive language to support programming of the PIC16/17. Directives are helpful in making the development of your assemble source code shorter and more maintainable.

## **16.11 Software Simulator (MPLAB-SIM)**

The MPLAB-SIM Software Simulator allows code development in a PC host environment. It allows the user to simulate the PIC16/17 series microcontrollers on an instruction level. On any given instruction, the user may examine or modify any of the data areas or provide external stimulus to any of the pins. The input/output radix can be set by the user and the execution can be performed in; single step, execute until break, or in a trace mode.

MPLAB-SIM fully supports symbolic debugging using MPLAB-C and MPASM. The Software Simulator offers the low cost flexibility to develop and debug code outside of the laboratory environment making it an excellent multi-project software development tool.

## **16.12 C Compiler (MPLAB-C)**

The MPLAB-C Code Development System is a complete 'C' compiler and integrated development environment for Microchip's PIC16/17 family of microcontrollers. The compiler provides powerful integration capabilities and ease of use not found with other compilers.

For easier source level debugging, the compiler provides symbol information that is compatible with the MPLAB IDE memory display (PICMASTER emulator software versions 1.13 and later).

## **16.13 Fuzzy Logic Development System (fuzzyTECH-MP)**

*fuzzyTECH-MP* fuzzy logic development tool is available in two versions - a low cost introductory version, MP Explorer, for designers to gain a comprehensive working knowledge of fuzzy logic system design; and a full-featured version, *fuzzyTECH-MP*, edition for implementing more complex systems.

Both versions include Microchip's *fuzzyLAB*<sup>™</sup> demonstration board for hands-on experience with fuzzy logic systems implementation.

## **16.14 MP-DriveWay<sup>™</sup> – Application Code Generator**

MP-DriveWay is an easy-to-use Windows-based Application Code Generator. With MP-DriveWay you can visually configure all the peripherals in a PIC16/17 device and, with a click of the mouse, generate all the initialization and many functional code modules in C language. The output is fully compatible with Microchip's MPLAB-C C compiler. The code produced is highly modular and allows easy integration of your own code. MP-DriveWay is intelligent enough to maintain your code through subsequent code generation.

## **16.15 SEEVAL<sup>®</sup> 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 Serial<sup>™</sup> and secure serials. The Total Endurance<sup>™</sup> 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.

## **16.16 TrueGauge<sup>®</sup> Intelligent Battery Management**

The TrueGauge development tool supports system development with the MTA11200B TrueGauge Intelligent Battery Management IC. System design verification can be accomplished before hardware prototypes are built. User interface is graphically-oriented and measured data can be saved in a file for exporting to Microsoft Excel.

## **16.17 KEELOQ<sup>®</sup> 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.

**TABLE 16-1: DEVELOPMENT TOOLS FROM MICROCHIP**

Product	** MPLAB™ Integrated Development Environment	MPLAB™ C Compiler	MP-DriveWay Applications Code Generator	fuzzyTECH®-MP Explorer/Edition Fuzzy Logic Dev. Tool	*** PICMASTER®/PICMASTER-CE In-Circuit Emulator	ICEPIC Low-Cost In-Circuit Emulator	****PRO MATE™ II Universal Microchip Programmer	PICSTART® Lite Ultra Low-Cost Dev. Kit	PICSTART® Plus Low-Cost Universal Dev. Kit
PIC12C508, 509	SW007002	SW006005	—	—	EM167015/ EM167101	—	DV007003	—	DV003001
PIC14000	SW007002	SW006005	—	—	EM147001/ EM147101	—	DV007003	—	DV003001
PIC16C52, 54, 54A, 55, 56, 57, 58A	SW007002	SW006005	SW006006	DV005001/ DV005002	EM167015/ EM167101	EM167201	DV007003	DV162003	DV003001
PIC16C55A, 556, 558	SW007002	SW006005	—	DV005001/ DV005002	EM167033/ EM167113	—	DV007003	—	DV003001
PIC16C61	SW007002	SW006005	SW006006	DV005001/ DV005002	EM167021/ N/A	EM167205	DV007003	DV162003	DV003001
PIC16C62, 62A, 64, 64A	SW007002	SW006005	SW006006	DV005001/ DV005002	EM167025/ EM167103	EM167203	DV007003	DV162002	DV003001
PIC16C620, 621, 622	SW007002	SW006005	SW006006	DV005001/ DV005002	EM167023/ EM167109	EM167202	DV007003	DV162003	DV003001
PIC16C63, 65, 65A, 73, 73A, 74, 74A	SW007002	SW006005	SW006006	DV005001/ DV005002	EM167025/ EM167103	EM167204	DV007003	DV162002	DV003001
PIC16C642, 662*	SW007002	SW006005	—	—	EM167035/ EM167105	—	DV007003	DV162002	DV003001
PIC16C71	SW007002	SW006005	SW006006	DV005001/ DV005002	EM167027/ EM167105	EM167205	DV007003	DV162003	DV003001
PIC16C710, 711	SW007002	SW006005	SW006006	DV005001/ DV005002	EM167027/ EM167105	—	DV007003	DV162003	DV003001
PIC16C72	SW007002	SW006005	SW006006	—	EM167025/ EM167103	—	DV007003	DV162002	DV003001
PIC16F83	SW007002	SW006005	SW006006	DV005001/ DV005002	EM167029/ EM167107	—	DV007003	DV162003	DV003001
PIC16C84	SW007002	SW006005	SW006006	DV005001/ DV005002	EM167029/ EM167107	EM167206	DV007003	DV162003	DV003001
PIC16F84	SW007002	SW006005	SW006006	DV005001/ DV005002	EM167029/ EM167107	—	DV007003	DV162003	DV003001
PIC16C923, 924*	SW007002	SW006005	SW006006	DV005001/ DV005002	EM167031/ EM167111	—	DV007003	—	DV003001
PIC17C42, 42A, 43, 44	SW007002	SW006005	SW006006	DV005001/ DV005002	EM177007/ EM177107	—	DV007003	—	DV003001

\*\*Contact Microchip Technology for availability date  
 \*\*MPLAB Integrated Development Environment includes MPLAB-SIM Simulator and MPA/SM Assembler  
 \*\*\*All PICMASTER and PICMASTER-CE ordering part numbers above include PRO MATE II programmer  
 \*\*\*\*PRO MATE socket modules are ordered separately. See development systems ordering guide for specific ordering part numbers

Product	TRUEGAUGE® Development Kit	SEEVAL® Designers Kit	Hopping Code Security Programmer Kit	Hopping Code Security Eval/Demo Kit
All 2 wire and 3 wire Serial EEPROM's	N/A	DV243001	N/A	N/A
MTA11200B	DV114001	N/A	N/A	N/A
HCS200, 300, 301 *	N/A	N/A	PG306001	DM303001

## 17.0 ELECTRICAL CHARACTERISTICS FOR PIC16C710 AND PIC16C711

### Absolute Maximum Ratings †

Ambient temperature under bias.....	-55 to +125°C
Storage temperature.....	-65°C to +150°C
Voltage on any pin with respect to VSS (except VDD and MCLR).....	-0.3V to (VDD + 0.3V)
Voltage on VDD with respect to VSS.....	0 to +7.5V
Voltage on MCLR with respect to VSS (Note 2).....	0 to +14V
Total power dissipation (Note 1).....	1.0W
Maximum current out of VSS pin.....	300 mA
Maximum current into VDD pin.....	250 mA
Input clamp current, I <sub>IK</sub> (V <sub>I</sub> < 0 or V <sub>I</sub> > VDD).....	±20 mA
Output clamp current, I <sub>OK</sub> (V <sub>O</sub> < 0 or V <sub>O</sub> > VDD).....	±20 mA
Maximum output current sunk by any I/O pin.....	25 mA
Maximum output current sourced by any I/O pin.....	25 mA
Maximum current sunk by PORTA.....	200 mA
Maximum current sourced by PORTA.....	200 mA
Maximum current sunk by PORTB.....	200 mA
Maximum current sourced by PORTB.....	200 mA

**Note 1:** Power dissipation is calculated as follows:  $P_{dis} = V_{DD} \times \{I_{DD} - \sum I_{OH}\} + \sum \{(V_{DD} - V_{OH}) \times I_{OH}\} + \sum (V_{OL} \times I_{OL})$

**Note 2:** Voltage spikes below VSS at the MCLR pin, inducing currents greater than 80 mA, may cause latch-up. Thus, a series resistor of 50-100Ω should be used when applying a “low” level to the MCLR pin rather than pulling this pin directly to VSS.

† NOTICE: 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 those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

# PIC16C7X

Applicable Devices	710	71	711	72	73	73A	74	74A
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**TABLE 17-1: CROSS REFERENCE OF DEVICE SPECS FOR OSCILLATOR CONFIGURATIONS AND FREQUENCIES OF OPERATION (COMMERCIAL DEVICES)**

OSC	PIC16C710-04 PIC16C711-04	PIC16C710-10 PIC16C711-10	PIC16C710-20 PIC16C711-20	PIC16LC710-04 PIC16LC711-04	PIC16C710/JW PIC16C711/JW
RC	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 21 µA max. at 4V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 2.7 mA typ. at 5.5V IPD: 1.5 µA typ. at 4V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 2.7 mA typ. at 5.5V IPD: 1.5 µA typ. at 4V Freq: 4 MHz max.	VDD: 3.0V to 6.0V IDD: 2.0 mA typ. at 3.0V IPD: 0.9 µA typ. at 3V Freq: 4 MHz max.	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 21 µA max. at 4V Freq: 4 MHz max.
XT	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 21 µA max. at 4V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 2.7 mA typ. at 5.5V IPD: 1.5 µA typ. at 4V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 2.7 mA typ. at 5.5V IPD: 1.5 µA typ. at 4V Freq: 4 MHz max.	VDD: 3.0V to 6.0V IDD: 2.0 mA typ. at 3.0V IPD: 0.9 µA typ. at 3V Freq: 4 MHz max.	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 21 µA max. at 4V Freq: 4 MHz max.
HS	VDD: 4.5V to 5.5V IDD: 13.5 mA typ. at 5.5V IPD: 1.5 µA typ. at 4.5V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 30 mA max. at 5.5V IPD: 1.5 µA typ. at 4.5V Freq: 10 MHz max.	VDD: 4.5V to 5.5V IDD: 30 mA max. at 5.5V IPD: 1.5 µA typ. at 4.5V Freq: 20 MHz max.	Do not use in HS mode	VDD: 4.5V to 5.5V IDD: 30 mA max. at 5.5V IPD: 1.5 µA typ. at 4.5V Freq: 10 MHz max.
LP	VDD: 4.0V to 6.0V IDD: 52.5 µA typ. at 32 kHz, 4.0V IPD: 0.9 µA typ. at 4.0V Freq: 200 kHz max.	Do not use in LP mode	Do not use in LP mode	VDD: 3.0V to 6.0V IDD: 48 µA max. at 32 kHz, 3.0V IPD: 5.0 µA max. at 3.0V Freq: 200 kHz max.	VDD: 3.0V to 6.0V IDD: 48 µA max. at 32 kHz, 3.0V IPD: 5.0 µA max. at 3.0V Freq: 200 kHz max.

The shaded sections indicate oscillator selections which are tested for functionality, but not for MIN/MAX specifications. It is recommended that the user select the device type that ensures the specifications required.



# PIC16C7X

Applicable Devices 710 71 711 72 73 73A 74 74A

- 17.1 DC Characteristics:** PIC16C710-04 (Commercial, Industrial, Automotive)<sup>(5)</sup>  
 PIC16C711-04 (Commercial, Industrial, Automotive)<sup>(5)</sup>  
 PIC16C710-10 (Commercial, Industrial, Automotive)<sup>(5)</sup>  
 PIC16C711-10 (Commercial, Industrial, Automotive)<sup>(5)</sup>  
 PIC16C710-20 (Commercial, Industrial, Automotive)<sup>(5)</sup>  
 PIC16C711-20 (Commercial, Industrial, Automotive)<sup>(5)</sup>

DC CHARACTERISTICS		Standard Operating Conditions (unless otherwise stated)					
		Operating temperature -40°C ≤ TA ≤ +125°C for automotive, -40°C ≤ TA ≤ +85°C for industrial and 0°C ≤ TA ≤ +71°C for commercial					
Param. No.	Characteristic	Sym	Min	Typ†	Max	Units	Conditions
D001 D001A	Supply Voltage	VDD	4.0 4.5	- -	6.0 5.5	V V	XT, RC and LP osc configuration HS osc configuration
D002*	RAM Data Retention Voltage (Note 1)	VDR	-	1.5	-	V	Device in SLEEP mode
D003	VDD start voltage to ensure internal Power-on Reset signal	VPOR	-	VSS	-	V	See section on Power-on Reset for details
D004*	VDD rise rate to ensure internal Power-on Reset signal	SVDD	0.05	-	-	V/ms	See section on Power-on Reset for details
D005	Brown-out Reset Voltage	BVDD	3.7	4.0	4.3	V	BODEN configuration bit is enabled
D010 D013	Supply Current (Note 2)	IDD	-	2.7 13.5	5 30	mA mA	XT, RC osc configuration (PIC16C710/711-04) FOSC = 4 MHz, VDD = 5.5V (Note 4) HS osc configuration (PIC16C710/711-20) FOSC = 20 MHz, VDD = 5.5V
D015	Brown-out Reset Current (Note 6)	ΔIBOR	-	300*	500	μA	BOR enabled VDD = 5.0V
D020 D021 D021A D021B	Power-down Current (Note 3)	IPD	-	10.5 1.5 1.5 1.5	42 21 24 TBD	μA μA μA μA	VDD = 4.0V, WDT enabled, -40°C to +85°C VDD = 4.0V, WDT disabled, -0°C to +70°C VDD = 4.0V, WDT disabled, -40°C to +85°C VDD = 4.0V, WDT disabled, -40°C to +125°C
D023	Brown-out Reset Current (Note 6)	ΔIBOR	-	300*	500	μA	BOR enabled 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 in SLEEP mode 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 configuration, current through Rext is not included. The current through the resistor can be estimated by the formula  $I_r = V_{DD}/2R_{ext}$  (mA) with Rext in kOhm.

5: Automotive operating range is Advance Information for this device.

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.

# PIC16C7X

Applicable Devices 710 71 711 72 73 73A 74 74A

## 17.2 DC Characteristics: PIC16LC710-04 (Commercial, Industrial) PIC16LC711-04 (Commercial, Industrial)

DC CHARACTERISTICS		Standard Operating Conditions (unless otherwise stated)					Conditions
Param No.	Characteristic	Sym	Min	Typ†	Max	Units	
D001	Supply Voltage	VDD	3.0	-	6.0	V	LP, XT, RC osc configuration (DC 4 MHz)
D002*	RAM Data Retention Voltage (Note 1)	VDR	-	1.5	-	V	Device in SLEEP mode
D003	VDD start voltage to ensure internal Power-on Reset signal	VPOR	-	VSS	-	V	See section on Power-on Reset for details
D004*	VDD rise rate to ensure internal Power-on Reset signal	SVDD	0.05	-	-	V/ms	See section on Power-on Reset for details
D005	Brown-out Reset Voltage	BVDD	3.7	4.0	4.3	V	BODEN configuration bit is enabled
D010	Supply Current (Note 2)	IDD	-	2.0	3.8	mA	XT, RC osc configuration FOSC = 4 MHz, VDD = 3.0V (Note 4)
D010A			-	22.5	48	μA	LP osc configuration FOSC = 32 kHz, VDD = 3.0V, WDT disabled
D015	Brown-out Reset Current (Note 5)	ΔIBOR	-	300*	500	μA	BOR enabled VDD = 3.0V
D020	Power-down Current (Note 3)	IPD	-	7.5	30	μA	VDD = 3.0V, WDT enabled, -40°C to +85°C
D021			-	0.9	5	μA	VDD = 3.0V, WDT disabled, 0°C to +70°C
D021A			-	0.9	5	μA	VDD = 3.0V, WDT disabled, -40°C to +85°C
D021B			-	0.9	10	μA	VDD = 3.0V, WDT disabled, -40°C to +125°C
D023	Brown-out Reset Current (Note 5)	ΔIBOR	-	300*	500	μA	BOR enabled VDD = 3.0V

\* 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 in SLEEP mode 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:

QSC1 = 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 configuration, current through Rext is not included. The current through the resistor can be estimated by the formula  $I_r = V_{DD}/2R_{ext}$  (mA) with Rext in kOhm.

5: 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.

# PIC16C7X

Applicable Devices 710 71 711 72 73 73A 74 74A

- 17.3 DC Characteristics:** PIC16C710-04 (Commercial, Industrial, Automotive)<sup>(4)</sup>  
 PIC16C711-04 (Commercial, Industrial, Automotive)<sup>(4)</sup>  
 PIC16C710-10 (Commercial, Industrial, Automotive)<sup>(4)</sup>  
 PIC16C711-10 (Commercial, Industrial, Automotive)<sup>(4)</sup>  
 PIC16C710-20 (Commercial, Industrial, Automotive)<sup>(4)</sup>  
 PIC16C711-20 (Commercial, Industrial, Automotive)<sup>(4)</sup>  
 PIC16LC710-04 (Commercial, Industrial)  
 PIC16LC711-04 (Commercial, Industrial)

Standard Operating Conditions (unless otherwise stated)							
DC CHARACTERISTICS							
Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$ for automotive, $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$ for industrial and $0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$ for commercial							
Operating voltage VDD range as described in DC spec Section 17.1 and Section 17.2.							
Param No.	Characteristic	Sym	Min	Typ †	Max	Units	Conditions
<b>Input Low Voltage</b>							
D030	I/O ports with TTL buffer	V <sub>IL</sub>	V <sub>SS</sub>	-	0.5V	V	
D031	with Schmitt Trigger buffer		V <sub>SS</sub>	-	0.2V <sub>DD</sub>	V	
D032	MCLR, RA4/T0CKI, OSC1 (in RC mode)		V <sub>SS</sub>	-	0.2V <sub>DD</sub>	V	
D033	OSC1 (in XT, HS and LP)		V <sub>SS</sub>	-	0.3V <sub>DD</sub>	V	Note1
<b>Input High Voltage</b>							
D040	I/O ports with TTL buffer	V <sub>IH</sub>	2.0	-	V <sub>DD</sub>	V	4.5 ≤ V <sub>DD</sub> ≤ 5.5V
D040A			0.8V <sub>DD</sub>	-	V <sub>DD</sub>	V	For V <sub>DD</sub> > 5.5V or V <sub>DD</sub> < 4.5V
D041	with Schmitt Trigger buffer		0.8V <sub>DD</sub>	-	V <sub>DD</sub>	V	For entire V <sub>DD</sub> range
D042	MCLR, RA4/T0CKI RB0/INT		0.8V <sub>DD</sub>	-	V <sub>DD</sub>	V	
D042A	OSC1 (XT, HS and LP)		0.7V <sub>DD</sub>	-	V <sub>DD</sub>	V	Note1
D043	OSC1 (in RC mode)		0.9V <sub>DD</sub>	-	V <sub>DD</sub>	V	
D070	PORTB weak pull-up current	I <sub>PURB</sub>	50	250	400	μA	V <sub>DD</sub> = 5V, V <sub>PIN</sub> = V <sub>SS</sub>
<b>Input Leakage Current (Notes 2, 3)</b>							
D060	I/O ports	I <sub>IL</sub>	-	-	±1	μA	V <sub>SS</sub> ≤ V <sub>PIN</sub> ≤ V <sub>DD</sub> , Pin at hi-impedance
D061	MCLR, RA4/T0CKI		-	-	±5	μA	V <sub>SS</sub> ≤ V <sub>PIN</sub> ≤ V <sub>DD</sub>
D063	OSC1		-	-	±5	μA	V <sub>SS</sub> ≤ V <sub>PIN</sub> ≤ V <sub>DD</sub> , XT, HS and LP osc configuration
<b>Output Low Voltage</b>							
D080	I/O ports	V <sub>OL</sub>	-	-	0.6	V	I <sub>OL</sub> = 8.5 mA, V <sub>DD</sub> = 4.5V, -40°C to +85°C
D080A			-	-	0.6	V	I <sub>OL</sub> = 7.0 mA, V <sub>DD</sub> = 4.5V, -40°C to +125°C
D083	OSC2/CLKOUT (RC osc config)		-	-	0.6	V	I <sub>OL</sub> = 1.6 mA, V <sub>DD</sub> = 4.5V, -40°C to +85°C
D083A			-	-	0.6	V	I <sub>OL</sub> = 1.2 mA, V <sub>DD</sub> = 4.5V, -40°C to +125°C

† 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 configuration, the OSC1/CLKIN pin is a Schmitt Trigger input. It is not recommended that the PIC16C7X be driven with external clock in RC mode.

2: The leakage current on the MCLR 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 coming out of the pin.

4: Automotive operating range is Advance Information for this device.

# PIC16C7X

Applicable Devices 710 71 711 72 73 73A 74 74A

Standard Operating Conditions (unless otherwise stated)											
Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$ for automotive, $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$ for industrial and $0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$ for commercial Operating voltage $V_{DD}$ range as described in DC spec Section 17.1 and Section 17.2.											
Param No.	Characteristic	Sym	Min	Typ †	Max	Units	Conditions				
D090	<b>Output High Voltage</b> I/O ports (Note 3)	VOH	$V_{DD} - 0.7$	-	-	V	IOH = -3.0 mA, $V_{DD} = 4.5\text{V}$ , -40°C to +85°C				
D090A								V	-	-	IOH = -2.5 mA, $V_{DD} = 4.5\text{V}$ , -40°C to +125°C
D092											
D092A								V	-	-	IOH = -1.0 mA, $V_{DD} = 4.5\text{V}$ , -40°C to +125°C
D100	<b>Capacitive Loading Specs on Output Pins</b> OSC2 pin	Cosc2	-	-	15	pF	In XT, HS and LP modes when external clock is used to drive OSC1.				
D101	All I/O pins and OSC2 (in RC mode)	Cio	-	-	50	pF					

† 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 configuration, the OSC1/CLKIN pin is a Schmitt Trigger input. It is not recommended that the PIC16C7X be driven with external clock in RC mode.
- 2: The leakage current on the MCLR 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 coming out of the pin.
- 4: Automotive operating range is Advance Information for this device.

PRELIMINARY

## 17.4 Timing Parameter Symbology

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

1. TppS2ppS
2. TppS
3. TCC:ST (I<sup>2</sup>C specifications only)
4. Ts (I<sup>2</sup>C specifications only)

<b>T</b>			
F	Frequency	T	Time

Lowercase letters (pp) and their meanings:

<b>pp</b>			
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	$\overline{WR}$

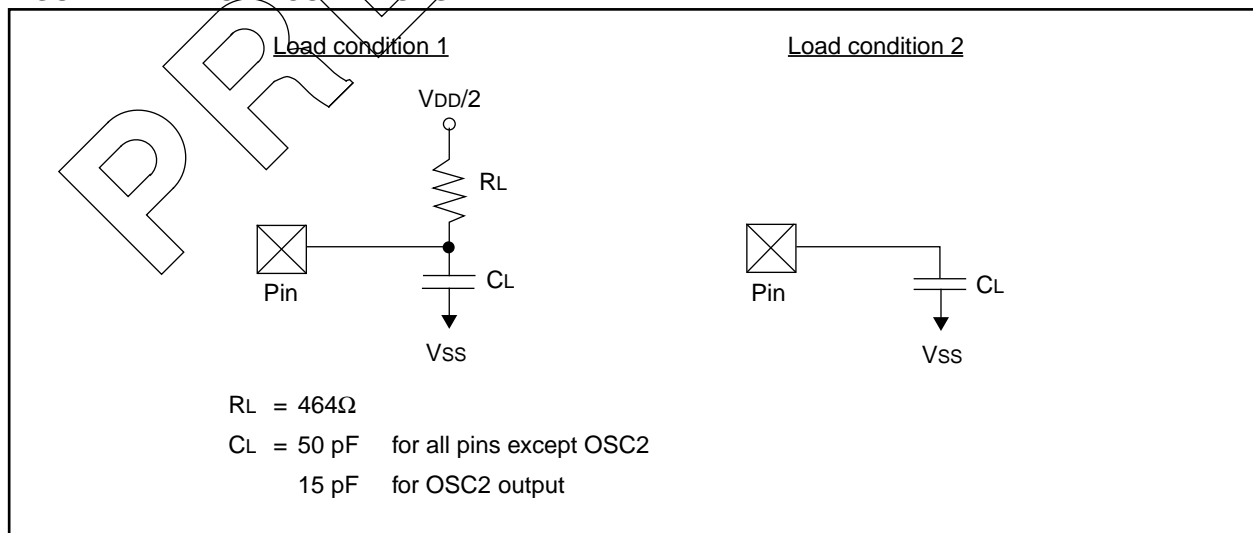
Uppercase letters and their meanings:

<b>S</b>			
F	Fall	P	Period
H	High	R	Rise
I	Invalid (Hi-impedance)	V	Valid
L	Low	Z	Hi-impedance
<b>I<sup>2</sup>C only</b>		High	High
AA	output access	Low	Low
BUF	Bus free		

TCC:ST (I<sup>2</sup>C specifications only)

<b>CC</b>			
HD	Hold	SU	Setup
<b>ST</b>		STO	STOP condition
DAT	DATA input hold		
STA	START condition		

**FIGURE 17-1: LOAD CONDITIONS**



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Applicable Devices 710 71 711 72 73 73A 74 74A

## 17.5 Timing Diagrams and Specifications

FIGURE 17-2: EXTERNAL CLOCK TIMING

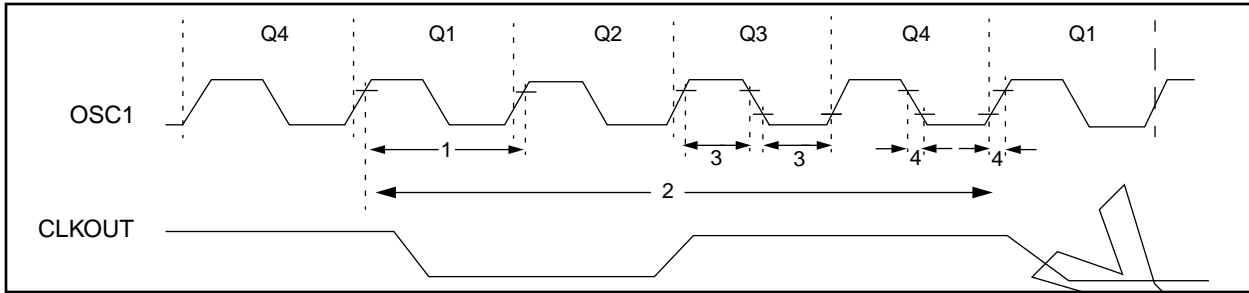


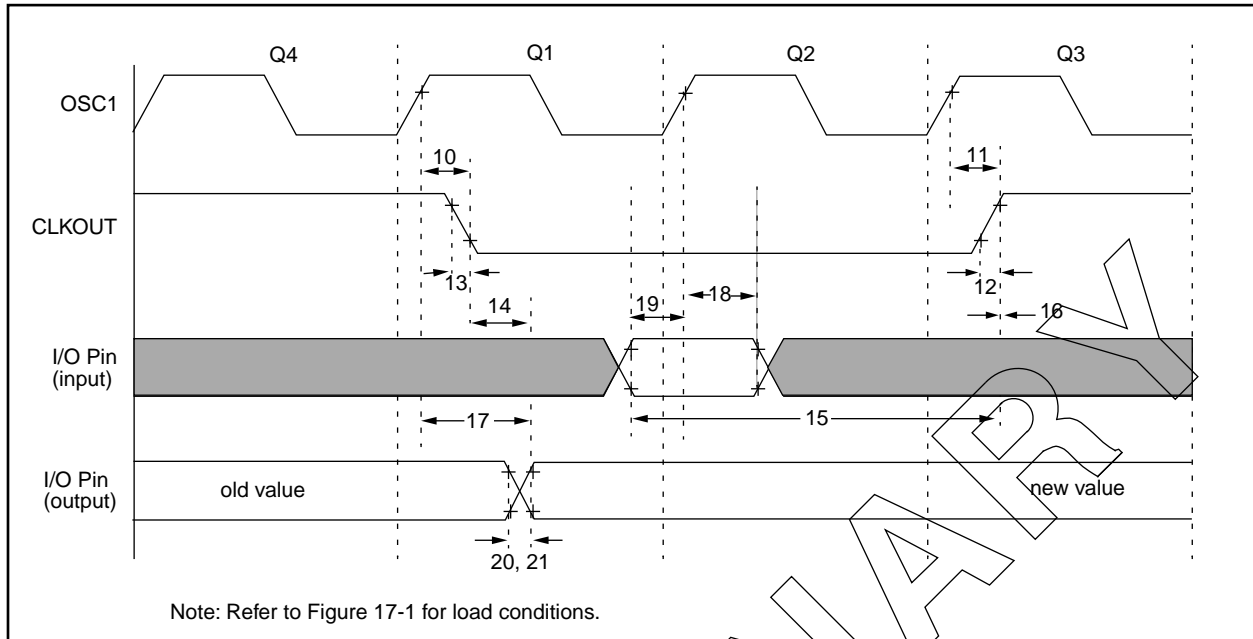
TABLE 17-2: CLOCK TIMING REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions	
	Fos	<b>External CLKIN Frequency (Note 1)</b>	DC	—	4	MHz	XT and RC osc mode	
			DC	—	4	MHz	HS osc mode (PIC16C710/711-04.)	
			DC	—	20	MHz	HS osc mode (PIC16C710/711-20)	
			DC	—	200	kHz	LP osc mode	
			<b>Oscillator Frequency (Note 1)</b>	DC	—	4	MHz	RC osc mode
				0.1	—	4	MHz	XT osc mode
				4	—	4	MHz	HS osc mode (PIC16C710/711-04)
1	Tosc	<b>External CLKIN Period (Note 1)</b>	4	—	10	MHz	HS osc mode (PIC16C710/711-10)	
			4	—	20	MHz	HS osc mode (PIC16C710/711-20)	
1	Tosc	<b>Oscillator Period (Note 1)</b>	5	—	200	kHz	LP osc mode	
			250	—	—	ns	XT and RC osc mode	
			250	—	—	ns	HS osc mode (PIC16C710/711-04)	
			100	—	—	ns	HS osc mode (PIC16C710/711-10)	
			50	—	—	ns	HS osc mode (PIC16C710/711-20)	
	2	Tcy	<b>Instruction Cycle Time (Note 1)</b>	5	—	—	μs	LP osc mode
				200	—	DC	ns	Tcy = 4/Fosc
3	TosL, TosH	<b>External Clock in (OSC1) High or Low Time</b>	250	—	10,000	ns	RC osc mode	
			250	—	250	ns	XT osc mode	
			100	—	250	ns	HS osc mode (PIC16C710/711-10)	
4	TosR, TosF	<b>External Clock in (OSC1) Rise or Fall Time</b>	50	—	250	ns	HS osc mode (PIC16C710/711-20)	
			5	—	—	μs	LP osc mode	
4	TosR, TosF	<b>External Clock in (OSC1) Rise or Fall Time</b>	—	—	25	ns	XT oscillator	
			—	—	50	ns	LP oscillator	
			—	—	15	ns	HS oscillator	

† 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. OSC2 is disconnected (has no loading) for the PIC16C710/711.

**FIGURE 17-3: CLKOUT AND I/O TIMING**



**TABLE 17-3: CLKOUT AND I/O TIMING REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
10*	TosH2ckL	OSC1↑ to CLKOUT↓	—	15	30	ns	Note 1
11*	TosH2ckH	OSC1↑ to CLKOUT↑	—	15	30	ns	Note 1
12*	TckR	CLKOUT rise time	—	5	15	ns	Note 1
13*	TckF	CLKOUT fall time	—	5	15	ns	Note 1
14*	TckL2ioV	CLKOUT ↓ to Port out valid	—	—	0.5T <sub>CY</sub> + 20	ns	Note 1
15*	TioV2ckH	Port in valid before CLKOUT ↑	0.25T <sub>CY</sub> + 25	—	—	ns	Note 1
16*	TckH2ioI	Port in hold after CLKOUT ↑	0	—	—	ns	Note 1
17*	TosH2ioV	OSC1↑ (Q1 cycle) to Port out valid	—	—	80 - 100	ns	
18*	TosH2ioI	OSC1↑ (Q2 cycle) to Port input invalid (I/O in hold time)	TBD	—	—	ns	
19*	TioV2osH	Port input valid to OSC1↑ (I/O in setup time)	TBD	—	—	ns	
20*	TioR	Port output rise time	PIC16C710/711	—	10	25	ns
			PIC16LC710/711	—	—	60	ns
21*	TioF	Port output fall time	PIC16C710/711	—	10	25	ns
			PIC16LC710/711	—	—	60	ns
22††*	Tinp	INT pin high or low time	20	—	—	ns	
23††*	Trbp	RB7:RB4 change INT high or low time	20	—	—	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.

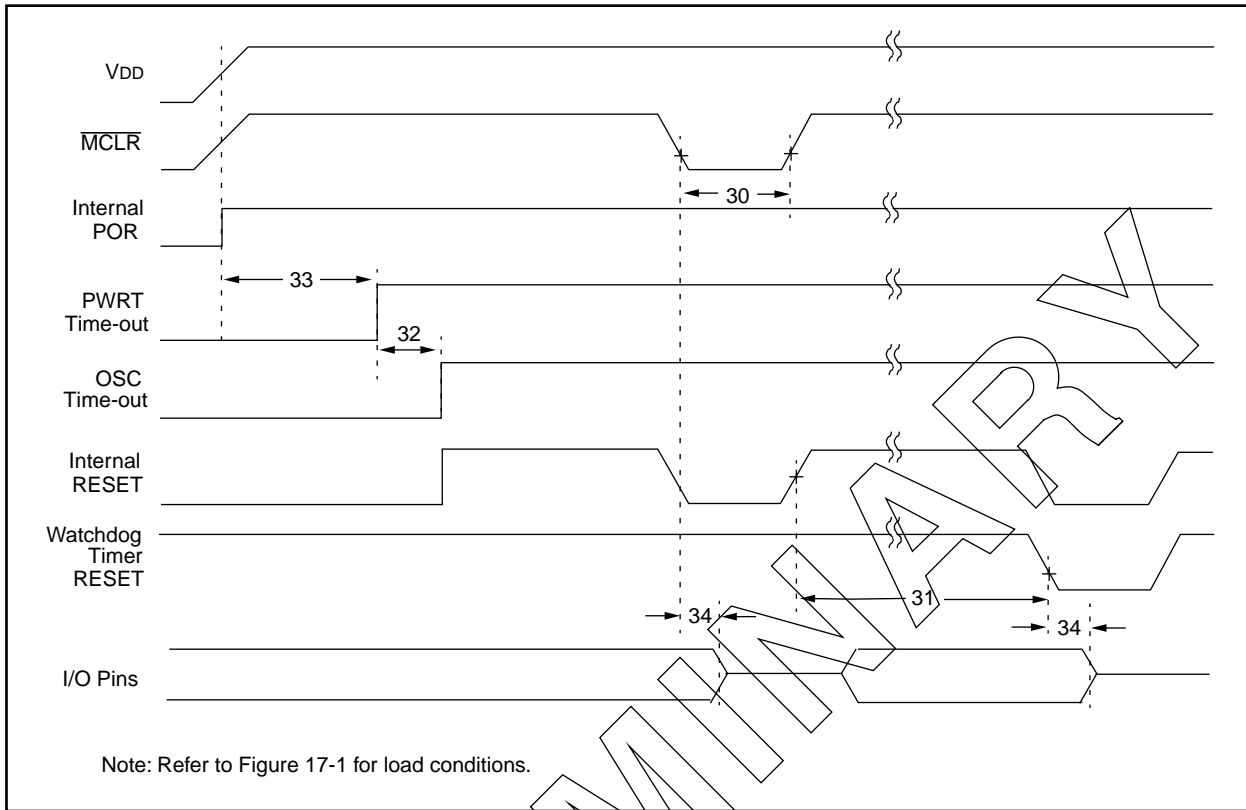
†† These parameters are asynchronous events not related to any internal clock edges.

Note 1: Measurements are taken in RC Mode where CLKOUT output is 4 x T<sub>OSC</sub>.

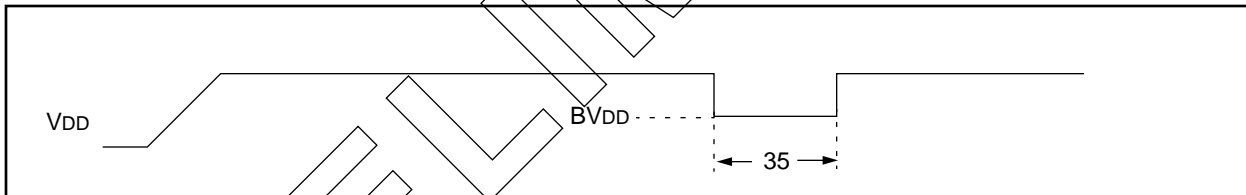
# PIC16C7X

Applicable Devices 710 71 711 72 73 73A 74 74A

**FIGURE 17-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER TIMING**



**FIGURE 17-5: BROWN-OUT RESET TIMING**



**TABLE 17-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER REQUIREMENTS**

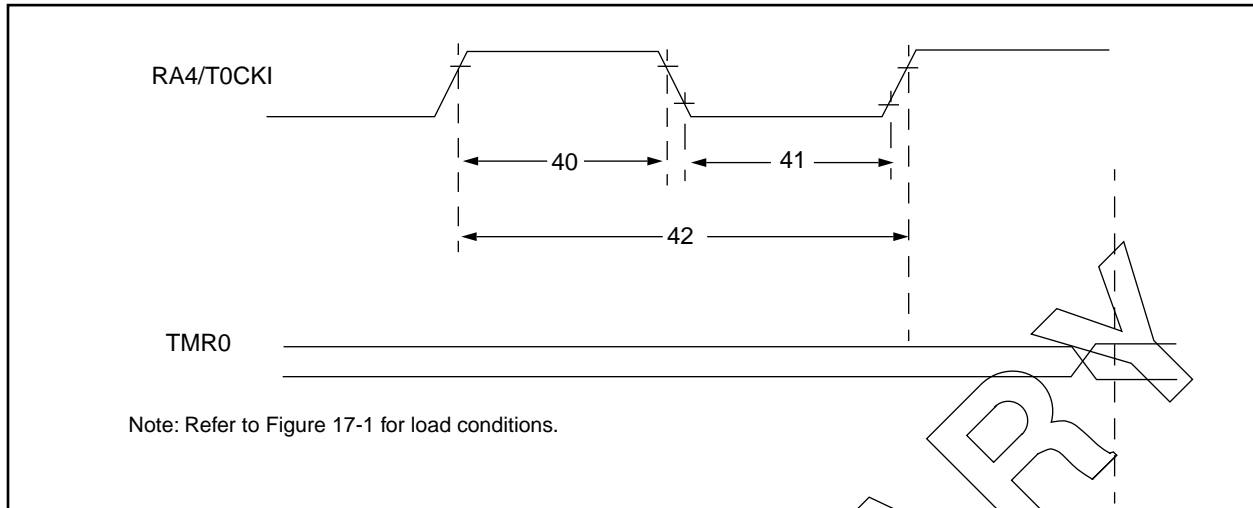
Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
30	$T_{mcl}$	MCLR Pulse Width (low)	1	—	—	$\mu$ s	$V_{DD} = 5V, -40^{\circ}C$ to $+125^{\circ}C$
31	$T_{wdt}$	Watchdog Timer Time-out Period (No Prescaler)	7*	18	33*	ms	$V_{DD} = 5V, -40^{\circ}C$ to $+125^{\circ}C$
32	$T_{ost}$	Oscillation Start-up Timer Period	—	$1024T_{osc}$	—	—	$T_{osc} = OSC1$ period
33	$T_{pwrt}$	Power up Timer Period	28*	72	132*	ms	$V_{DD} = 5V, -40^{\circ}C$ to $+125^{\circ}C$
34	$T_{ioz}$	I/O Hi-impedance from MCLR Low or Watchdog Timer Reset	—	—	1.1	$\mu$ s	
35	$T_{BOR}$	Brown-out Reset pulse width	100	—	—	$\mu$ s	$3.8V \leq V_{DD} \leq 4.2V$

\* 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 17-6: TIMER0 CLOCK TIMINGS**



**TABLE 17-5: TIMER0 CLOCK REQUIREMENTS**

Param No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions	
40	Tt0H	T0CKI High Pulse Width	No Prescaler	$0.5T_{CY} + 20^*$	—	—	ns	
			With Prescaler	$10^*$	—	—	ns	
41	Tt0L	T0CKI Low Pulse Width	No Prescaler	$0.5T_{CY} + 20^*$	—	—	ns	
			With Prescaler	$10^*$	—	—	ns	
42	Tt0P	T0CKI Period	Greater of: $20\mu s$ or $\frac{T_{CY} + 40^*}{N}$		—	—	ns	N = prescale value (1, 2, 4, ..., 256)
48	Tcke2tmr1	Delay from external clock edge to timer increment	$2T_{osc}$	—	$7T_{osc}$	—		

\* 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.

# PIC16C7X

Applicable Devices 710 71 711 72 73 73A 74 74A

**TABLE 17-6: A/D CONVERTER CHARACTERISTICS:**  
**PIC16C710-04 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE<sup>(3)</sup>)**  
**PIC16C711-04 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE<sup>(3)</sup>)**  
**PIC16C710-10 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE<sup>(3)</sup>)**  
**PIC16C711-10 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE<sup>(3)</sup>)**  
**PIC16C710-20 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE<sup>(3)</sup>)**  
**PIC16C711-20 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE<sup>(3)</sup>)**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
	NR	Resolution	—	—	8-bits	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NINT	Integral error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NDIF	Differential error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NFS	Full scale error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NOFF	Offset error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	—	Monotonicity	—	guaranteed	—	—	$V_{SS} \leq A_{IN} \leq V_{REF}$
	VREF	Reference voltage	3.0V	—	$V_{DD} + 0.3$	V	
	VAIN	Analog input voltage	$V_{SS} - 0.3$	—	$V_{REF} + 0.3$	V	
	ZAIN	Recommended impedance of analog voltage source	—	—	10.0	k $\Omega$	
	IAD	A/D conversion current ( $V_{DD}$ )	—	180	—	$\mu A$	Average current consumption when A/D is on. (Note 1)
	IREF	VREF input current (Note 2)	—	—	1 10	mA $\mu A$	During sampling All other times

\* 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: When A/D is off, it will not consume any current other than minor leakage current. The power-down current spec includes any such leakage from the A/D module.

2: VREF current is from RA3 pin or VDD pin, whichever is selected as reference input.

3: Automotive operating range is Advance Information for this device.

PRELIMINARY

**TABLE 17-7: A/D CONVERTER CHARACTERISTICS:  
PIC16LC710-04 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE<sup>(4)</sup>)  
PIC16LC711-04 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE<sup>(4)</sup>)**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
	NR	Resolution	—	—	8-bits	—	VREF = VDD = 3.0V (Note 1)
	NINT	Integral error	—	—	less than ±1 LSb	—	VREF = VDD = 3.0V (Note 1)
	NDIF	Differential error	—	—	less than ±1 LSb	—	VREF = VDD = 3.0V (Note 1)
	NFS	Full scale error	—	—	less than ±1 LSb	—	VREF = VDD = 3.0V (Note 1)
	NOFF	Offset error	—	—	less than ±1 LSb	—	VREF = VDD = 3.0V (Note 1)
	—	Monotonicity	—	guaranteed	—	—	VSS ≤ AIN ≤ VREF
	VREF	Reference voltage	3.0V	—	VDD + 0.3	V	
	VAIN	Analog input voltage	VSS - 0.3	—	VREF + 0.3	V	
	ZAIN	Recommended impedance of analog voltage source	—	—	10.0	kΩ	
	IAD	A/D conversion current (VDD)	—	180	—	μA	Average current consumption when A/D is on. (Note 2)
	IREF	VREF input current (Note 3)	—	—	1 10	μA μA	During sampling All other times

\* 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: These specifications apply if VREF = 3.0V and if VDD ≥ 3.0V. VIN must be between VSS and VREF

2: When A/D is off, it will not consume any current other than minor leakage current. The power-down current spec includes any such leakage from the A/D module.

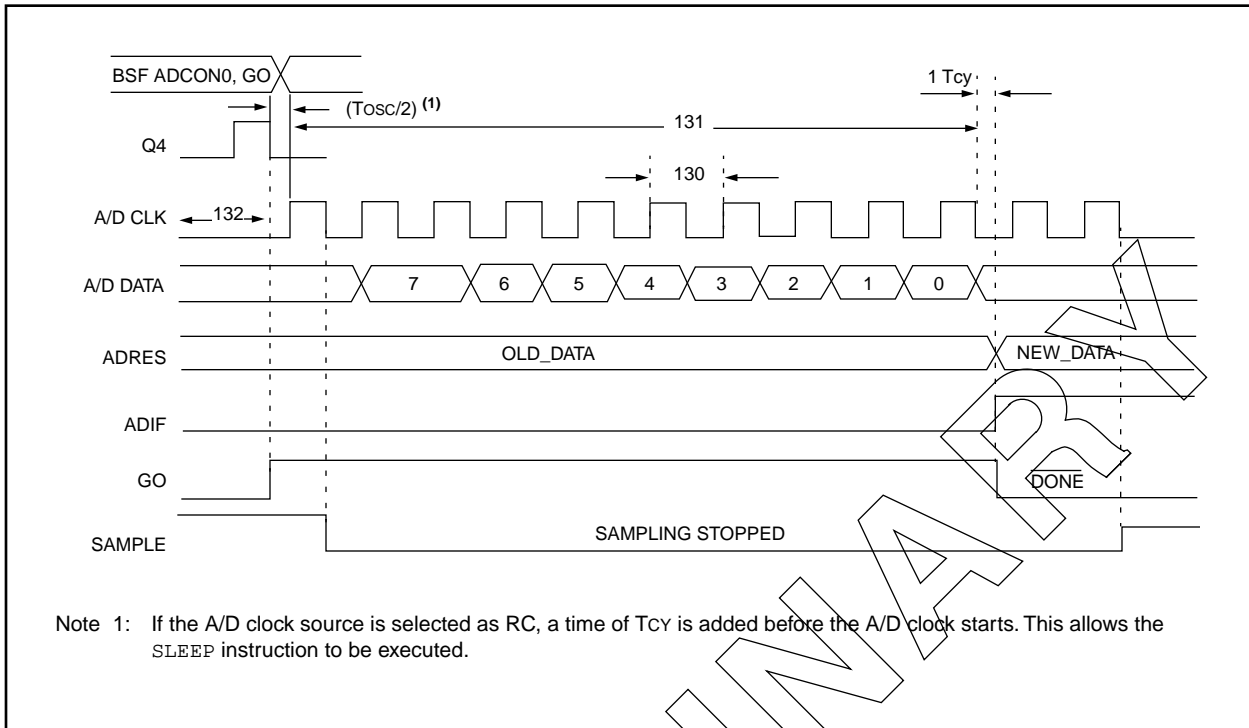
3: VREF current is from RA3 pin or VDD pin, whichever is selected as reference input.

4: Automotive operating range is Advance Information for this device.

# PIC16C7X

Applicable Devices 710 71 711 72 73 73A 74 74A

FIGURE 17-7: A/D CONVERSION TIMING



Note 1: If the A/D clock source is selected as RC, a time of  $T_{CY}$  is added before the A/D clock starts. This allows the SLEEP instruction to be executed.

TABLE 17-8: A/D CONVERSION REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
130	TAD	A/D clock period	1.6	—	—	$\mu s$	$V_{REF} \geq 3.0V$
130	TAD	A/D Internal RC Oscillator source	2.0	—	—	$\mu s$	$V_{REF}$ full range
			3.0	6.0	9.0	$\mu s$	ADCS1:ADCS0 = 11 (RC oscillator source)
			2.0	4.0	6.0	$\mu s$	PIC16LC710, $V_{DD} = 3.0V$
131	TCNV	Conversion time (not including S/H time). Note 1	—	9.5TAD	—	—	
132	TACQ	Acquisition time	Note 2	20	—	$\mu s$	

\* 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  $T_{CY}$  cycle.

Note 2: See Section 13.1 for min conditions.

Applicable Devices	710	71	711	72	73	73A	74	74A
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## 18.0 DC AND AC CHARACTERISTICS GRAPHS AND TABLES FOR PIC16C710 AND PIC16C711

NOT AVAILABLE AT THIS TIME

# PIC16C7X

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Applicable Devices	710	71	711	72	73	73A	74	74A
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NOTES:

## 19.0 ELECTRICAL CHARACTERISTICS FOR PIC16C71

### Absolute Maximum Ratings †

Ambient temperature under bias.....	-55 to +125°C
Storage temperature.....	-65°C to +150°C
Voltage on any pin with respect to VSS (except VDD and $\overline{\text{MCLR}}$ ).....	-0.3V to (VDD + 0.3V)
Voltage on VDD with respect to VSS.....	0 to +7.5V
Voltage on $\overline{\text{MCLR}}$ with respect to VSS (Note 2).....	0 to +14V
Total power dissipation (Note 1).....	800 mW
Maximum current out of VSS pin.....	150 mA
Maximum current into VDD pin.....	100 mA
Input clamp current, I <sub>IK</sub> (V <sub>I</sub> < 0 or V <sub>I</sub> > VDD).....	±20 mA
Output clamp current, I <sub>OK</sub> (V <sub>O</sub> < 0 or V <sub>O</sub> > VDD).....	±20 mA
Maximum output current sunk by any I/O pin.....	25 mA
Maximum output current sourced by any I/O pin.....	20 mA
Maximum current sunk by PORTA.....	80 mA
Maximum current sourced by PORTA.....	50 mA
Maximum current sunk by PORTB.....	150 mA
Maximum current sourced by PORTB.....	100 mA

**Note 1:** Power dissipation is calculated as follows:  $P_{dis} = V_{DD} \times \{I_{DD} - \sum I_{OH}\} + \sum \{(V_{DD} - V_{OH}) \times I_{OH}\} + \sum (V_{OL} \times I_{OL})$

**Note 2:** Voltage spikes below VSS at the  $\overline{\text{MCLR}}$  pin, inducing currents greater than 80 mA, may cause latch-up. Thus, a series resistor of 50-100Ω should be used when applying a “low” level to the  $\overline{\text{MCLR}}$  pin rather than pulling this pin directly to VSS.

† NOTICE: 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 those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

**TABLE 19-1: CROSS REFERENCE OF DEVICE SPECS FOR OSCILLATOR CONFIGURATIONS AND FREQUENCIES OF OPERATION (COMMERCIAL DEVICES)**

OSC	PIC16C71-04	PIC16C71-20	PIC16LC71-04	JW Devices
RC	VDD: 4.0V to 6.0V IDD: 3.3 mA max. at 5.5V IPD: 14 μA max. at 4V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 1.8 mA typ. at 5.5V IPD: 1.0 μA typ. at 4V Freq: 4 MHz max.	VDD: 3.0V to 6.0V IDD: 1.4 mA typ. at 3.0V IPD: 0.6 μA typ. at 3V Freq: 4 MHz max.	VDD: 4.0V to 6.0V IDD: 3.3 mA max. at 5.5V IPD: 14 μA max. at 4V Freq: 4 MHz max.
XT	VDD: 4.0V to 6.0V IDD: 3.3 mA max. at 5.5V IPD: 14 μA max. at 4V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 1.8 mA typ. at 5.5V IPD: 1.0 μA typ. at 4V Freq: 4 MHz max.	VDD: 3.0V to 6.0V IDD: 1.4 mA typ. at 3.0V IPD: 0.6 μA typ. at 3V Freq: 4 MHz max.	VDD: 4.0V to 6.0V IDD: 3.3 mA max. at 5.5V IPD: 14 μA max. at 4V Freq: 4 MHz max.
HS	VDD: 4.5V to 5.5V IDD: 13.5 mA typ. at 5.5V IPD: 1.0 μA typ. at 4.5V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 30 mA max. at 5.5V IPD: 1.0 μA typ. at 4.5V Freq: 20 MHz max.	Do not use in HS mode	VDD: 4.5V to 5.5V IDD: 30 mA max. at 5.5V IPD: 1.0 μA typ. at 4.5V Freq: 20 MHz max.
LP	VDD: 4.0V to 6.0V IDD: 15 μA typ. at 32 kHz, 4.0V IPD: 0.6 μA typ. at 4.0V Freq: 200 kHz max.	Do not use in LP mode	VDD: 3.0V to 6.0V IDD: 32 μA max. at 32 kHz, 3.0V IPD: 9 μA max. at 3.0V Freq: 200 kHz max.	VDD: 3.0V to 6.0V IDD: 32 μA max. at 32 kHz, 3.0V IPD: 9 μA max. at 3.0V Freq: 200 kHz max.

The shaded sections indicate oscillator selections which are tested for functionality, but not for MIN/MAX specifications. It is recommended that the user select the device type that ensures the specifications required.

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## 19.1 DC Characteristics: PIC16C71-04 (Commercial, Industrial) PIC16C71-20 (Commercial, Industrial)

DC CHARACTERISTICS		Standard Operating Conditions (unless otherwise stated)					
		Operating temperature -40°C ≤ TA ≤ +85°C for industrial and 0°C ≤ TA ≤ +70°C for commercial					
Param No.	Characteristic	Sym	Min	Typ†	Max	Units	Conditions
D001 D001A	Supply Voltage	VDD	4.0 4.5	- -	6.0 5.5	V V	XT, RC and LP osc configuration HS osc configuration
D002*	RAM Data Retention Voltage (Note 1)	VDR	-	1.5	-	V	Device in SLEEP mode
D003	VDD start voltage to ensure internal Power-on Reset signal	VPOR	-	VSS	-	V	See section on Power-on Reset for details
D004*	VDD rise rate to ensure internal Power-on Reset signal	SVDD	0.05	-	-	V/ms	See section on Power-on Reset for details
D010 D013	Supply Current (Note 2)	IDD	- -	1.8 13.5	3.3 30	mA mA	FOSC = 4 MHz, VDD = 5.5V (Note 4) HS osc configuration (PIC16C71-20) FOSC = 20 MHz, VDD = 5.5V
D020 D021 D021A	Power-down Current (Note 3)	IPD	- - -	7 1.0 1.0	28 14 16	μA μA μA	VDD = 4.0V, WDT enabled, -40°C to +85°C VDD = 4.0V, WDT disabled, -0°C to +70°C VDD = 4.0V, WDT disabled, -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: This is the limit to which VDD can be lowered in SLEEP mode 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 configuration, current through Rext is not included. The current through the resistor can be estimated by the formula  $I_r = V_{DD}/2R_{ext}$  (mA) with Rext in kOhm.



## 19.2 DC Characteristics: PIC16LC71-04 (Commercial, Industrial)

DC CHARACTERISTICS		Standard Operating Conditions (unless otherwise stated)					
		Operating temperature -40°C ≤ TA ≤ +85°C for industrial and 0°C ≤ TA ≤ +70°C for commercial					
Param No.	Characteristic	Sym	Min	Typ†	Max	Units	Conditions
D001	Supply Voltage	VDD	3.0	-	6.0	V	XT, RC, and LP osc configuration
D002*	RAM Data Retention Voltage (Note 1)	VDR	-	1.5	-	V	Device in SLEEP mode
D003	VDD start voltage to ensure internal Power-on Reset signal	VPOR	-	VSS	-	V	See section on Power-on Reset for details
D004*	VDD rise rate to ensure internal Power-on Reset signal	SVDD	0.05	-	-	V/ms	See section on Power-on Reset for details
D010	Supply Current (Note 2)	IDD	-	1.4	2.5	mA	FOSC = 4 MHz, VDD = 3.0V (Note 4)
D010A			-	15	32	μA	FOSC = 32 kHz, VDD = 3.0V, WDT disabled
D020	Power-down Current (Note 3)	IPD	-	5	20	μA	VDD = 3.0V, WDT enabled, -40°C to +85°C
D021			-	0.6	9	μA	VDD = 3.0V, WDT disabled, 0°C to +70°C
D021A			-	0.6	12	μA	VDD = 3.0V, WDT disabled, -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: This is the limit to which VDD can be lowered in SLEEP mode 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 configuration, current through Rext is not included. The current through the resistor can be estimated by the formula  $I_r = V_{DD}/2R_{ext}$  (mA) with Rext in kOhm.

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**19.3 DC Characteristics: PIC16C71-04 (Commercial, Industrial)  
PIC16C71-20 (Commercial, Industrial)  
PIC16LC71-04 (Commercial, Industrial)**

Standard Operating Conditions (unless otherwise stated)							
DC CHARACTERISTICS							
Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$ for industrial and $0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$ for commercial							
Operating voltage $V_{DD}$ range as described in DC spec Section 19.1 and Section 19.2.							
Param No.	Characteristic	Sym	Min	Typ †	Max	Units	Conditions
D030	<b>Input Low Voltage</b> I/O ports with TTL buffer	$V_{IL}$	$V_{SS}$	-	0.5V	V	
D031	with Schmitt Trigger buffer		$V_{SS}$	-	0.2V <sub>DD</sub>	V	
D032	$\overline{\text{MCLR}}$ , RA4/T0CKI, OSC1 (in RC mode)		$V_{SS}$	-	0.2V <sub>DD</sub>	V	
D033	OSC1 (in XT, HS and LP)		$V_{SS}$	-	0.3V <sub>DD</sub>	V	Note1
D040	<b>Input High Voltage</b> I/O ports (Note 4) with TTL buffer	$V_{IH}$	0.36V <sub>DD</sub>	-	V <sub>DD</sub>	V	$4.5 \leq V_{DD} \leq 5.5\text{V}$
D040A			0.45V <sub>DD</sub>	-	V <sub>DD</sub>	V	For $V_{DD} > 5.5\text{V}$ or $V_{DD} < 4.5\text{V}$
D041	with Schmitt Trigger buffer		0.85V <sub>DD</sub>	-	V <sub>DD</sub>	V	For entire VDD range
D042	$\overline{\text{MCLR}}$ RA4/T0CKI		0.85V <sub>DD</sub>	-	V <sub>DD</sub>	V	
D042A	OSC1 (XT, HS and LP)		0.7V <sub>DD</sub>	-	V <sub>DD</sub>	V	Note1
D043	OSC1 (in RC mode)		0.9V <sub>DD</sub>	-	V <sub>DD</sub>	V	
D070	PORTB weak pull-up current	IPURB	50	250	†400	μA	$V_{DD} = 5\text{V}$ , $V_{PIN} = V_{SS}$
D060	<b>Input Leakage Current</b> (Notes 2, 3) I/O ports	$I_{IL}$	-	-	±1	μA	$V_{SS} \leq V_{PIN} \leq V_{DD}$ , Pin at hi-impedance
D061	$\overline{\text{MCLR}}$ , RA4/T0CKI		-	-	±5	μA	$V_{SS} \leq V_{PIN} \leq V_{DD}$
D063	OSC1		-	-	±5	μA	$V_{SS} \leq V_{PIN} \leq V_{DD}$ , XT, HS and LP osc configuration
D080	<b>Output Low Voltage</b> I/O ports	$V_{OL}$	-	-	0.6	V	$I_{OL} = 8.5\text{mA}$ , $V_{DD} = 4.5\text{V}$ , $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$
D083	OSC2/CLKOUT (RC osc config)		-	-	0.6	V	$I_{OL} = 1.6\text{mA}$ , $V_{DD} = 4.5\text{V}$ , $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$
D090	<b>Output High Voltage</b> I/O ports (Note 3)	$V_{OH}$	$V_{DD} - 0.7$	-	-	V	$I_{OH} = -3.0\text{mA}$ , $V_{DD} = 4.5\text{V}$ , $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$
D092	OSC2/CLKOUT (RC osc config)		$V_{DD} - 0.7$	-	-	V	$I_{OH} = -1.3\text{mA}$ , $V_{DD} = 4.5\text{V}$ , $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$
D100	<b>Capacitive Loading Specs on Output Pins</b> OSC2 pin	$C_{OSC2}$			15	pF	In XT, HS and LP modes when external clock is used to drive OSC1.
D101	All I/O pins and OSC2 (in RC mode)	$C_{IO}$			50	pF	

† 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 configuration, the OSC1 pin is a Schmitt trigger input. It is not recommended that the PIC16C71 be driven with external clock in RC mode.
- 2: The leakage current on the  $\overline{\text{MCLR}}$  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 coming out of the pin.
- 4: PIC16C71 Rev. "Ax" INT pin has a TTL input buffer. PIC16C71 Rev. "Bx" INT pin has a Schmitt Trigger input buffer.

## 19.4 Timing Parameter Symbology

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

- |             |           |  |
|-------------|-----------|--|
| 1. TppS2ppS | 3. TCC:ST | (I <sup>2</sup> C specifications only) |
| 2. TppS     | 4. Ts     | (I <sup>2</sup> C specifications only) |

<b>T</b>			
F	Frequency	T	Time

Lowercase letters (pp) and their meanings:

<b>pp</b>			
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	$\overline{WR}$

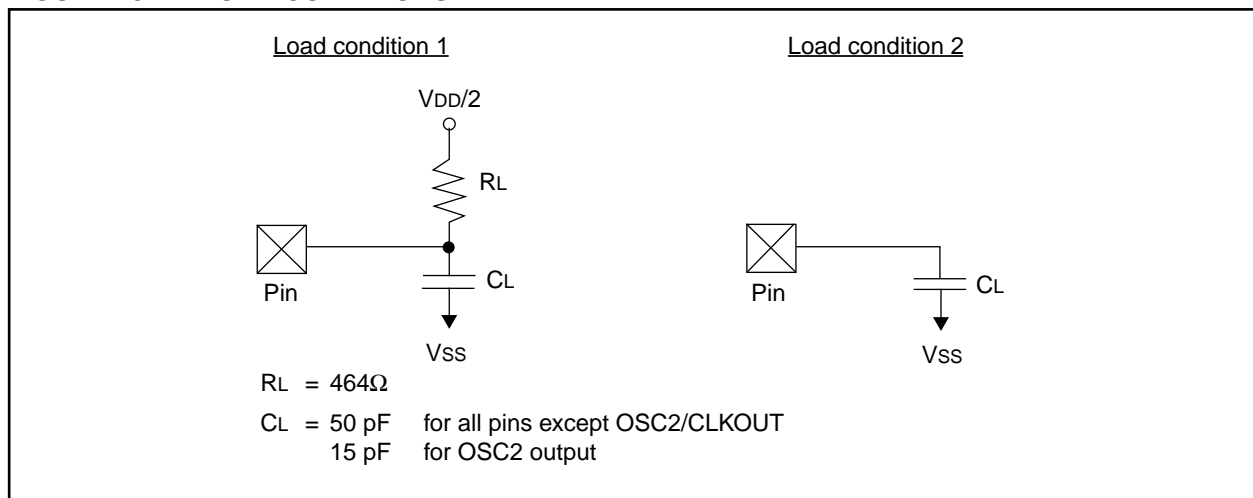
Uppercase letters and their meanings:

<b>S</b>			
F	Fall	P	Period
H	High	R	Rise
I	Invalid (Hi-impedance)	V	Valid
L	Low	Z	Hi-impedance
<b>I<sup>2</sup>C only</b>			
AA	output access	High	High
BUF	Bus free	Low	Low

TCC:ST (I<sup>2</sup>C specifications only)

<b>CC</b>			
HD	Hold	SU	Setup
<b>ST</b>			
DAT	DATA input hold	STO	STOP condition
STA	START condition		

**FIGURE 19-1: LOAD CONDITIONS**



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## 19.5 Timing Diagrams and Specifications

FIGURE 19-2: EXTERNAL CLOCK TIMING

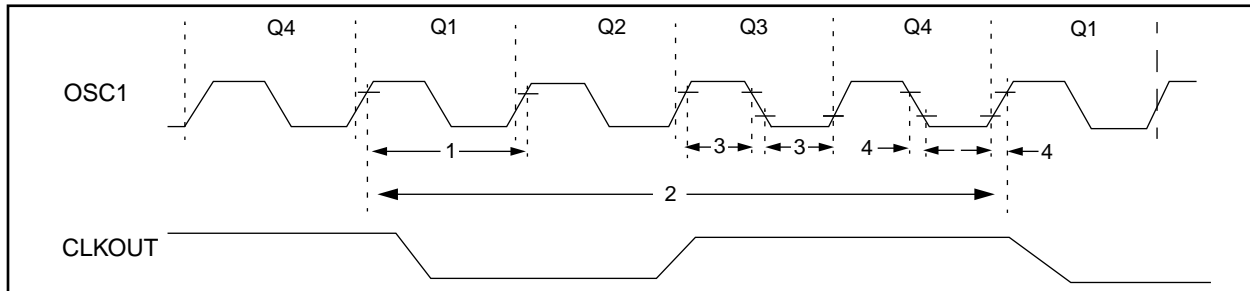


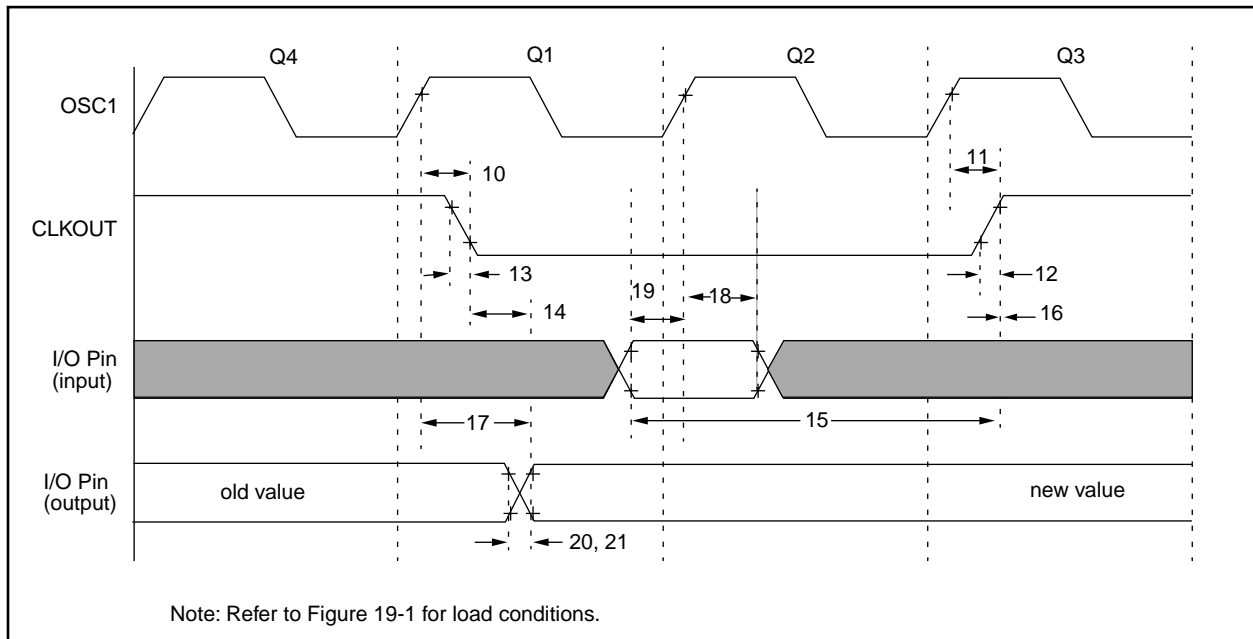
TABLE 19-2: EXTERNAL CLOCK TIMING REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
	Fosc	External CLKIN Frequency (Note 1)	DC	—	4	MHz	XT and RC osc mode
			DC	—	4	MHz	HS osc mode (PIC16C71-04)
			DC	—	20	MHz	HS osc mode (PIC16C71-20)
			DC	—	200	kHz	LP osc mode
		Oscillator Frequency (Note 1)	DC	—	4	MHz	RC osc mode
			0.1	—	4	MHz	XT osc mode
			1	—	4	MHz	HS osc mode (PIC16C71-04)
			1	—	20	MHz	HS osc mode (PIC16C71-20)
1	Tosc	External CLKIN Period (Note 1)	250	—	—	ns	XT and RC osc mode
			250	—	—	ns	HS osc mode (PIC16C71-04)
			50	—	—	ns	HS osc mode (PIC16C71-20)
			5	—	—	μs	LP osc mode
		Oscillator Period (Note 1)	250	—	—	ns	RC osc mode
			250	—	10,000	ns	XT osc mode
			250	—	1,000	ns	HS osc mode (PIC16C71-04)
			50	—	1,000	ns	HS osc mode (PIC16C71-20)
			5	—	—	μs	LP osc mode
2	Tcy	Instruction Cycle Time (Note 1)	1.0	Tcy	DC	μs	Tcy = 4/Fosc
3	TosL, TosH	External Clock in (OSC1) High or Low Time	50	—	—	ns	XT oscillator
			2.5	—	—	μs	LP oscillator
			10	—	—	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

† 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. OSC2 is disconnected (has no loading) for the PIC16C71.

**FIGURE 19-3: CLKOUT AND I/O TIMING**



**TABLE 19-3: CLKOUT AND I/O TIMING REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
10*	TosH2ckL	OSC1↑ to CLKOUT↓	—	15	30	ns	Note 1
11*	TosH2ckH	OSC1↑ to CLKOUT↑	—	15	30	ns	Note 1
12*	TckR	CLKOUT rise time	—	5	15	ns	Note 1
13*	TckF	CLKOUT fall time	—	5	15	ns	Note 1
14*	TckL2ioV	CLKOUT ↓ to Port out valid	—	—	0.5T <sub>CY</sub> + 20	ns	Note 1
15*	TioV2ckH	Port in valid before CLKOUT ↑	0.25T <sub>CY</sub> + 25	—	—	ns	Note 1
16*	TckH2ioL	Port in hold after CLKOUT ↑	0	—	—	ns	Note 1
17*	TosH2ioV	OSC1↑ (Q1 cycle) to Port out valid	—	—	80 - 100	ns	
18*	TosH2ioL	OSC1↑ (Q2 cycle) to Port input invalid (I/O in hold time)	PIC16C71	100	—	—	ns
			PIC16LC71	200	—	—	ns
19*	TioV2osH	Port input valid to OSC1↑ (I/O in setup time)	0	—	—	ns	
20*	TioR	Port output rise time	PIC16C71	—	10	25	ns
			PIC16LC71	—	—	60	ns
21*	TioF	Port output fall time	PIC16C71	—	10	25	ns
			PIC16LC71	—	—	60	ns
22††*	Tinp	INT pin high or low time	20	—	—	ns	
23††*	Trbp	RB7:RB4 change INT high or low time	20	—	—	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.

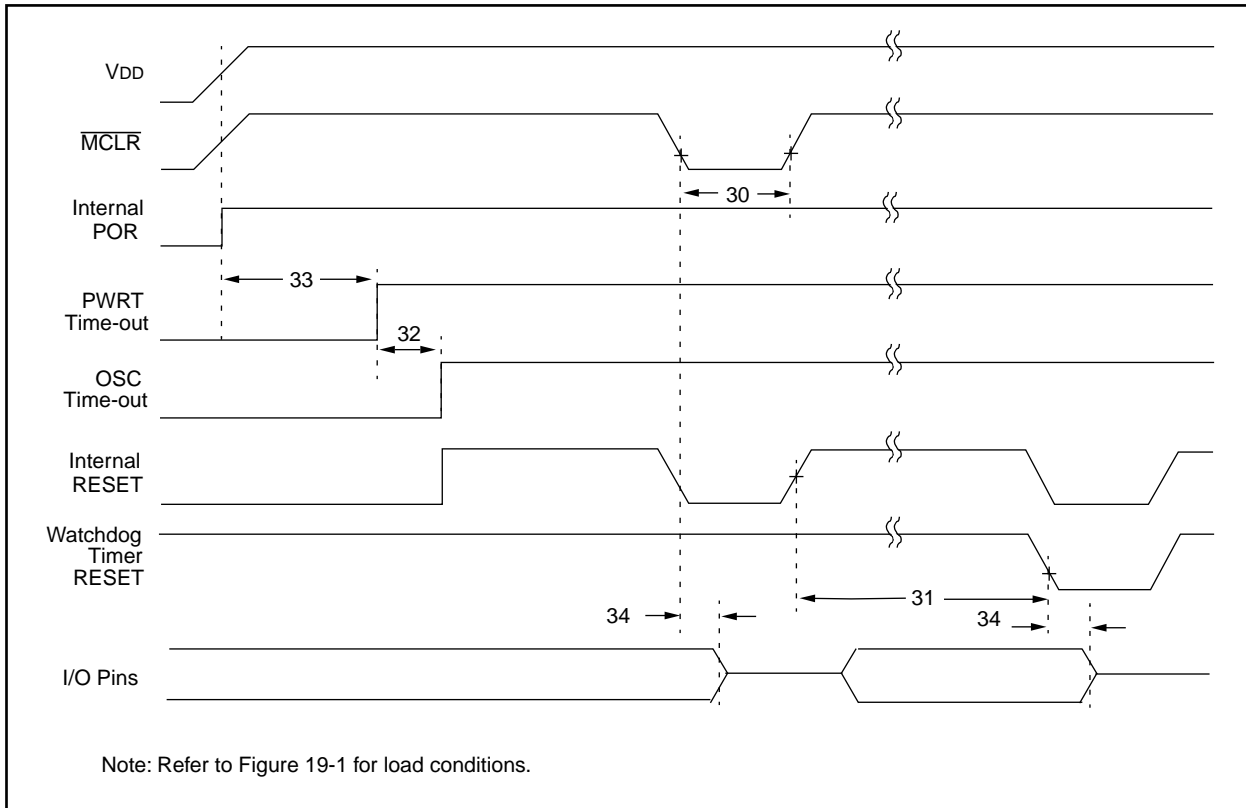
†† These parameters are asynchronous events not related to any internal clock edges.

Note 1: Measurements are taken in RC Mode where CLKOUT output is 4 x T<sub>OSC</sub>.

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**FIGURE 19-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER TIMING**



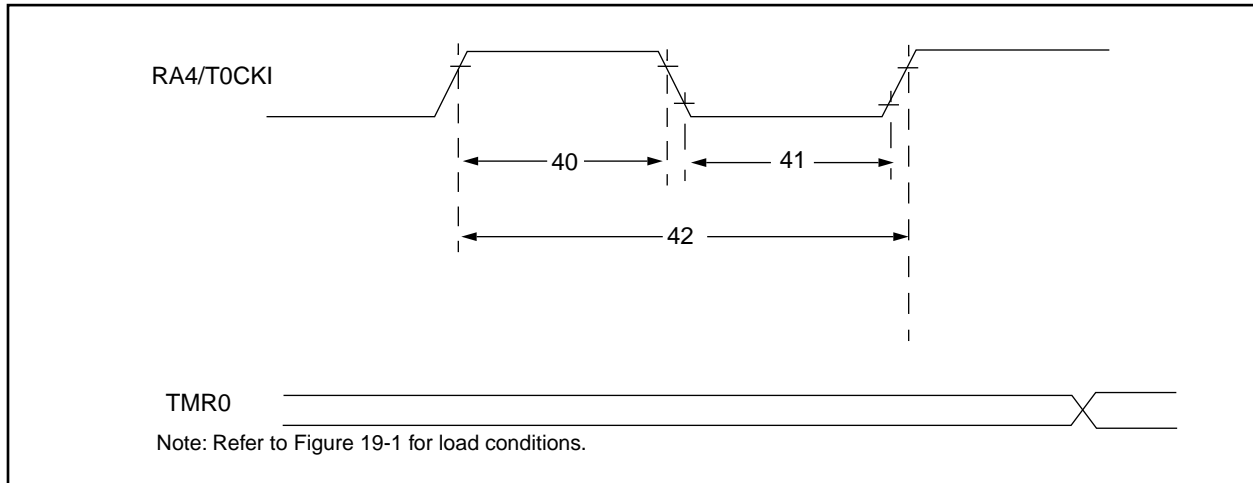
**TABLE 19-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
30	Tmcl	MCLR Pulse Width (low)	200	—	—	ns	V <sub>DD</sub> = 5V, -40°C to +85°C
31	Twdt	Watchdog Timer Time-out Period (No Prescaler)	7*	18	33*	ms	V <sub>DD</sub> = 5V, -40°C to +85°C
32	Tost	Oscillation Start-up Timer Period	—	1024 T <sub>osc</sub>	—	—	T <sub>osc</sub> = OSC1 period
33	Tpwrt	Power-up Timer Period	28*	72	132*	ms	V <sub>DD</sub> = 5V, -40°C to +85°C
34	Tioz	I/O High Impedance from MCLR Low	—	—	100	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 19-5: TIMER0 CLOCK TIMINGS**



**TABLE 19-5: TIMER0 CLOCK REQUIREMENTS**

Param No.	Sym	Characteristic		Min	Typ†	Max	Units	Conditions
40	Tt0H	T0CKI High Pulse Width	No Prescaler	$0.5T_{CY} + 20^*$	—	—	ns	
			With Prescaler	$10^*$	—	—	ns	
41	Tt0L	T0CKI Low Pulse Width	No Prescaler	$0.5T_{CY} + 20^*$	—	—	ns	
			With Prescaler	$10^*$	—	—	ns	
42	Tt0P	T0CKI Period		Greater of: $20\mu s$ or $\frac{T_{CY} + 40^*}{N}$	—	—	ns	N = prescale value (2, 4, ..., 256)

\* 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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**TABLE 19-6: A/D CONVERTER CHARACTERISTICS:  
PIC16C71-04 (COMMERCIAL, INDUSTRIAL)  
PIC16C71-20 (COMMERCIAL, INDUSTRIAL)**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
	NR	Resolution	—	—	8 bits	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NINT	Integral error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NDIF	Differential error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NFS	Full scale error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NOFF	Offset error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	—	Monotonicity	—	guaranteed	—	—	$V_{SS} \leq A_{IN} \leq V_{REF}$
	VREF	Reference voltage	3.0V	—	$V_{DD} + 0.3$	V	
	VAIN	Analog input voltage	$V_{SS} - 0.3$	—	VREF	V	
	ZAIN	Recommended impedance of analog voltage source	—	—	10.0	k $\Omega$	
	IAD	A/D conversion current (VDD)	—	180	—	$\mu A$	Average current consumption when A/D is on. (Note 1)
	IREF	VREF input current (Note 2)	—	—	1 40	mA $\mu A$	During sampling All other times

\* 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: When A/D is off, it will not consume any current other than minor leakage current. The power-down current spec includes any such leakage from the A/D module.

2: VREF current is from RA3 pin or VDD pin, whichever is selected as reference input.



**TABLE 19-7: A/D CONVERTER CHARACTERISTICS:  
PIC16LC71-04 (COMMERCIAL, INDUSTRIAL)**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
	NR	Resolution	—	—	8 bits	—	VREF = VDD = 3.0V (Note 1)
	NINT	Integral error	—	—	less than ±2 LSb	—	VREF = VDD = 3.0V (Note 1)
	NDIF	Differential error	—	—	less than ±2 LSb	—	VREF = VDD = 3.0V (Note 1)
	NFS	Full scale error	—	—	less than ±2 LSb	—	VREF = VDD = 3.0V (Note 1)
	NOFF	Offset error	—	—	less than ±2 LSb	—	VREF = VDD = 3.0V (Note 1)
	—	Monotonicity	—	guaranteed	—	—	VSS ≤ AIN ≤ VREF
	VREF	Reference voltage	3.0V	—	VDD + 0.3	V	
	VAIN	Analog input voltage	VSS - 0.3	—	VREF	V	
	ZAIN	Recommended impedance of analog voltage source	—	—	10.0	kΩ	
	IAD	A/D conversion current (VDD)	—	180	—	μA	Average current consumption when A/D is on. (Note 2)
	IREF	VREF input current (Note 3)	—	—	1 10	mA μA	During sampling All other times

\* 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: These specifications apply if VREF = 3.0V and if VDD ≥ 3.0V. VIN must be between VSS and VREF

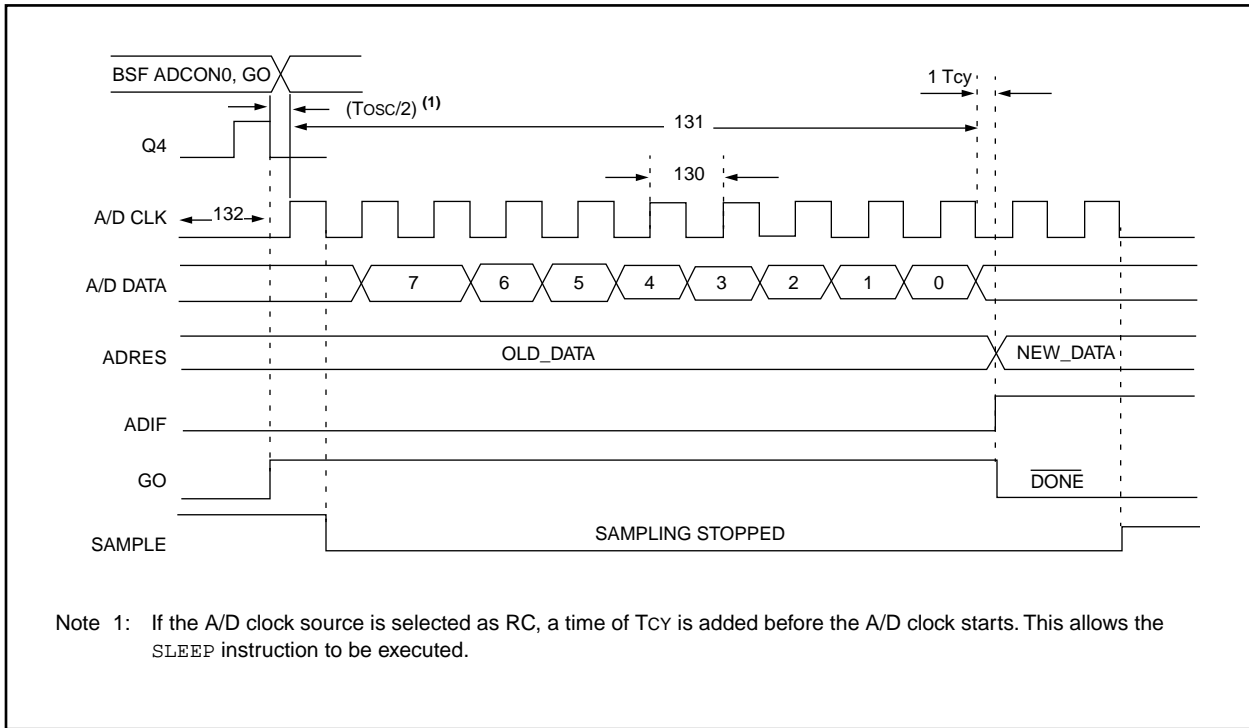
2: When A/D is off, it will not consume any current other than minor leakage current. The power-down current spec includes any such leakage from the A/D module.

3: VREF current is from RA3 pin or VDD pin, whichever is selected as reference input.

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**FIGURE 19-6: A/D CONVERSION TIMING**



**TABLE 19-8: A/D CONVERSION REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions	
130	TAD	A/D clock period	2.0	—	—	$\mu\text{s}$	TOSC based, $V_{REF} \geq 3.0\text{V}$	
			PIC16C71	2.0	4.0	6.0	$\mu\text{s}$	A/D RC Mode
			PIC16LC71	3.0	6.0	9.0	$\mu\text{s}$	A/D RC Mode
131	T <sub>CNV</sub>	Conversion time (not including S/H time) (Note 1)	—	10TAD	—	—		
132	TACQ	Acquisition time	Note 2	20	—	$\mu\text{s}$		

\* 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  $T_{CY}$  cycle.

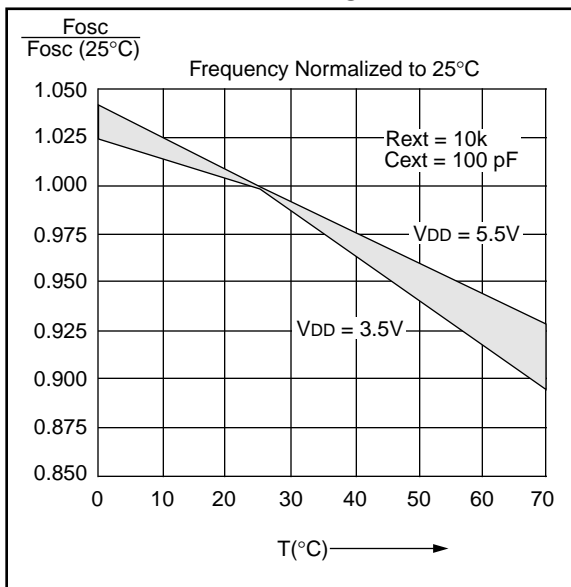
Note 2: See Section 13.1 for min conditions.

## 20.0 DC AND AC CHARACTERISTICS GRAPHS AND TABLES FOR PIC16C71

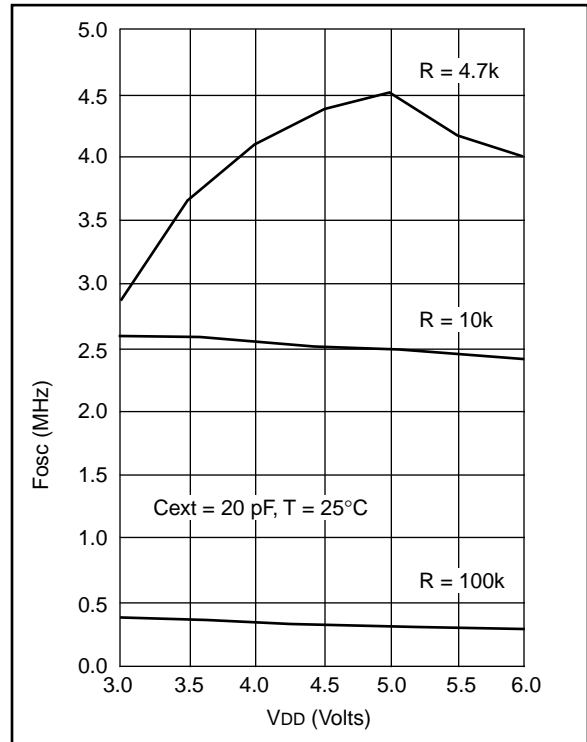
The graphs and tables provided in this section are for design guidance and are not tested or guaranteed. In some graphs or tables the data presented are outside specified operating range (e.g. outside specified  $V_{DD}$  range). This is for information only and devices are guaranteed to operate properly only within the specified range.

The data presented in this section is a statistical summary of data collected on units from different lots over a period of time and matrix samples. 'Typical' represents the mean of the distribution while 'max' or 'min' represents (mean +  $3\sigma$ ) and (mean -  $3\sigma$ ) respectively where  $\sigma$  is standard deviation.

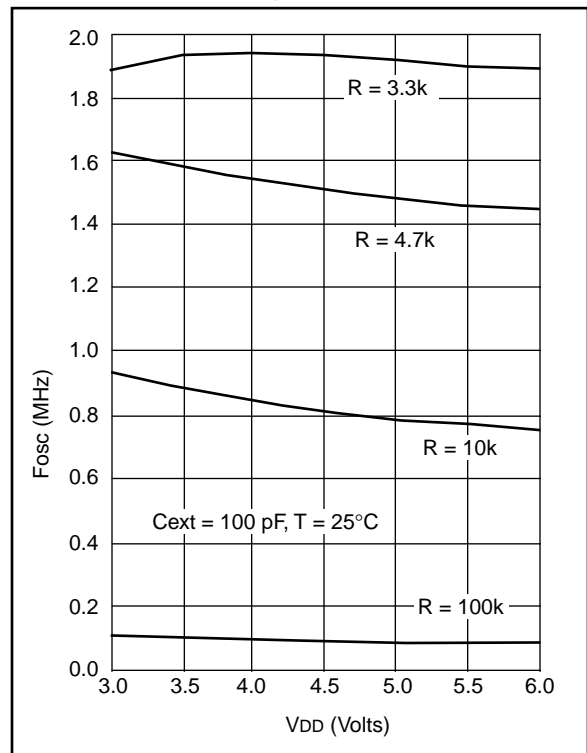
**FIGURE 20-1: TYPICAL RC OSCILLATOR FREQUENCY VS. TEMPERATURE**



**FIGURE 20-2: TYPICAL RC OSCILLATOR FREQUENCY VS.  $V_{DD}$**



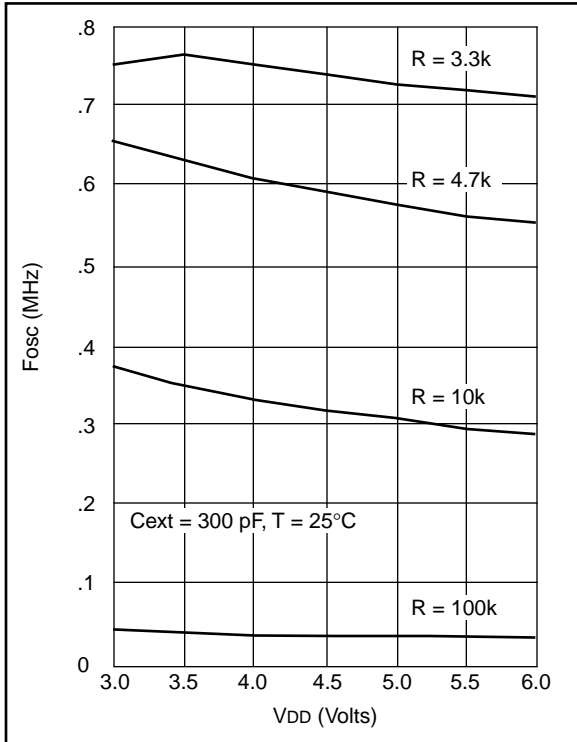
**FIGURE 20-3: TYPICAL RC OSCILLATOR FREQUENCY VS.  $V_{DD}$**



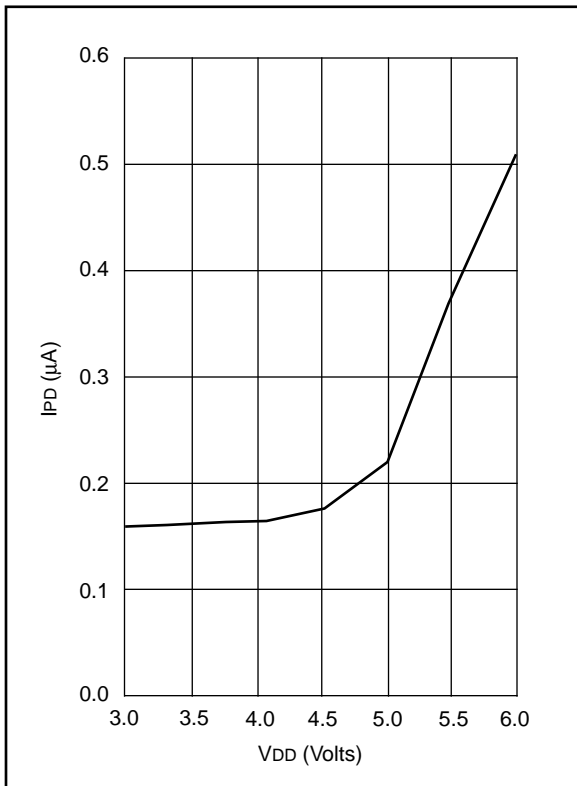
# PIC16C7X

Applicable Devices 710 71 711 72 73 73A 74 74A

**FIGURE 20-4: TYPICAL RC OSCILLATOR FREQUENCY vs. V<sub>DD</sub>**



**FIGURE 20-5: TYPICAL I<sub>PD</sub> vs. V<sub>DD</sub> WATCHDOG TIMER DISABLED 25°C**

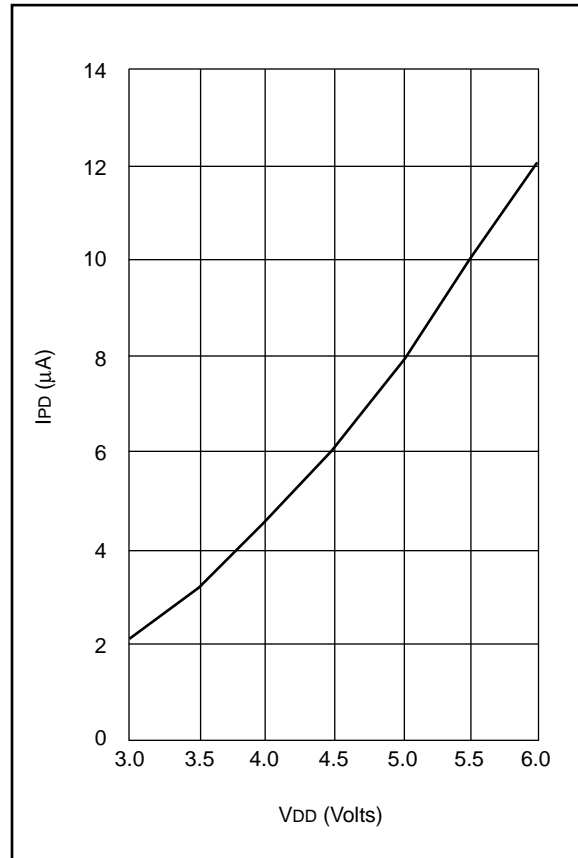


**TABLE 20-1: RC OSCILLATOR FREQUENCIES**

Cext	Rext	Average	
		Fosc @ 5V, 25°C	
20 pf	4.7k	4.52 MHz	±17.35%
	10k	2.47 MHz	±10.10%
	100k	290.86 kHz	±11.90%
100 pf	3.3k	1.92 MHz	±9.43%
	4.7k	1.49 MHz	±9.83%
	10k	788.77 kHz	±10.92%
300 pf	100k	88.11 kHz	±16.03%
	3.3k	726.89 kHz	±10.97%
	4.7k	573.95 kHz	±10.14%
10k	10k	307.31 kHz	±10.43%
	100k	33.82 kHz	±11.24%

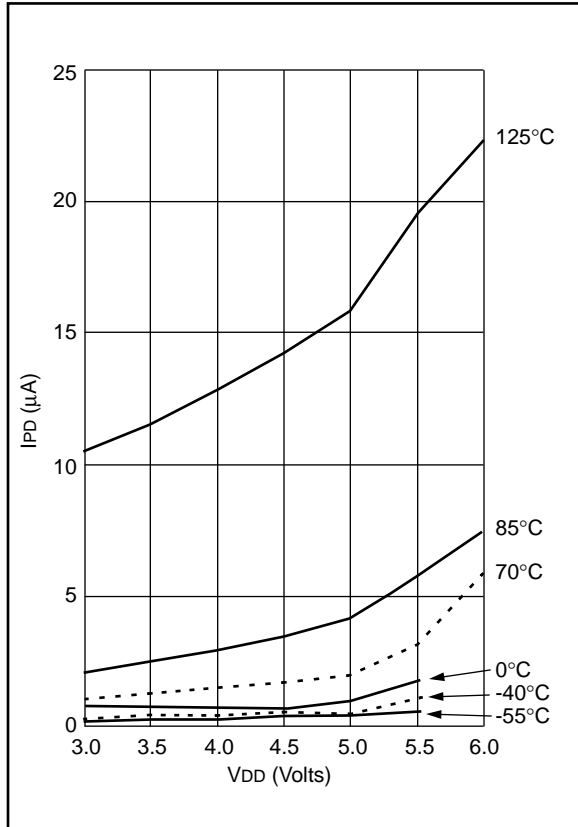
The percentage variation indicated here is part to part variation due to normal process distribution. The variation indicated is ±3 standard deviation from average value for V<sub>DD</sub> = 5V.

**FIGURE 20-6: TYPICAL I<sub>PD</sub> vs. V<sub>DD</sub> WATCHDOG TIMER ENABLED 25°C**

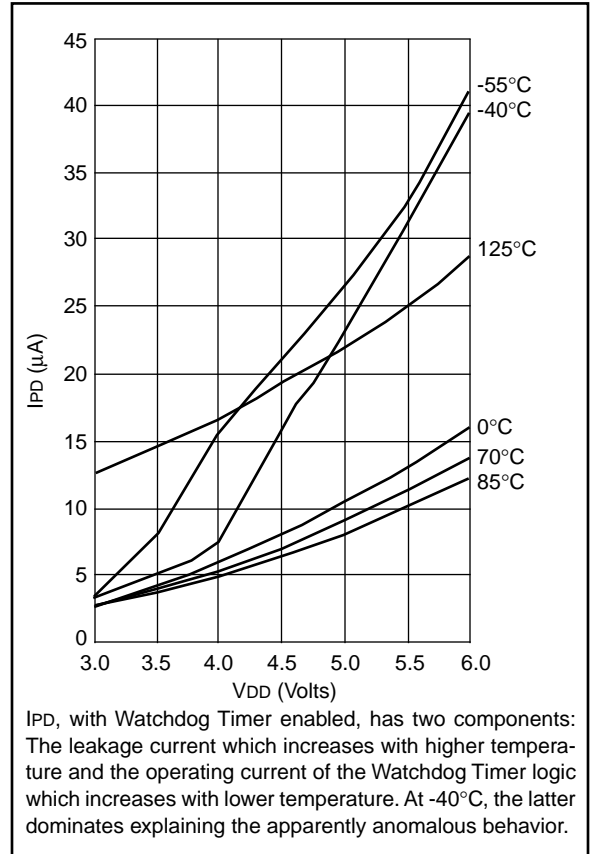


Data based on matrix samples. See first page of this section for details.

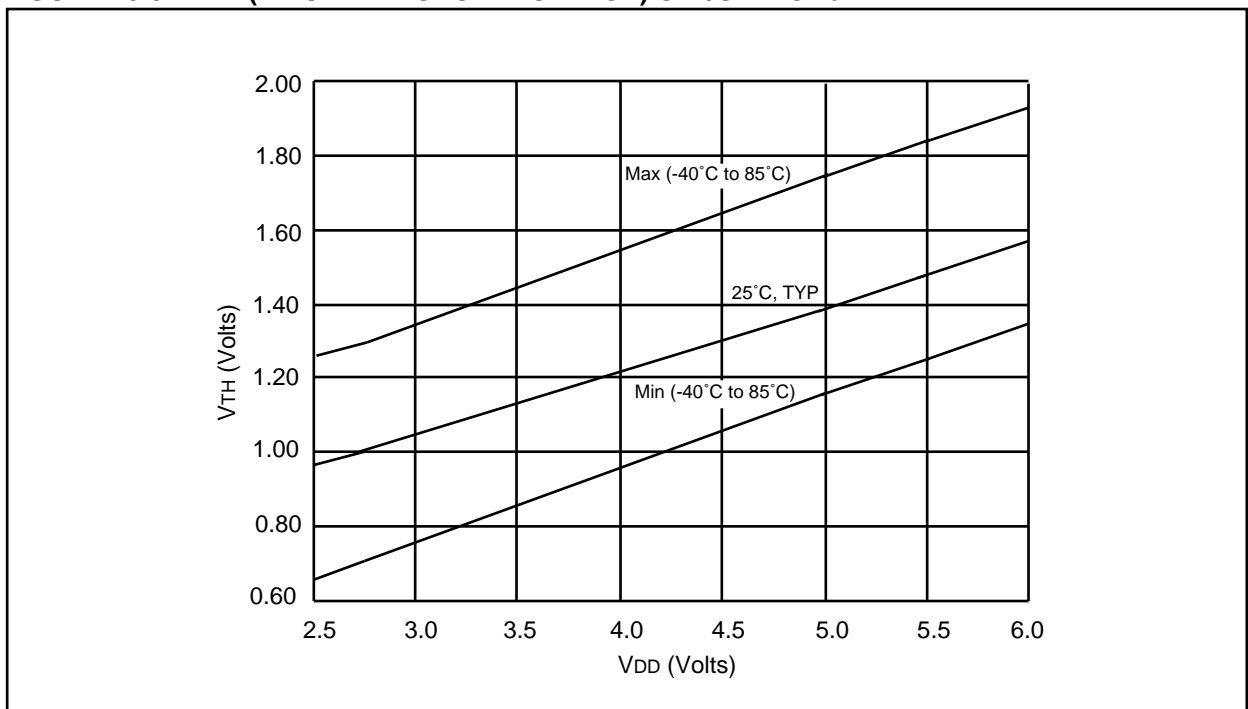
**FIGURE 20-7: MAXIMUM IPD vs. VDD  
WATCHDOG DISABLED**



**FIGURE 20-8: MAXIMUM IPD vs. VDD  
WATCHDOG ENABLED**



**FIGURE 20-9: VTH (INPUT THRESHOLD VOLTAGE) OF I/O PINS vs. VDD**

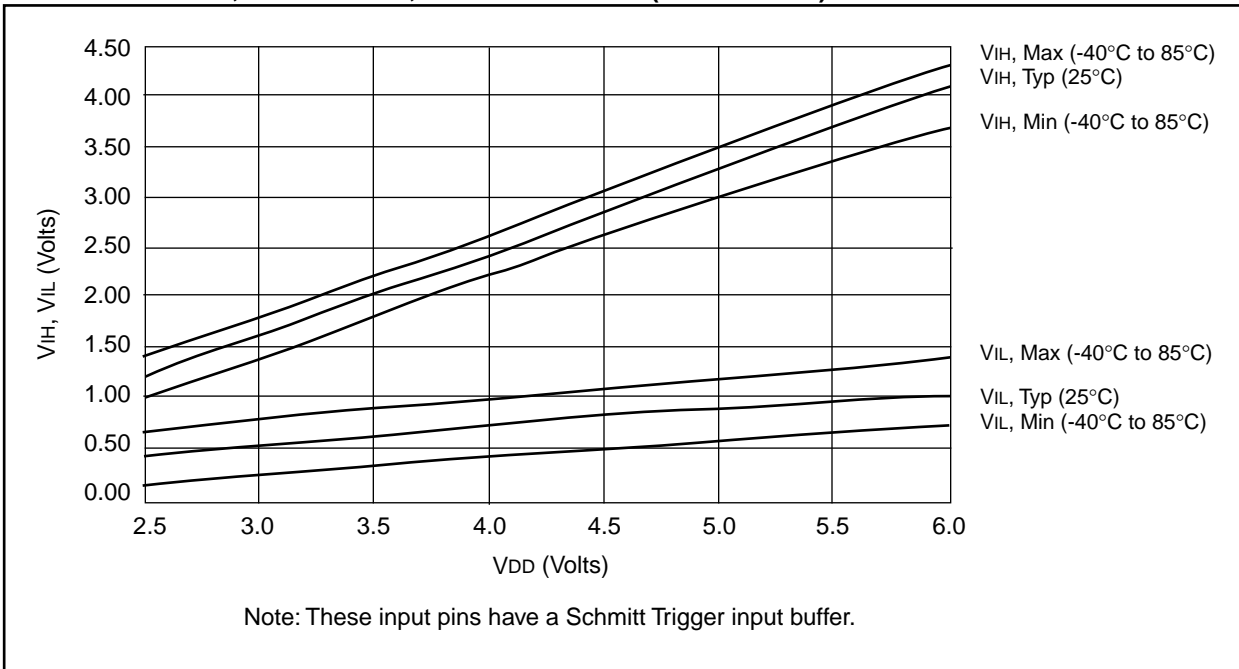


Data based on matrix samples. See first page of this section for details.

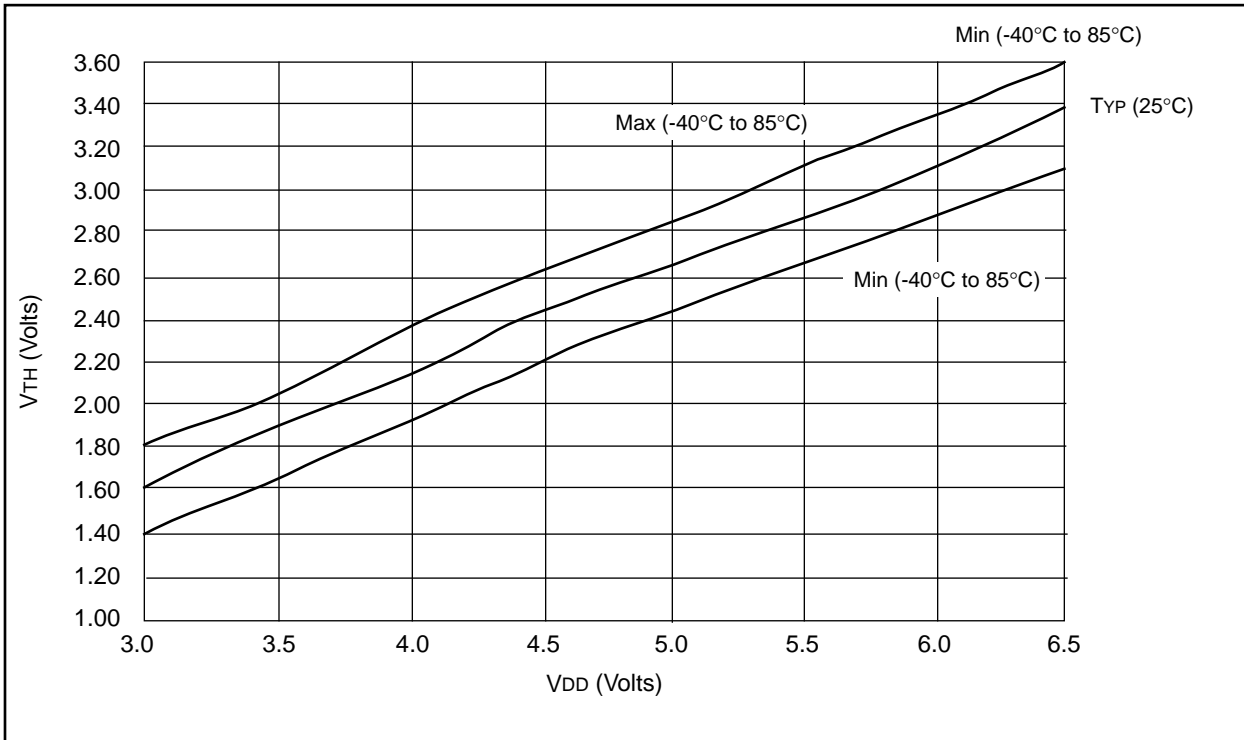
# PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

**FIGURE 20-10:  $V_{IH}$ ,  $V_{IL}$  OF  $\overline{MCLR}$ ,  $T0CKI$  AND  $OSC1$  (IN RC MODE) vs.  $V_{DD}$**

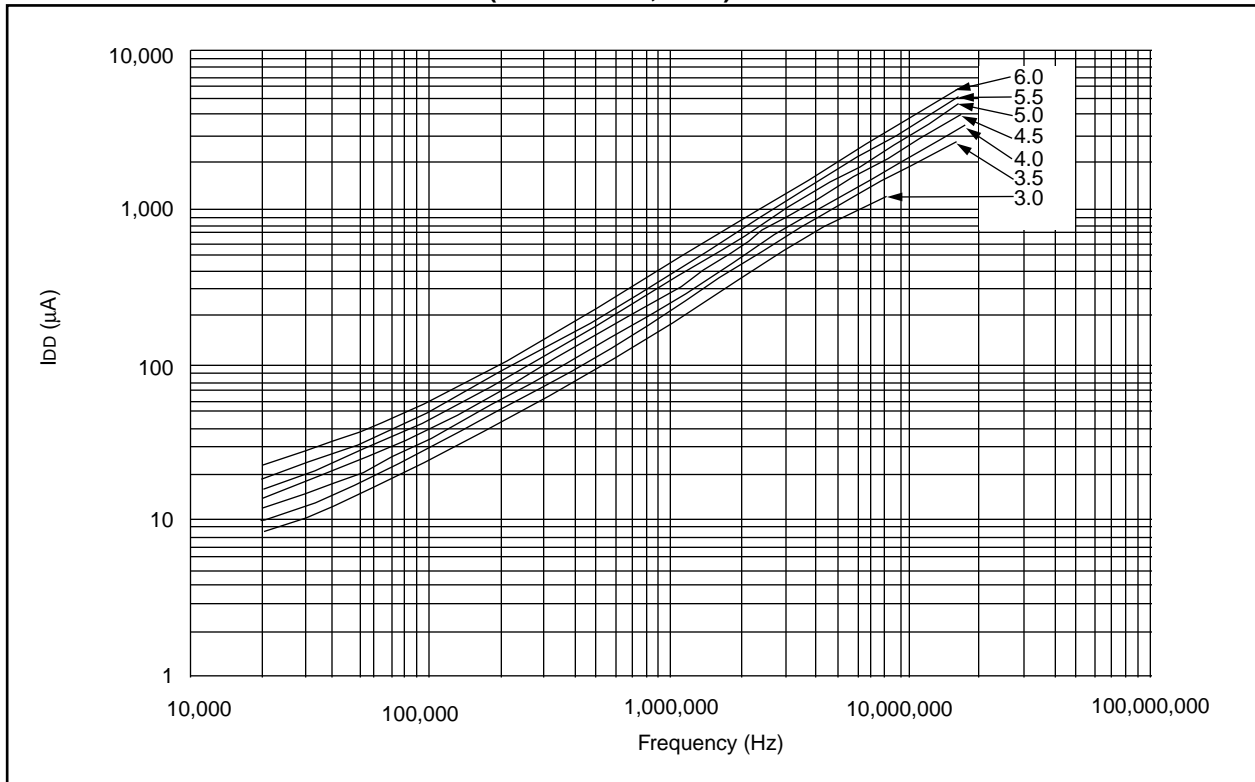


**FIGURE 20-11:  $V_{TH}$  (INPUT THRESHOLD VOLTAGE) OF  $OSC1$  INPUT (IN XT, HS, AND LP MODES) vs.  $V_{DD}$**

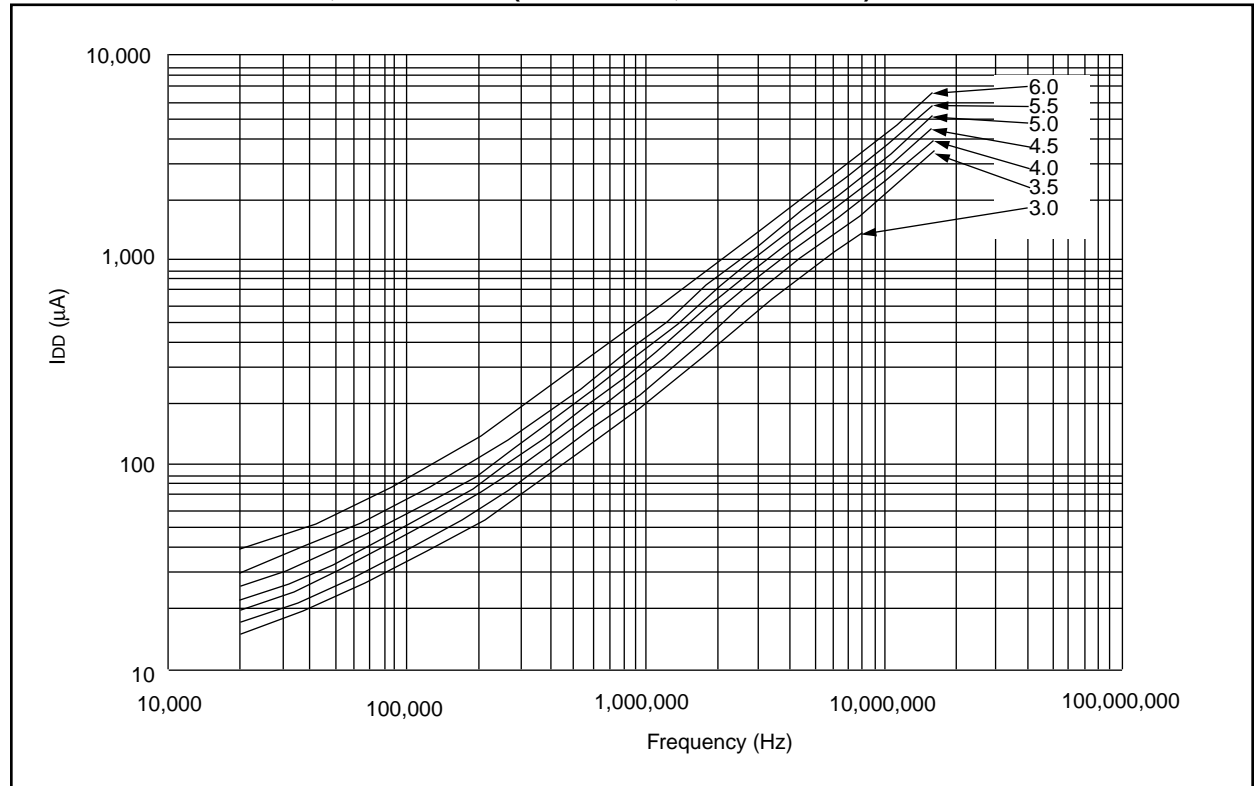


Data based on matrix samples. See first page of this section for details.

**FIGURE 20-12: TYPICAL  $I_{DD}$  vs. FREQ (EXT CLOCK, 25°C)**



**FIGURE 20-13: MAXIMUM,  $I_{DD}$  vs. FREQ (EXT CLOCK, -40° TO +85°C)**

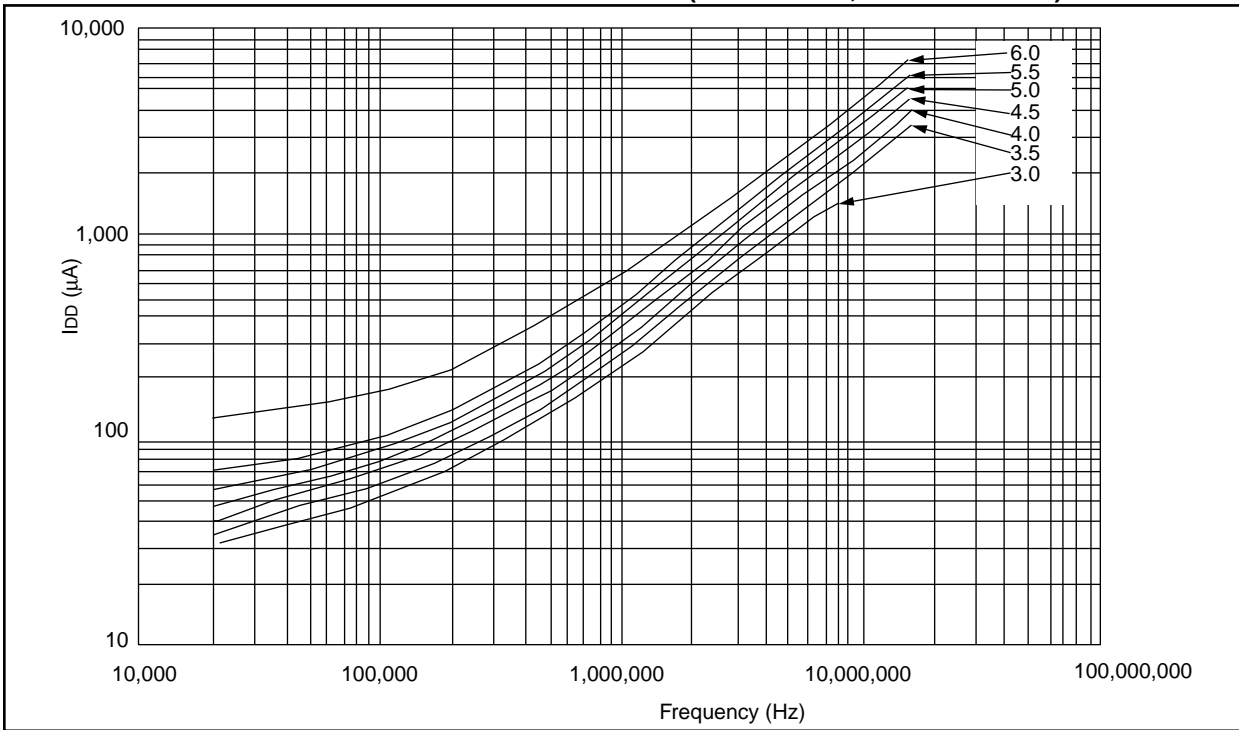


Data based on matrix samples. See first page of this section for details.

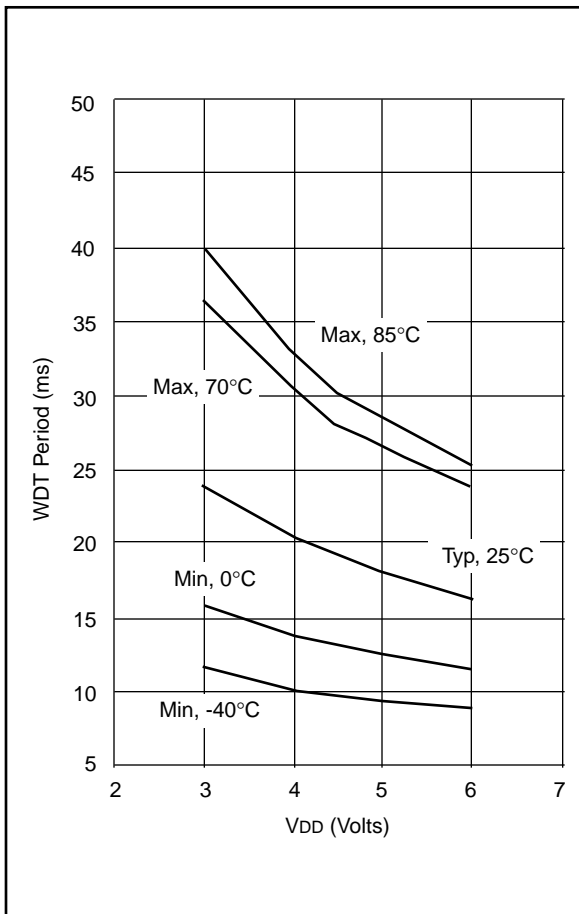
# PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

**FIGURE 20-14: MAXIMUM  $I_{DD}$  vs. FREQ WITH A/D OFF (EXT CLOCK,  $-55^{\circ}$  TO  $+125^{\circ}$ C)**



**FIGURE 20-15: WDT TIMER TIME-OUT PERIOD vs.  $V_{DD}$**



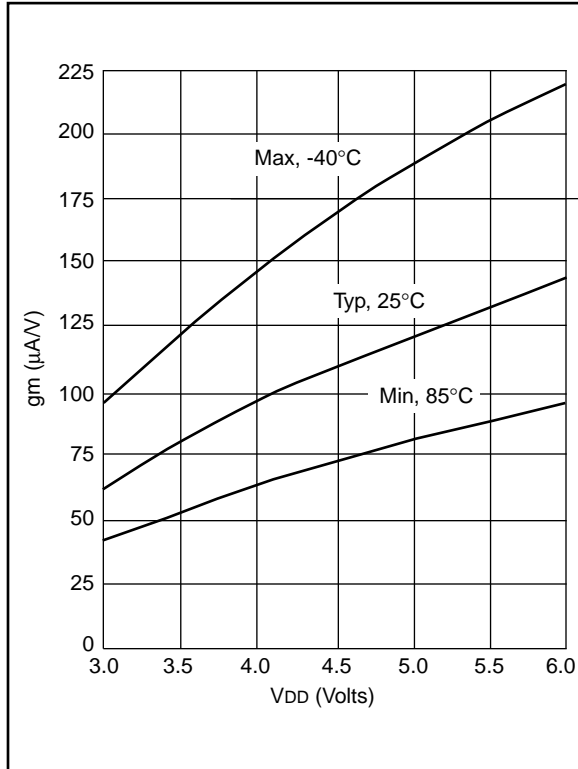
**FIGURE 20-16: TRANSCONDUCTANCE ( $g_m$ ) OF HS OSCILLATOR vs.  $V_{DD}$**



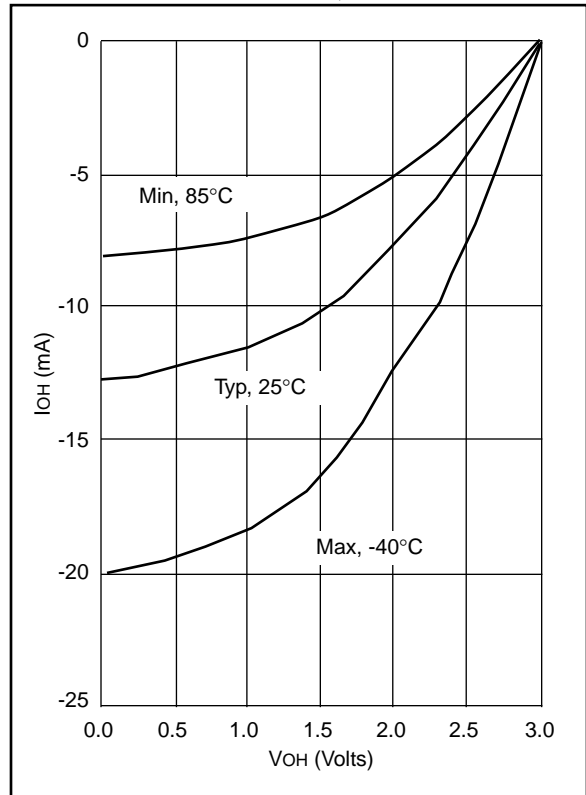
Data based on matrix samples. See first page of this section for details.



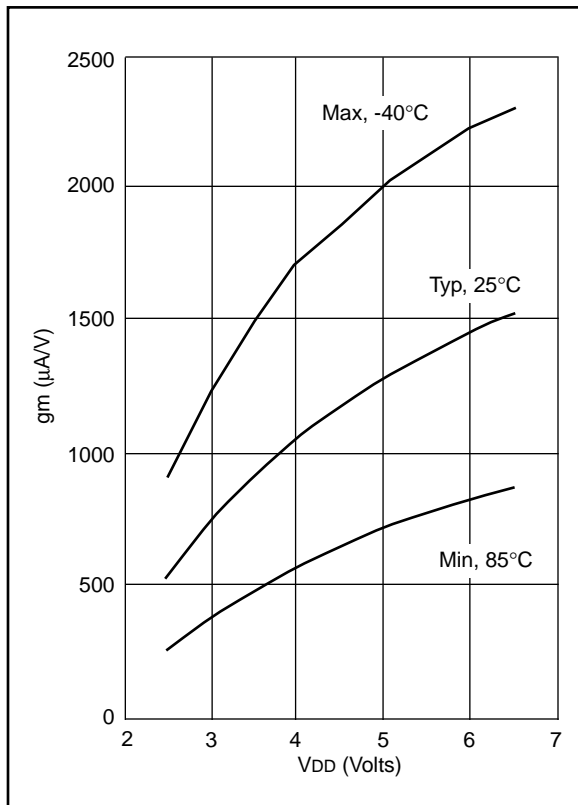
**FIGURE 20-17: TRANSCONDUCTANCE (gm) OF LP OSCILLATOR vs. VDD**



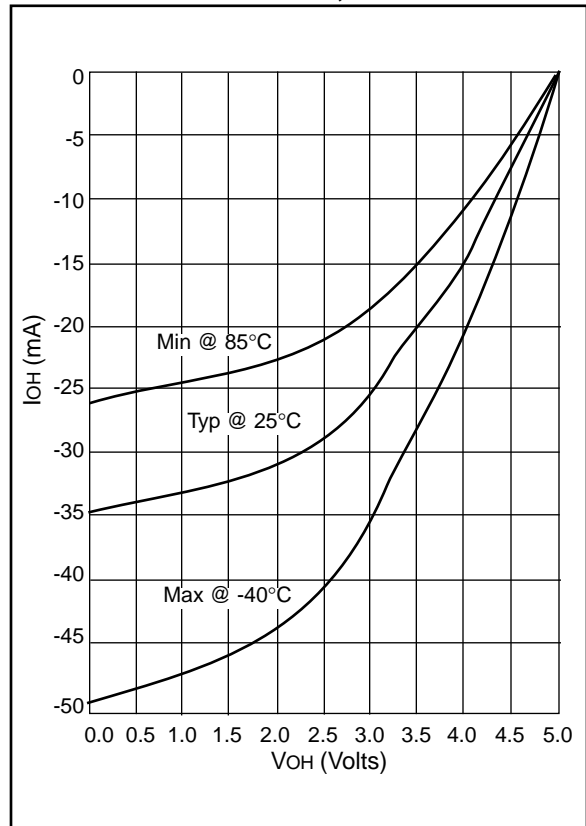
**FIGURE 20-19: I<sub>OH</sub> vs. V<sub>OH</sub>, V<sub>DD</sub> = 3V**



**FIGURE 20-18: TRANSCONDUCTANCE (gm) OF XT OSCILLATOR vs. VDD**



**FIGURE 20-20: I<sub>OH</sub> vs. V<sub>OH</sub>, V<sub>DD</sub> = 5V**



Data based on matrix samples. See first page of this section for details.

# PIC16C7X

Applicable Devices 710 71 711 72 73 73A 74 74A

FIGURE 20-21: IOL vs. VOL, VDD = 3V

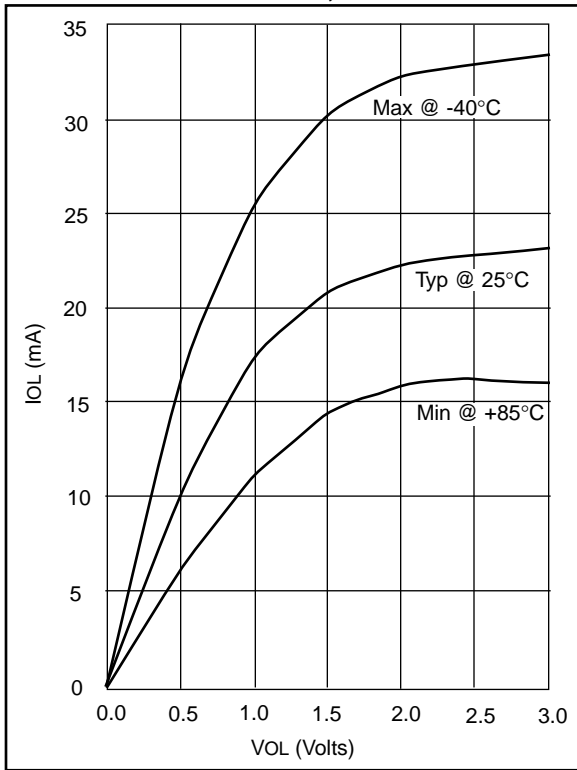
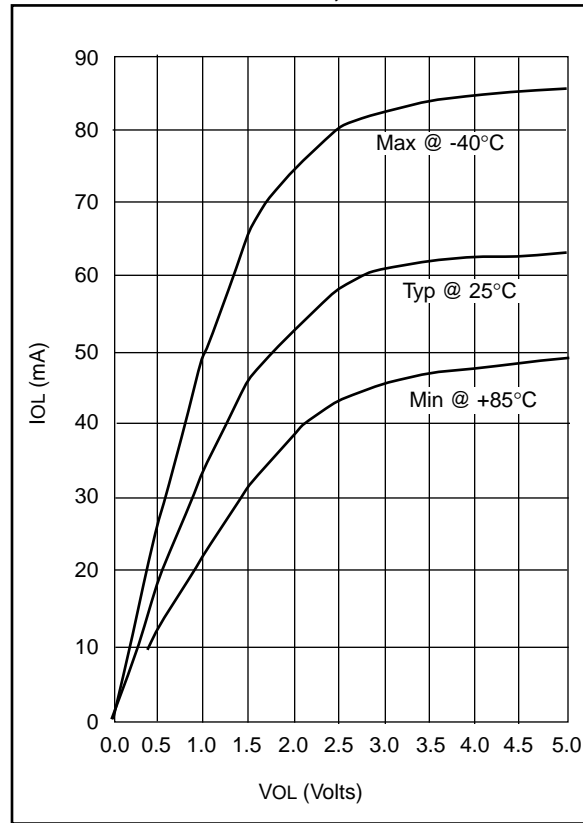


FIGURE 20-22: IOL vs. VOL, VDD = 5V



Data based on matrix samples. See first page of this section for details.

## 21.0 ELECTRICAL CHARACTERISTICS FOR PIC16C72

### Absolute Maximum Ratings †

Ambient temperature under bias.....	-55 to +125°C
Storage temperature .....	-65°C to +150°C
Voltage on any pin with respect to VSS (except VDD and $\overline{\text{MCLR}}$ ) .....	-0.3V to (VDD + 0.3V)
Voltage on VDD with respect to VSS .....	0 to +7.5V
Voltage on $\overline{\text{MCLR}}$ with respect to VSS (Note 2) .....	0 to +14V
Total power dissipation (Note 1).....	1.0W
Maximum current out of VSS pin .....	300 mA
Maximum current into VDD pin .....	250 mA
Input clamp current, I <sub>IK</sub> (V <sub>I</sub> < 0 or V <sub>I</sub> > VDD) .....	±20 mA
Output clamp current, I <sub>OK</sub> (V <sub>O</sub> < 0 or V <sub>O</sub> > VDD).....	±20 mA
Maximum output current sunk by any I/O pin.....	25 mA
Maximum output current sourced by any I/O pin .....	25 mA
Maximum current sunk by PORTA and PORTB (combined).....	200 mA
Maximum current sourced by PORTA and PORTB (combined).....	200 mA
Maximum current sunk by PORTC .....	200 mA
Maximum current sourced by PORTC .....	200 mA

**Note 1:** Power dissipation is calculated as follows:  $P_{dis} = V_{DD} \times \{I_{DD} - \sum I_{OH}\} + \sum \{(V_{DD} - V_{OH}) \times I_{OH}\} + \sum (V_{OL} \times I_{OL})$

**Note 2:** Voltage spikes below VSS at the  $\overline{\text{MCLR}}$  pin, inducing currents greater than 80 mA, may cause latch-up. Thus, a series resistor of 50-100Ω should be used when applying a “low” level to the  $\overline{\text{MCLR}}$  pin rather than pulling this pin directly to VSS.

† NOTICE: 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 those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

# PIC16C7X

Applicable Devices	710	71	711	72	73	73A	74	74A
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**TABLE 21-1: CROSS REFERENCE OF DEVICE SPECS FOR OSCILLATOR CONFIGURATIONS AND FREQUENCIES OF OPERATION (COMMERCIAL DEVICES)**

OSC	PIC16C72-04	PIC16C72-10	PIC16C72-20	PIC16LC72-04	JW Devices
RC	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 16 µA max. at 4V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 2.7 mA typ. at 5.5V IPD: 1.5 µA typ. at 4V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 2.7 mA typ. at 5.5V IPD: 1.5 µA typ. at 4V Freq: 4 MHz max.	VDD: 2.5V to 6.0V IDD: 2.0 mA typ. at 3.0V IPD: 0.9 µA typ. at 3V Freq: 4 MHz max.	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 16 µA max. at 4V Freq: 4 MHz max.
XT	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 16 µA max. at 4V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 2.7 mA typ. at 5.5V IPD: 1.5 µA typ. at 4V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 2.7 mA typ. at 5.5V IPD: 1.5 µA typ. at 4V Freq: 4 MHz max.	VDD: 2.5V to 6.0V IDD: 2.0 mA typ. at 3.0V IPD: 0.9 µA typ. at 3V Freq: 4 MHz max.	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 16 µA max. at 4V Freq: 4 MHz max.
HS	VDD: 4.5V to 5.5V IDD: 13.5 mA typ. at 5.5V IPD: 1.5 µA typ. at 4.5V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 10 mA max. at 5.5V IPD: 1.5 µA typ. at 4.5V Freq: 10 MHz max.	VDD: 4.5V to 5.5V IDD: 20 mA max. at 5.5V IPD: 1.5 µA typ. at 4.5V Freq: 20 MHz max.	Do not use in HS mode	VDD: 4.5V to 5.5V IDD: 20 mA max. at 5.5V IPD: 1.5 µA typ. at 4.5V Freq: 20 MHz max.
LP	VDD: 4.0V to 6.0V IDD: 52.5 µA typ. at 32 kHz, 4.0V IPD: 0.9 µA typ. at 4.0V Freq: 200 kHz max.	Do not use in LP mode	Do not use in LP mode	VDD: 2.5V to 6.0V IDD: 48 µA max. at 32 kHz, 3.0V IPD: 5.0 µA max. at 3.0V Freq: 200 kHz max.	VDD: 2.5V to 6.0V IDD: 48 µA max. at 32 kHz, 3.0V IPD: 5.0 µA max. at 3.0V Freq: 200 kHz max.

The shaded sections indicate oscillator selections which are tested for functionality, but not for MIN/MAX specifications. It is recommended that the user select the device type that ensures the specifications required.

**21.1 DC Characteristics: PIC16C72-04 (Commercial, Industrial, Automotive)  
 PIC16C72-10 (Commercial, Industrial, Automotive)  
 PIC16C72-20 (Commercial, Industrial, Automotive)**

DC CHARACTERISTICS		Standard Operating Conditions (unless otherwise stated)						Conditions
		Operating temperature -40°C ≤ TA ≤ +125°C for automotive, -40°C ≤ TA ≤ +85°C for industrial and 0°C ≤ TA ≤ +70°C for commercial						
Param No.	Characteristic	Sym	Min	Typ†	Max	Units		
D001 D001A	Supply Voltage	VDD	4.0 4.5	- -	6.0 5.5	V V	XT, RC and LP osc configuration HS osc configuration	
D002*	RAM Data Retention Voltage (Note 1)	VDR	-	1.5	-	V	Device in SLEEP mode	
D003	VDD start voltage to ensure internal Power-on Reset Signal	VPOR	-	VSS	-	V	See section on Power-on Reset for details	
D004*	VDD rise rate to ensure internal Power-on Reset Signal	SVDD	0.05	-	-	V/ms	See section on Power-on Reset for details	
D005	Brown-out Reset Voltage	BVDD	3.7	4.0	4.3	V	BODEN bit in configuration word enabled	
D010  D013	Supply Current (Note 2,5)	IDD	- -	2.7 10	5 20	mA mA	XT, RC osc configuration (PIC16C72-04) FOSC = 4 MHz, VDD = 5.5V (Note 4)  HS osc configuration (PIC16C72-20) FOSC = 20 MHz, VDD = 5.5V	
D015	Brown-out Reset Current (Note 6)	ΔIBOR	-	350	425	μA	BOR enabled VDD = 5.0V	
D020 D021 D021A D021B	Power-down Current (Note 3,5)	IPD	- - - -	10.5 1.5 1.5 2.5	42 16 19 19	μA μA μA μA	VDD = 4.0V, WDT enabled, -40°C to +85°C VDD = 4.0V, WDT disabled, -0°C to +70°C VDD = 4.0V, WDT disabled, -40°C to +85°C VDD = 4.0V, WDT disabled, -40°C to +125°C	
D023	Brown-out Reset Current (Note 6)	ΔIBOR	-	350	425	μA	BOR enabled 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 in SLEEP mode 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 configuration, current through Rext is not included. The current through the resistor can be estimated by the formula  $I_r = V_{DD}/2R_{ext}$  (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.

# PIC16C7X

Applicable Devices 710 71 711 72 73 73A 74 74A

## 21.2 DC Characteristics: PIC16LC72-04 (Commercial, Industrial)

DC CHARACTERISTICS		Standard Operating Conditions (unless otherwise stated)					
		Operating temperature -40°C ≤ TA ≤ +85°C for industrial and 0°C ≤ TA ≤ +70°C for commercial					
Param No.	Characteristic	Sym	Min	Typ†	Max	Units	Conditions
D001	Supply Voltage	VDD	2.5	-	6.0	V	LP, XT, RC osc configuration (DC - 4 MHz)
D002*	RAM Data Retention Voltage (Note 1)	VDR	-	1.5	-	V	Device in SLEEP mode
D003	VDD start voltage to ensure internal Power-on Reset signal	VPOR	-	VSS	-	V	See section on Power-on Reset for details
D004*	VDD rise rate to ensure internal Power-on Reset signal	SVDD	0.05	-	-	V/ms	See section on Power-on Reset for details
D005	Brown-out Reset Voltage	BVDD	3.7	4.0	4.3	V	BODEN bit in configuration word enabled
D010	Supply Current (Note 2,5)	IDD	-	2.0	3.8	mA	XT, RC osc configuration FOSC = 4 MHz, VDD = 3.0V (Note 4)
D010A			-	22.5	48	μA	LP osc configuration FOSC = 32 kHz, VDD = 3.0V, WDT disabled
D015*	Brown-out Reset Current (Note 6)	ΔIBOR	-	350	425	μA	BOR enabled VDD = 3.0V
D020	Power-down Current (Note 3,5)	IPD	-	7.5	30	μA	VDD = 3.0V, WDT enabled, -40°C to +85°C
D021			-	0.9	5	μA	VDD = 3.0V, WDT disabled, 0°C to +70°C
D021A			-	0.9	5	μA	VDD = 3.0V, WDT disabled, -40°C to +85°C
D023*	Brown-out Reset Current (Note 6)	ΔIBOR	-	300	500	μA	BOR enabled VDD = 3.0V

\* 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 in SLEEP mode 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 configuration, current through Rext is not included. The current through the resistor can be estimated by the formula  $I_r = V_{DD}/2R_{ext}$  (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.

# PIC16C7X

Applicable Devices 710 71 711 72 73 73A 74 74A

- 21.3 DC Characteristics:** PIC16C72-04 (Commercial, Industrial, Automotive)  
 PIC16C72-10 (Commercial, Industrial, Automotive)  
 PIC16C72-20 (Commercial, Industrial, Automotive)  
 PIC16LC72-04 (Commercial, Industrial)

DC CHARACTERISTICS		Standard Operating Conditions (unless otherwise stated)						
		Operating temperature -40°C ≤ TA ≤ +125°C for automotive, -40°C ≤ TA ≤ +85°C for industrial and 0°C ≤ TA ≤ +70°C for commercial						
		Operating voltage VDD range as described in DC spec Section 21.1 and Section 21.2.						
Param No.	Characteristic	Sym	Min	Typ †	Max	Units	Conditions	
D030	<b>Input Low Voltage</b> I/O ports with TTL buffer	VIL	VSS	-	0.5V	V	Note1	
D031	with Schmitt Trigger buffer		VSS	-	0.2VDD	V		
D032	MCLR, RA4/T0CKI, OSC1 (in RC mode)		VSS	-	0.2VDD	V		
D033	OSC1 (in XT, HS and LP)		VSS	-	0.3VDD	V		
D040	<b>Input High Voltage</b> I/O ports with TTL buffer	VIH	2.0	-	VDD	V	4.5 ≤ VDD ≤ 5.5V For VDD > 5.5V or VDD < 4.5V For entire VDD range	
D040A			0.8VDD	-	VDD	V		
D041	with Schmitt Trigger buffer		0.8VDD	-	VDD	V		
D042	MCLR, RA4/T0CKI, RC7:RC4, RB0/INT		0.8VDD	-	VDD	V		
D042A	OSC1 (XT, HS and LP)		0.7VDD	-	VDD	V		
D043	OSC1 (in RC mode)	0.9VDD	-	VDD	V	Note1		
D070	PORTB weak pull-up current	IPURB	50	250	†400	µA	VDD = 5V, VPIN = VSS	
D060	<b>Input Leakage Current</b> (Notes 2, 3) I/O ports	IIL	-	-	±1	µA	VSS ≤ VPIN ≤ VDD, Pin at hi-impedance	
D061	MCLR, RA4/T0CKI		-	-	±5	µA		VSS ≤ VPIN ≤ VDD
D063	OSC1		-	-	±5	µA		VSS ≤ VPIN ≤ VDD, XT, HS and LP osc configuration
D080	<b>Output Low Voltage</b> I/O ports	VOL	-	-	0.6	V	IOL = 8.5 mA, VDD = 4.5V, -40°C to +85°C	
D080A			-	-	0.6	V		IOL = 7.0 mA, VDD = 4.5V, -40°C to +125°C
D083	OSC2/CLKOUT (RC osc config)		-	-	0.6	V		IOL = 1.6 mA, VDD = 4.5V, -40°C to +85°C
D083A			-	-	0.6	V		IOL = 1.2 mA, VDD = 4.5V, -40°C to +125°C

† 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 configuration, the OSC1/CLKIN pin is a Schmitt trigger input. It is not recommended that the PIC16C7X be driven with external clock in RC mode.
- 2: The leakage current on the MCLR 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 coming out of the pin.

# PIC16C7X

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Standard Operating Conditions (unless otherwise stated)							
Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$ for automotive, $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$ for industrial and $0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$ for commercial Operating voltage $V_{DD}$ range as described in DC spec Section 21.1 and Section 21.2.							
Param No.	Characteristic	Sym	Min	Typ †	Max	Units	Conditions
D090	<b>Output High Voltage</b> I/O ports (Note 3)	VOH	$V_{DD} - 0.7$	-	-	V	IOH = -3.0 mA, $V_{DD} = 4.5\text{V}$ , -40°C to +85°C
D090A			$V_{DD} - 0.7$	-	-	V	
D092	OSC2/CLKOUT (RC osc config)		$V_{DD} - 0.7$	-	-	V	IOH = -1.3 mA, $V_{DD} = 4.5\text{V}$ , -40°C to +85°C
D092A			$V_{DD} - 0.7$	-	-	V	
D100	<b>Capacitive Loading Specs on Output Pins</b> OSC2 pin	COSC2	-	-	15	pF	In XT, HS and LP modes when external clock is used to drive OSC1.
D101	All I/O pins and OSC2 (in RC mode)	CIO	-	-	50	pF	
D102	SCL, SDA in I <sup>2</sup> C mode	CB	-	-	400	pF	

† 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 configuration, the OSC1/CLKIN pin is a Schmitt trigger input. It is not recommended that the PIC16C7X be driven with external clock in RC mode.
- 2: The leakage current on the  $\overline{\text{MCLR}}$  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 coming out of the pin.



## 21.4 Timing Parameter Symbology

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

- |             |           |  |
|-------------|-----------|--|
| 1. TppS2ppS | 3. TCC:ST | (I <sup>2</sup> C specifications only) |
| 2. TppS     | 4. Ts     | (I <sup>2</sup> C specifications only) |

<b>T</b>			
F	Frequency	T	Time

Lowercase letters (pp) and their meanings:

<b>pp</b>			
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	$\overline{WR}$

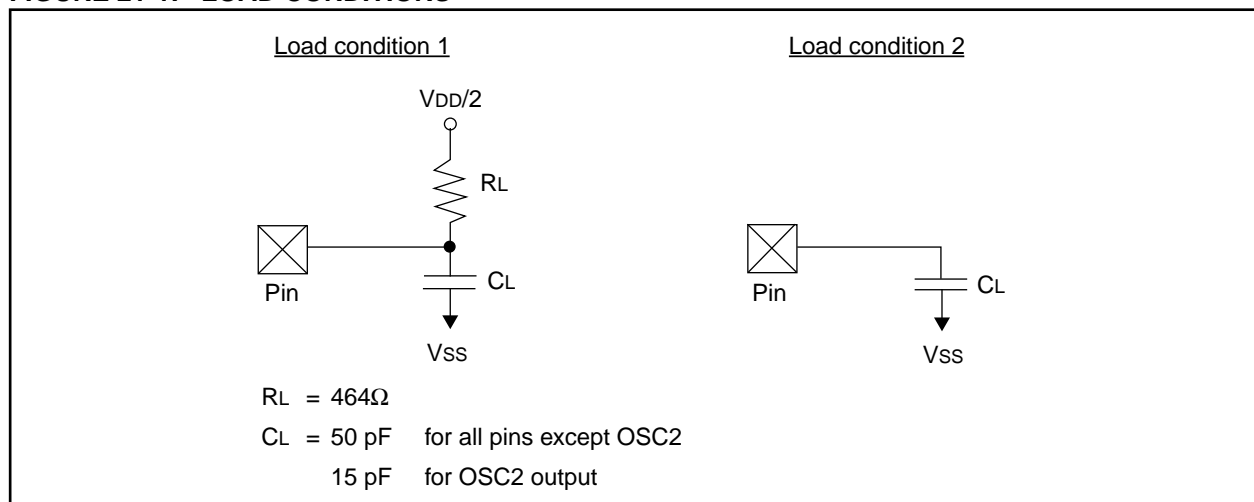
Uppercase letters and their meanings:

<b>S</b>			
F	Fall	P	Period
H	High	R	Rise
I	Invalid (Hi-impedance)	V	Valid
L	Low	Z	Hi-impedance
<b>I<sup>2</sup>C only</b>			
AA	output access	High	High
BUF	Bus free	Low	Low

TCC:ST (I<sup>2</sup>C specifications only)

<b>CC</b>			
HD	Hold	SU	Setup
<b>ST</b>			
DAT	DATA input hold	STO	STOP condition
STA	START condition		

**FIGURE 21-1: LOAD CONDITIONS**



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## 21.5 Timing Diagrams and Specifications

FIGURE 21-2: EXTERNAL CLOCK TIMING

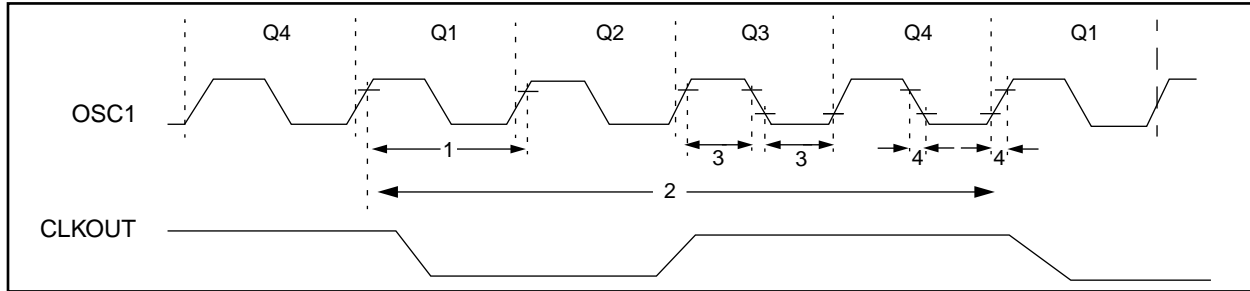


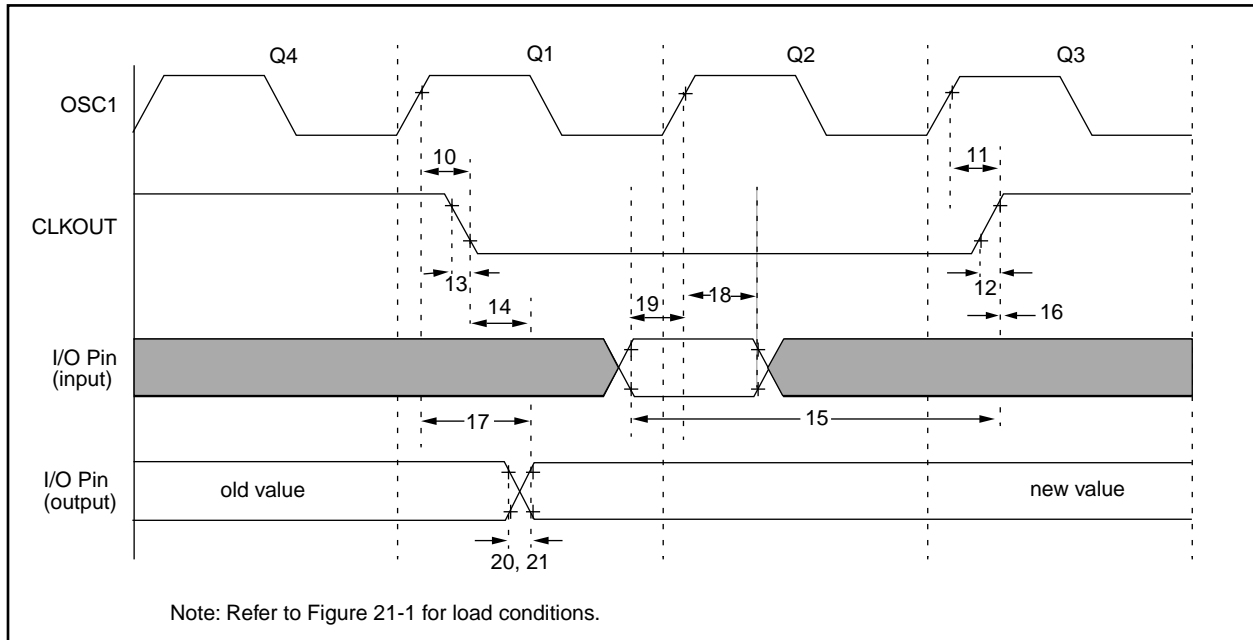
TABLE 21-2: CLOCK TIMING REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions	
	Fos	<b>External CLKIN Frequency (Note 1)</b>	DC	—	4	MHz	XT and RC osc mode	
			DC	—	4	MHz	HS osc mode (PIC16C72-04)	
			DC	—	20	MHz	HS osc mode (PIC16C72-20)	
			DC	—	200	kHz	LP osc mode	
			<b>Oscillator Frequency (Note 1)</b>	DC	—	4	MHz	RC osc mode
				0.1	—	4	MHz	XT osc mode
				4	—	4	MHz	HS osc mode (PIC16C72-04)
				4	—	10	MHz	HS osc mode (PIC16C72-10)
				4	—	20	MHz	HS osc mode (PIC16C72-20)
				5	—	200	kHz	LP osc mode
1	Tosc	<b>External CLKIN Period (Note 1)</b>	250	—	—	ns	XT and RC osc mode	
			250	—	—	ns	HS osc mode (PIC16C72-04)	
			100	—	—	ns	HS osc mode (PIC16C72-10)	
			50	—	—	ns	HS osc mode (PIC16C72-20)	
			5	—	—	μs	LP osc mode	
			<b>Oscillator Period (Note 1)</b>	250	—	—	ns	RC osc mode
				250	—	10,000	ns	XT osc mode
				250	—	250	ns	HS osc mode (PIC16C72-04)
				100	—	250	ns	HS osc mode (PIC16C72-10)
				50	—	250	ns	HS osc mode (PIC16C72-20)
			5	—	—	μs	LP osc mode	
2	Tcy	<b>Instruction Cycle Time (Note 1)</b>	200	—	DC	ns	Tcy = 4/Fosc	
3	TosL, TosH	<b>External Clock in (OSC1) High or Low Time</b>	100	—	—	ns	XT oscillator	
			2.5	—	—	μs	LP oscillator	
			15	—	—	ns	HS oscillator	
4	TosR, TosF	<b>External Clock in (OSC1) Rise or Fall Time</b>	—	—	25	ns	XT oscillator	
			—	—	50	ns	LP oscillator	
			—	—	15	ns	HS oscillator	

† 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 21-3: CLKOUT AND I/O TIMING**



**TABLE 21-3: CLKOUT AND I/O TIMING REQUIREMENTS**

Parameter 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	—	—	0.5T <sub>cy</sub> + 20	ns	Note 1
15*	TioV2ckH	Port in valid before CLKOUT ↑	Tosc + 200	—	—	ns	Note 1
16*	TckH2ioL	Port in hold after CLKOUT ↑	0	—	—	ns	Note 1
17*	TosH2ioV	OSC1↑ (Q1 cycle) to Port out valid	—	50	150	ns	
18*	TosH2ioL	OSC1↑ (Q2 cycle) to Port input invalid (I/O in hold time)	PIC16C72	100	—	—	ns
			PIC16LC72	200	—	—	ns
19*	TioV2osH	Port input valid to OSC1↑ (I/O in setup time)	0	—	—	ns	
20*	TioR	Port output rise time	PIC16C72	—	10	40	ns
			PIC16LC72	—	—	80	ns
21*	TioF	Port output fall time	PIC16C72	—	10	40	ns
			PIC16LC72	—	—	80	ns
22††*	Tinp	INT pin high or low time	T <sub>cy</sub>	—	—	ns	
23††*	Trbp	RB7:RB4 change INT high or low time	T <sub>cy</sub>	—	—	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.

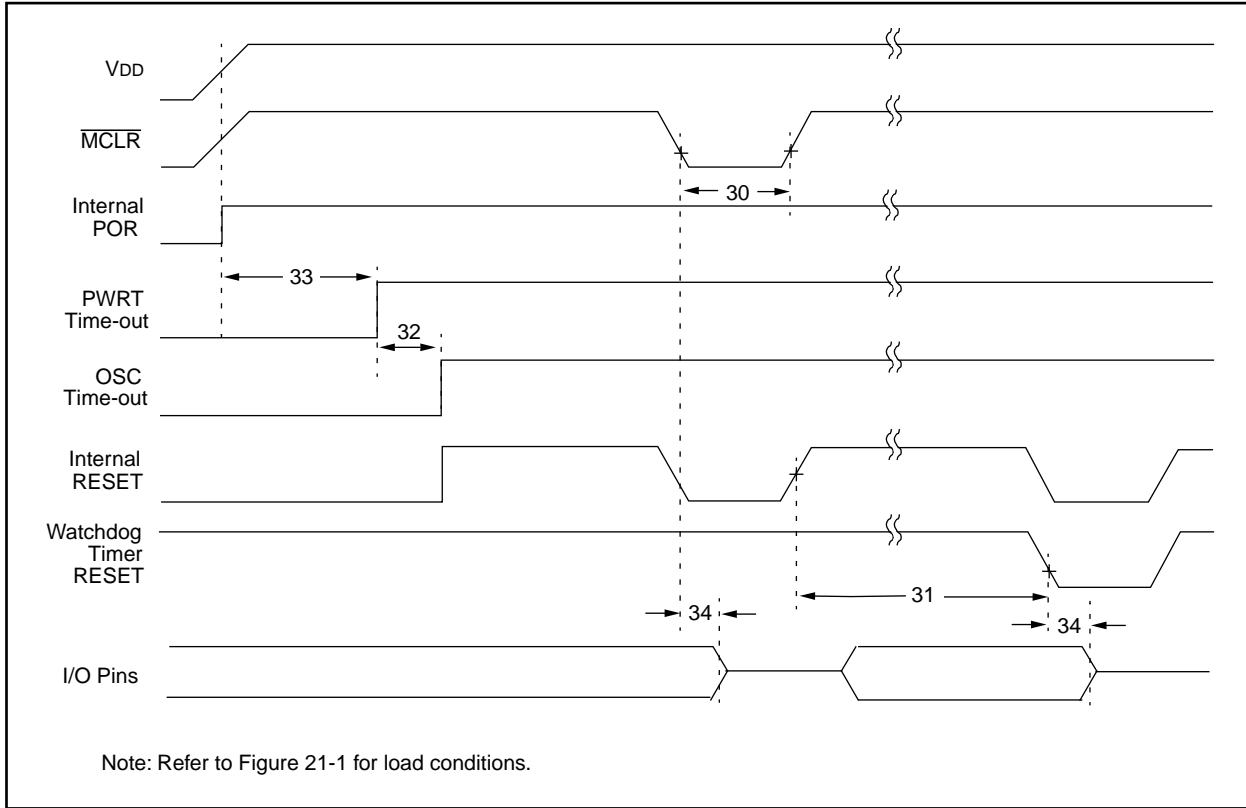
†† These parameters are asynchronous events not related to any internal clock edges.

Note 1: Measurements are taken in RC Mode where CLKOUT output is 4 x T<sub>osc</sub>.

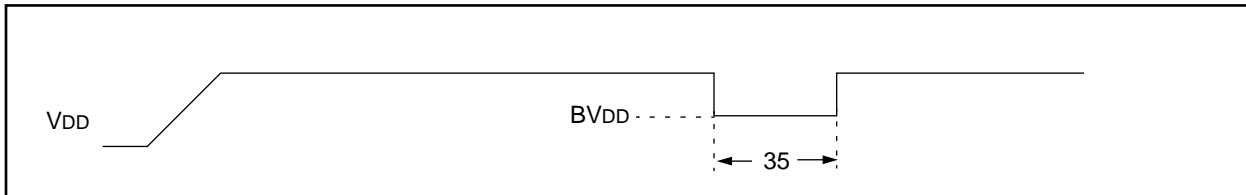
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**FIGURE 21-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER TIMING**



**FIGURE 21-5: BROWN-OUT RESET TIMING**



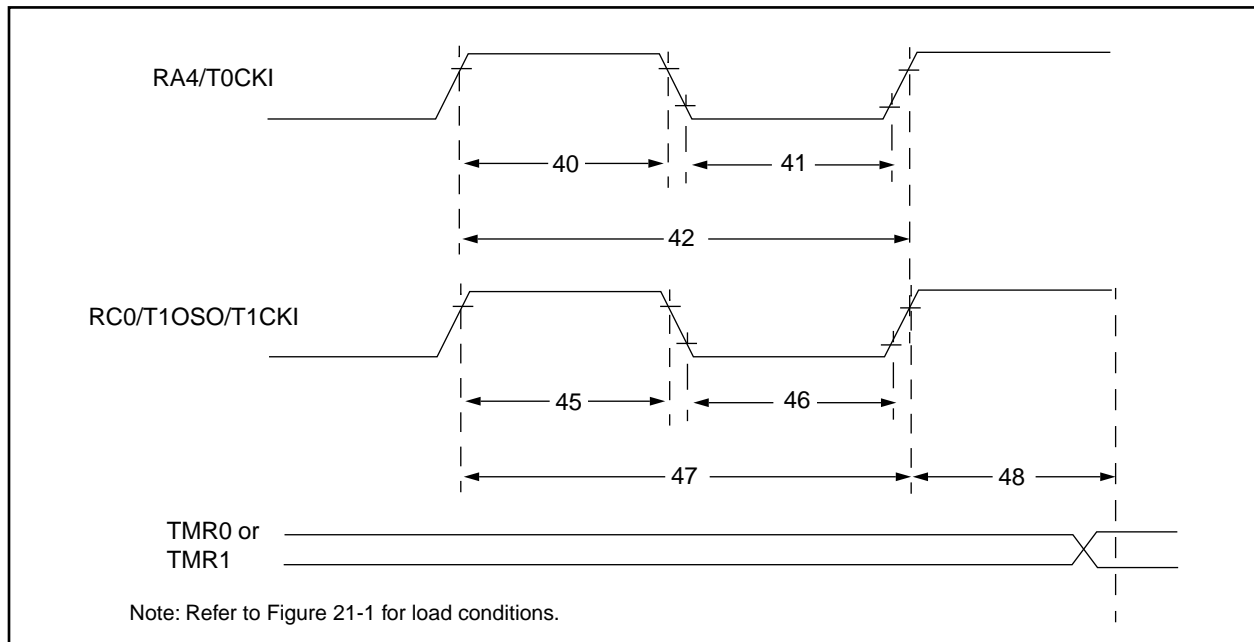
**TABLE 21-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER, POWER-UP TIMER, AND BROWN-OUT RESET REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
30	Tmcl	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	Oscillation Start-up Timer Period	—	1024Tosc	—	—	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 MCLR Low or Watchdog Timer 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.

**FIGURE 21-6: TIMER0 AND TIMER1 CLOCK TIMINGS**



**TABLE 21-5: TIMER0 AND TIMER1 CLOCK REQUIREMENTS**

Param No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
40*	Tt0H	T0CKI High Pulse Width	$0.5T_{CY} + 20$	—	—	ns	
		No Prescaler					
		With Prescaler	10	—	—	ns	
41*	Tt0L	T0CKI Low Pulse Width	$0.5T_{CY} + 20$	—	—	ns	
		No Prescaler					
		With Prescaler	10	—	—	ns	
42*	Tt0P	T0CKI Period	$\frac{T_{CY} + 40}{N}$	—	—	ns	N = prescale value (1, 2, 4, ..., 256)
45*	Tt1H	T1CKI High Time	$0.5T_{CY} + 20$	—	—	ns	
		Synchronous, no prescaler					
		Synchronous, with prescaler					
		PIC16C72	15	—	—	ns	
		PIC16LC72	25	—	—		
		Asynchronous	$2T_{CY}$	—	—	ns	
46*	Tt1L	T1CKI Low Time	$0.5T_{CY} + 20$	—	—	ns	
		Synchronous, no prescaler					
		Synchronous, with prescaler					
		PIC16C72	15	—	—	ns	
		PIC16LC72	25	—	—		
		Asynchronous	$2T_{CY}$	—	—	ns	
47*	Tt1P	T1CKI input period	$\frac{T_{CY} + 40}{N}$	—	—	ns	N = prescale value (1, 2, 4, 8)
		Synchronous					
		Asynchronous	$4T_{CY}$	—	—	ns	
	Ft1	Timer1 oscillator input frequency range (oscillator enabled by setting the T1OSCEN bit)	DC	—	200	kHz	
48	Tcke2tmr1	Delay from external clock edge to timer increment	$2T_{osc}$	—	$7T_{osc}$	—	

\* 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 21-7: CAPTURE/COMPARE/PWM TIMINGS (CCP1)

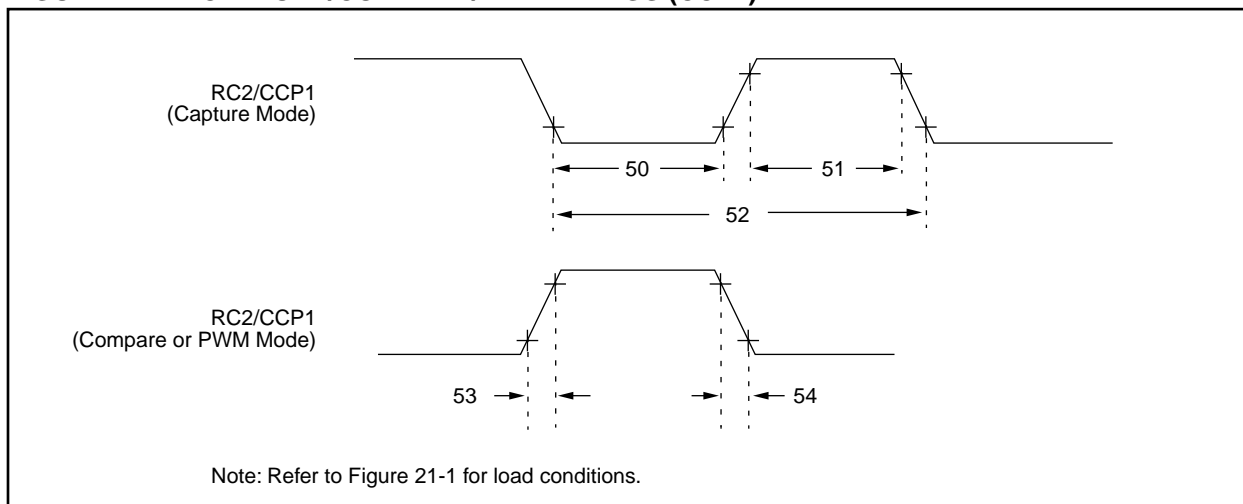


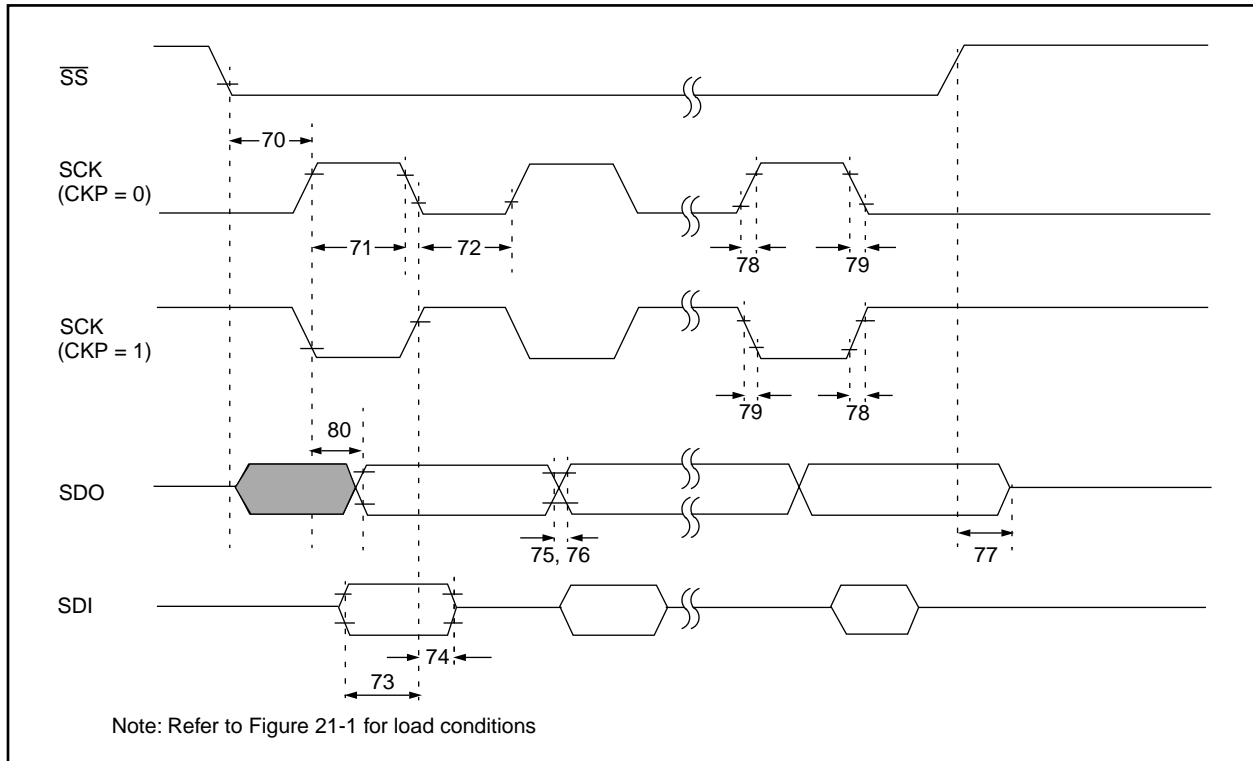
TABLE 21-6: CAPTURE/COMPARE/PWM REQUIREMENTS (CCP1)

Param No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions	
50*	TccL	CCP1 input low time	No Prescaler	$0.5T_{CY} + 20$	—	—	ns	
			With Prescaler	PIC16C72	10	—	—	ns
				PIC16LC72	20	—	—	ns
51*	TccH	CCP1 input high time	No Prescaler	$0.5T_{CY} + 20$	—	—	ns	
			With Prescaler	PIC16C72	10	—	—	ns
				PIC16LC72	20	—	—	ns
52*	TccP	CCP1 input period	$\frac{3T_{CY} + 40}{N}$	—	—	ns	N = prescale value (1,4 or 16)	
53*	TccR	CCP1 output rise time	PIC16C72	—	10	25	ns	
			PIC16LC72	—	25	45	ns	
54*	TccF	CCP1 output fall time	PIC16C72	—	10	25	ns	
			PIC16LC72	—	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 21-8: SPI MODE TIMING**



**TABLE 21-7: SPI MODE REQUIREMENTS**

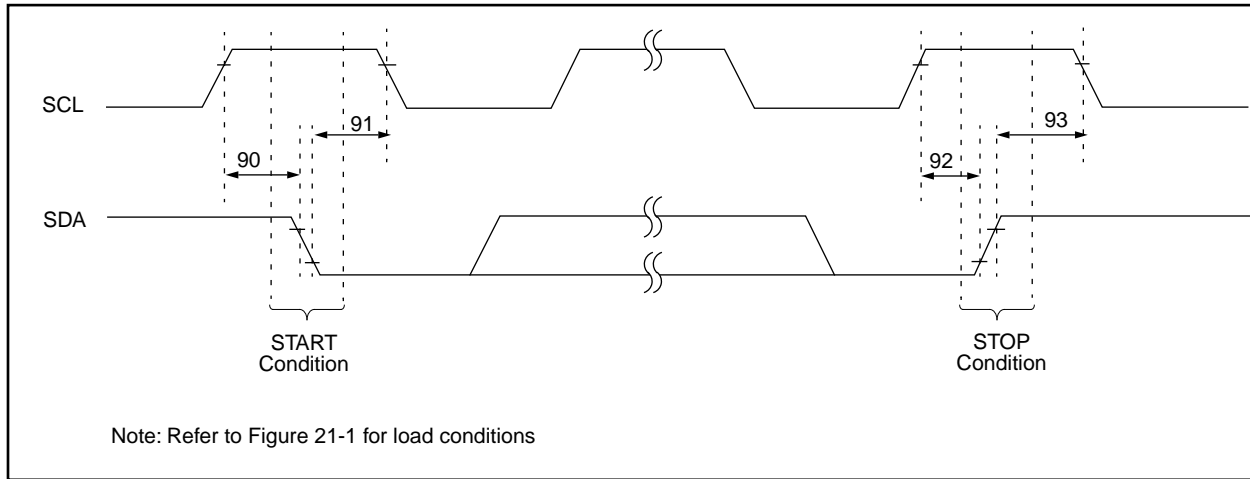
Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
70	TssL2scH, TssL2scL	$\overline{SS}$ ↓ to SCK↓ or SCK↑ input	T <sub>CY</sub>	—	—	ns	
71	TscH	SCK input high time (slave mode)	T <sub>CY</sub> + 20	—	—	ns	
72	TscL	SCK input low time (slave mode)	T <sub>CY</sub> + 20	—	—	ns	
73	TdiV2scH, TdiV2scL	Setup time of SDI data input to SCK edge	50	—	—	ns	
74	Tsch2diL, TscL2diL	Hold time of SDI data input to SCK edge	50	—	—	ns	
75	TdoR	SDO data output rise time	—	10	25	ns	
76	TdoF	SDO data output fall time	—	10	25	ns	
77	TssH2doZ	$\overline{SS}$ ↓ to SDO output hi-impedance	10	—	50	ns	
78	TscR	SCK output rise time (master mode)	—	10	25	ns	
79	TscF	SCK output fall time (master mode)	—	10	25	ns	
80	Tsch2doV, TscL2doV	SDO data output valid after SCK edge	—	—	50	ns	

† 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 21-9: I<sup>2</sup>C BUS START/STOP BITS TIMING**

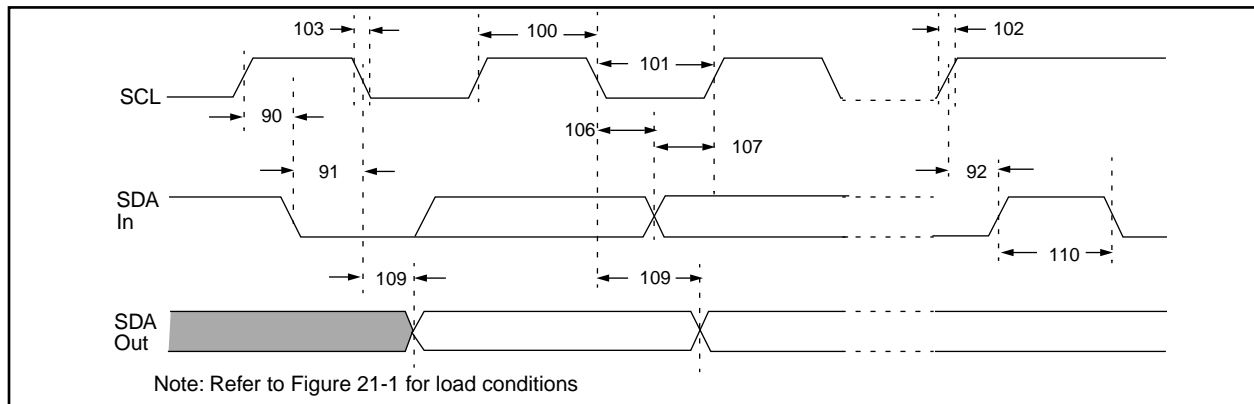


**TABLE 21-8: I<sup>2</sup>C BUS START/STOP BITS REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Typ	Max	Units	Conditions	
90	TSU:STA	START condition Setup time	100 kHz mode	4700	—	—	ns	Only relevant for repeated START condition
		400 kHz mode	600	—	—			
91	THD:STA	START condition Hold time	100 kHz mode	4000	—	—	ns	After this period the first clock pulse is generated
		400 kHz mode	600	—	—			
92	TSU:STO	STOP condition Setup time	100 kHz mode	4700	—	—	ns	
		400 kHz mode	600	—	—			
93	THD:STO	STOP condition Hold time	100 kHz mode	4000	—	—	ns	
		400 kHz mode	600	—	—			



**FIGURE 21-10: I<sup>2</sup>C BUS DATA TIMING**



**TABLE 21-9: I<sup>2</sup>C BUS DATA REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Max	Units	Conditions	
100	THIGH	Clock high time	100 kHz mode	4.0	—	μs	PIC16C72 must operate at a minimum of 1.5 MHz
			400 kHz mode	0.6	—	μs	PIC16C72 must operate at a minimum of 10 MHz
			SSP Module	1.5T <sub>CY</sub>	—		
101	TLOW	Clock low time	100 kHz mode	4.7	—	μs	PIC16C72 must operate at a minimum of 1.5 MHz
			400 kHz mode	1.3	—	μs	PIC16C72 must operate at a minimum of 10 MHz
			SSP Module	1.5T <sub>CY</sub>	—		
102	Tr	SDA and SCL rise time	100 kHz mode	—	1000	ns	
			400 kHz mode	20 + 0.1C <sub>b</sub>	300	ns	C <sub>b</sub> is specified to be from 10 to 400 pF
103	TF	SDA and SCL fall time	100 kHz mode	—	300	ns	
			400 kHz mode	20 + 0.1C <sub>b</sub>	300	ns	C <sub>b</sub> is specified to be from 10 to 400 pF
90	TSU:STA	START condition setup time	100 kHz mode	4.7	—	μs	Only relevant for repeated START condition
			400 kHz mode	0.6	—	μs	
91	THD:STA	START condition hold time	100 kHz mode	4.0	—	μs	After this period the first clock pulse is generated
			400 kHz mode	0.6	—	μs	
106	THD:DAT	Data input hold time	100 kHz mode	0	—	ns	
			400 kHz mode	0	0.9	μs	
107	TSU:DAT	Data input setup time	100 kHz mode	250	—	ns	Note 2
			400 kHz mode	100	—	ns	
92	TSU:STO	STOP condition setup time	100 kHz mode	4.7	—	μs	
			400 kHz mode	0.6	—	μs	
109	TAA	Output valid from clock	100 kHz mode	—	3500	ns	Note 1
			400 kHz mode	—	—	ns	
110	TBUF	Bus free time	100 kHz mode	4.7	—	μs	Time the bus must be free before a new transmission can start
			400 kHz mode	1.3	—	μs	
	C <sub>b</sub>	Bus capacitive loading	—	400	pF		

Note 1: As a transmitter, the device must provide this internal minimum delay time to bridge the undefined region (min. 300 ns) of the falling edge of SCL to avoid unintended generation of START or STOP conditions.

2: A fast-mode I<sup>2</sup>C-bus device can be used in a standard-mode I<sup>2</sup>C-bus system, but the requirement tsu;DAT ≥ 250 ns must then be met. This will automatically be the case if the device does not stretch the LOW period of the SCL signal, it must output the next data bit to the SDA line  
 TR max.+tsu;DAT = 1000 + 250 = 1250 ns (according to the standard-mode I<sup>2</sup>C bus specification) before the SCL line is released.

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**TABLE 21-10: A/D CONVERTER CHARACTERISTICS:  
PIC16C72-04 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE)  
PIC16C72-10 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE)  
PIC16C72-20 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE)**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
	NR	Resolution	—	—	8-bits	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NINT	Integral error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NDIF	Differential error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NFS	Full scale error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NOFF	Offset error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	—	Monotonicity	—	guaranteed	—	—	$V_{SS} \leq A_{IN} \leq V_{REF}$
	VREF	Reference voltage	3.0V	—	$V_{DD} + 0.3$	V	
	VAIN	Analog input voltage	$V_{SS} - 0.3$	—	$V_{REF} + 0.3$	V	
	ZAIN	Recommended impedance of analog voltage source	—	—	10.0	k $\Omega$	
	IAD	A/D conversion current ( $V_{DD}$ )	—	180	—	$\mu A$	Average current consumption when A/D is on. (Note 1)
	IREF	$V_{REF}$ input current (Note 2)	—	—	1 10	mA $\mu A$	During sampling All other times

\* 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: When A/D is off, it will not consume any current other than minor leakage current. The power-down current spec includes any such leakage from the A/D module.

2:  $V_{REF}$  current is from RA3 pin or  $V_{DD}$  pin, whichever is selected as reference input.

**TABLE 21-11: A/D CONVERTER CHARACTERISTICS:  
PIC16LC72-04 (COMMERCIAL, INDUSTRIAL)**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
	NR	Resolution	—	—	8-bits	—	VREF = VDD = 3.0V (Note 1)
	NINT	Integral error	—	—	less than ±1 LSb	—	VREF = VDD = 3.0V (Note 1)
	NDIF	Differential error	—	—	less than ±1 LSb	—	VREF = VDD = 3.0V (Note 1)
	NFS	Full scale error	—	—	less than ±1 LSb	—	VREF = VDD = 3.0V (Note 1)
	NOFF	Offset error	—	—	less than ±1 LSb	—	VREF = VDD = 3.0V (Note 1)
	—	Monotonicity	—	guaranteed	—	—	VSS ≤ AIN ≤ VREF
	VREF	Reference voltage	3.0V	—	VDD + 0.3	V	
	VAIN	Analog input voltage	VSS - 0.3	—	VREF + 0.3	V	
	ZAIN	Recommended impedance of analog voltage source	—	—	10.0	kΩ	
	IAD	A/D conversion current (VDD)	—	180	—	μA	Average current consumption when A/D is on. (Note 2)
	IREF	VREF input current (Note 3)	—	—	1 10	mA μA	During sampling All other times

\* 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: These specifications apply if VREF = 3.0V and if VDD ≥ 3.0V. Vin must be between VSS and VREF

2: When A/D is off, it will not consume any current other than minor leakage current. The power-down current spec includes any such leakage from the A/D module.

3: VREF current is from RA3 pin or VDD pin, whichever is selected as reference input.

4: Automotive operating range is Advance Information for this device.

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FIGURE 21-11: A/D CONVERSION TIMING

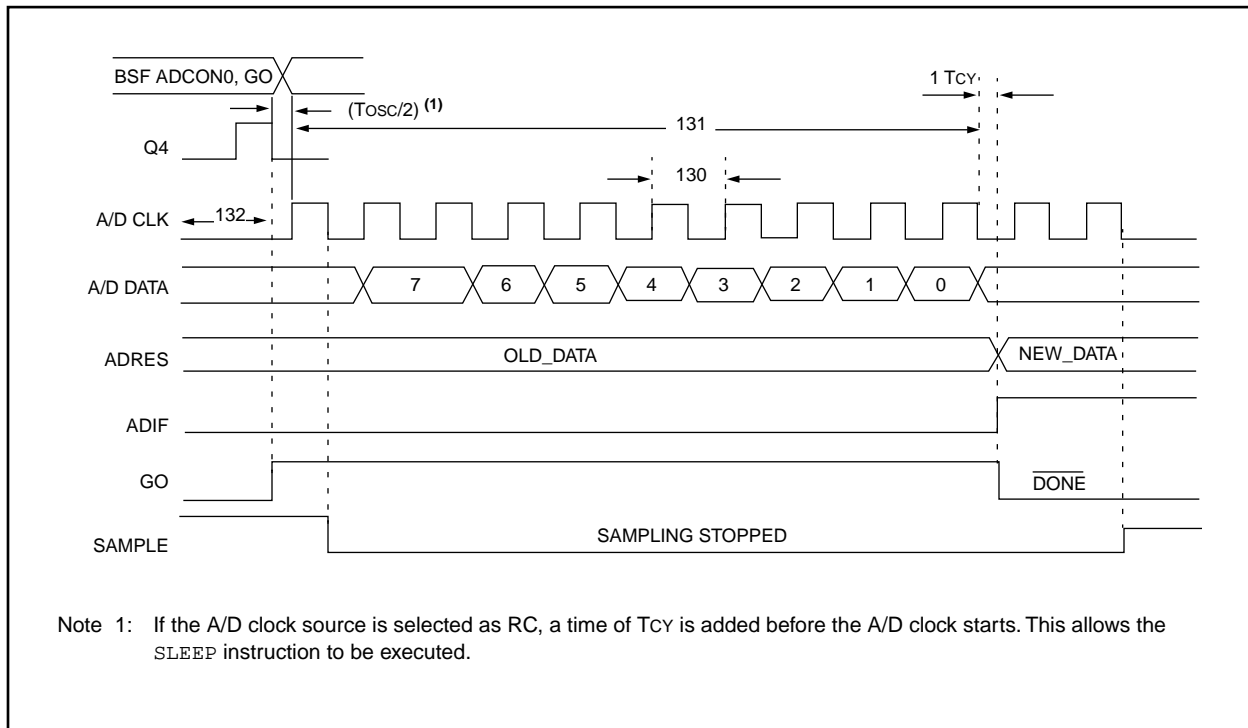


TABLE 21-12: A/D CONVERSION REQUIREMENTS

Parameter No.	Sym	Characteristic		Min	Typ†	Max	Units	Conditions
130	TAD	A/D clock period	PIC16C72	1.6	—	—	μs	TOSC based, VREF ≥ 3.0V
			PIC16LC72	2.0	—	—	μs	TOSC based, VREF full range
			PIC16C72	2.0	4.0	6.0	μs	A/D RC Mode
			PIC16LC72	3.0	6.0	9.0	μs	A/D RC Mode
131	Tcnv	Conversion time (not including S/H time) (Note 1)		—	9.5TAD	—	—	
132	TACQ	Acquisition time		Note 2	20	—	μs	

\* 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 13.1 for min conditions.

## 22.0 ELECTRICAL CHARACTERISTICS FOR PIC16C73/74

### Absolute Maximum Ratings †

Ambient temperature under bias.....	-55 to +125°C
Storage temperature .....	-65°C to +150°C
Voltage on any pin with respect to VSS (except VDD and $\overline{\text{MCLR}}$ ) .....	-0.3V to (VDD + 0.3V)
Voltage on VDD with respect to VSS .....	0 to +7.5V
Voltage on $\overline{\text{MCLR}}$ with respect to VSS (Note 2) .....	0 to +14V
Total power dissipation (Note 1).....	1.0W
Maximum current out of VSS pin .....	300 mA
Maximum current into VDD pin .....	250 mA
Input clamp current, I <sub>IK</sub> (V <sub>I</sub> < 0 or V <sub>I</sub> > VDD) .....	±20 mA
Output clamp current, I <sub>OK</sub> (V <sub>O</sub> < 0 or V <sub>O</sub> > VDD).....	±20 mA
Maximum output current sunk by any I/O pin.....	25 mA
Maximum output current sourced by any I/O pin .....	25 mA
Maximum current sunk by PORTA, PORTB, and PORTE (combined) (Note 3).....	200 mA
Maximum current sourced by PORTA, PORTB, and PORTE (combined) (Note 3) .....	200 mA
Maximum current sunk by PORTC and PORTD (combined) (Note 3).....	200 mA
Maximum current sourced by PORTC and PORTD (combined) (Note 3).....	200 mA

**Note 1:** Power dissipation is calculated as follows:  $P_{dis} = V_{DD} \times \{I_{DD} - \sum I_{OH}\} + \sum \{(V_{DD} - V_{OH}) \times I_{OH}\} + \sum (V_{OL} \times I_{OL})$

**Note 2:** Voltage spikes below VSS at the  $\overline{\text{MCLR}}$  pin, inducing currents greater than 80 mA, may cause latch-up. Thus, a series resistor of 50-100Ω should be used when applying a “low” level to the  $\overline{\text{MCLR}}$  pin rather than pulling this pin directly to VSS.

**Note 3:** PORTD and PORTE are not implemented on the PIC16C73.

† NOTICE: 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 those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

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**TABLE 22-1: CROSS REFERENCE OF DEVICE SPECS FOR OSCILLATOR CONFIGURATIONS AND FREQUENCIES OF OPERATION (COMMERCIAL DEVICES)**

OSC	PIC16C73-04 PIC16C74-04	PIC16C73-10 PIC16C74-10	PIC16C73-20 PIC16C74-20	PIC16LC73-04 PIC16LC74-04	JW Devices
RC	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 21 $\mu$ A max. at 4V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 2.7 mA typ. at 5.5V IPD: 1.5 $\mu$ A typ. at 4V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 2.7 mA typ. at 5.5V IPD: 1.5 $\mu$ A typ. at 4V Freq: 4 MHz max.	VDD: 3.0V to 6.0V IDD: 3.8 mA max. at 3.0V IPD: 13.5 $\mu$ A max. at 3V Freq: 4 MHz max.	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 21 $\mu$ A max. at 4V Freq: 4 MHz max.
XT	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 21 $\mu$ A max. at 4V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 2.7 mA typ. at 5.5V IPD: 1.5 $\mu$ A typ. at 4V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 2.7 mA typ. at 5.5V IPD: 1.5 $\mu$ A typ. at 4V Freq: 4 MHz max.	VDD: 3.0V to 6.0V IDD: 3.8 mA max. at 3.0V IPD: 13.5 $\mu$ A max. at 3V Freq: 4 MHz max.	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 21 $\mu$ A max. at 4V Freq: 4 MHz max.
HS	VDD: 4.5V to 5.5V IDD: 13.5 mA typ. at 5.5V IPD: 1.5 $\mu$ A typ. at 4.5V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 15 mA max. at 5.5V IPD: 1.5 $\mu$ A typ. at 4.5V Freq: 10 MHz max.	VDD: 4.5V to 5.5V IDD: 30 mA max. at 5.5V IPD: 1.5 $\mu$ A typ. at 4.5V Freq: 20 MHz max.	Do not use in HS mode	VDD: 4.5V to 5.5V IDD: 30 mA max. at 5.5V IPD: 1.5 $\mu$ A typ. at 4.5V Freq: 20 MHz max.
LP	VDD: 4.0V to 6.0V IDD: 52.5 $\mu$ A typ. at 32 kHz, 4.0V IPD: 0.9 $\mu$ A typ. at 4.0V Freq: 200 kHz max.	Do not use in LP mode	Do not use in LP mode	VDD: 3.0V to 6.0V IDD: 48 $\mu$ A max. at 32 kHz, 3.0V IPD: 13.5 $\mu$ A max. at 3.0V Freq: 200 kHz max.	VDD: 3.0V to 6.0V IDD: 48 $\mu$ A max. at 32 kHz, 3.0V IPD: 13.5 $\mu$ A max. at 3.0V Freq: 200 kHz max.

The shaded sections indicate oscillator selections which are tested for functionality, but not for MIN/MAX specifications. It is recommended that the user select the device type that ensures the specifications required.

**22.1 DC Characteristics:** PIC16C73-04 (Commercial, Industrial)  
 PIC16C74-04 (Commercial, Industrial)  
 PIC16C73-10 (Commercial, Industrial)  
 PIC16C74-10 (Commercial, Industrial)  
 PIC16C73-20 (Commercial, Industrial)  
 PIC16C74-20 (Commercial, Industrial)

DC CHARACTERISTICS		Standard Operating Conditions (unless otherwise stated)					
		Operating temperature -40°C ≤ TA ≤ +85°C for industrial and 0°C ≤ TA ≤ +70°C for commercial					
Param No.	Characteristic	Sym	Min	Typ†	Max	Units	Conditions
D001 D001A	Supply Voltage	VDD	4.0 4.5	- -	6.0 5.5	V V	XT, RC and LP osc configuration HS osc configuration
D002*	RAM Data Retention Voltage (Note 1)	VDR	-	1.5	-	V	Device in SLEEP mode
D003	VDD start voltage to ensure internal Power-on Reset signal	VPOR	-	VSS	-	V	See section on Power-on Reset for details
D004*	VDD rise rate to ensure internal Power-on Reset signal	SVDD	0.05	-	-	V/ms	See section on Power-on Reset for details
D010  D013	Supply Current (Note 2,5)	IDD	- -	2.7 13.5	5 30	mA mA	XT, RC osc configuration (PIC16C74-04) FOSC = 4 MHz, VDD = 5.5V (Note 4)  HS osc configuration (PIC16C74-20) FOSC = 20 MHz, VDD = 5.5V
D020 D021 D021A	Power-down Current (Note 3,5)	IPD	- - -	10.5 1.5 1.5	42 21 24	μA μA μA	VDD = 4.0V, WDT enabled, -40°C to +85°C VDD = 4.0V, WDT disabled, -0°C to +70°C VDD = 4.0V, WDT disabled, -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: This is the limit to which VDD can be lowered in SLEEP mode 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 configuration, current through Rext is not included. The current through the resistor can be estimated by the formula  $I_r = V_{DD}/2R_{ext}$  (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.

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## 22.2 DC Characteristics: PIC16LC73-04 (Commercial, Industrial) PIC16LC74-04 (Commercial, Industrial)

DC CHARACTERISTICS		Standard Operating Conditions (unless otherwise stated)						
		Operating temperature -40°C ≤ TA ≤ +85°C for industrial and 0°C ≤ TA ≤ +70°C for commercial						
Param No.	Characteristic	Sym	Min	Typ†	Max	Units	Conditions	
D001	Supply Voltage	VDD	3.0	-	6.0	V	LP, XT, RC osc configuration (DC - 4 MHz)	
D002*	RAM Data Retention Voltage (Note 1)	VDR	-	1.5	-	V	Device in SLEEP mode	
D003	VDD start voltage to ensure internal Power-on Reset signal	VPOR	-	VSS	-	V	See section on Power-on Reset for details	
D004*	VDD rise rate to ensure internal Power-on Reset signal	SVDD	0.05	-	-	V/ms	See section on Power-on Reset for details	
D010	Supply Current (Note 2,5)	IDD	-	2.0	3.8	mA	XT, RC osc configuration FOSC = 4 MHz, VDD = 3.0V (Note 4)	
D010A				-	22.5	48		μA
D020	Power-down Current (Note 3,5)	IPD	-	7.5	30	μA	VDD = 3.0V, WDT enabled, -40°C to +85°C	
D021				-	0.9	13.5	μA	VDD = 3.0V, WDT disabled, 0°C to +70°C
D021A				-	0.9	18	μA	VDD = 3.0V, WDT disabled, -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: This is the limit to which VDD can be lowered in SLEEP mode 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 configuration, current through Rext is not included. The current through the resistor can be estimated by the formula  $I_r = V_{DD}/2R_{ext}$  (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.



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- 22.3 DC Characteristics:** PIC16C73-04 (Commercial, Industrial)  
 PIC16C74-04 (Commercial, Industrial)  
 PIC16C73-10 (Commercial, Industrial)  
 PIC16C74-10 (Commercial, Industrial)  
 PIC16C73-20 (Commercial, Industrial)  
 PIC16C74-20 (Commercial, Industrial)  
 PIC16LC73-04 (Commercial, Industrial)  
 PIC16LC74-04 (Commercial, Industrial)

Standard Operating Conditions (unless otherwise stated)							
DC CHARACTERISTICS							
Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$ for industrial and $0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$ for commercial							
Operating voltage $V_{DD}$ range as described in DC spec Section 22.1 and Section 22.2.							
Param No.	Characteristic	Sym	Min	Typ †	Max	Units	Conditions
D030	<b>Input Low Voltage</b> I/O ports with TTL buffer	$V_{IL}$	$V_{SS}$	-	0.5V	V	
D031	with Schmitt Trigger buffer		$V_{SS}$	-	0.2V <sub>DD</sub>	V	
D032	$\overline{\text{MCLR}}$ , RA4/T0CKI, OSC1 (in RC mode)		$V_{SS}$	-	0.2V <sub>DD</sub>	V	
D033	OSC1 (in XT, HS and LP)		$V_{SS}$	-	0.3V <sub>DD</sub>	V	Note1
D040	<b>Input High Voltage</b> I/O ports with TTL buffer	$V_{IH}$	2.0	-	$V_{DD}$	V	$4.5\text{V} \leq V_{DD} \leq 5.5\text{V}$
D040A			0.8V <sub>DD</sub>	-	$V_{DD}$	V	For $V_{DD} > 5.5\text{V}$ or $V_{DD} < 4.5\text{V}$
D041	with Schmitt Trigger buffer		0.8V <sub>DD</sub>	-	$V_{DD}$	V	For entire $V_{DD}$ range
D042	$\overline{\text{MCLR}}$ , RA4/T0CKI, RC7:RC4, RD7:RD4, RB0/INT, RE2:RE0		0.8V <sub>DD</sub>	-	$V_{DD}$	V	
D042A	OSC1 (XT, HS and LP)		0.7V <sub>DD</sub>	-	$V_{DD}$	V	Note1
D043	OSC1 (in RC mode)		0.9V <sub>DD</sub>	-	$V_{DD}$	V	
D070	PORTB weak pull-up current	$I_{PURB}$	50	250	400	$\mu\text{A}$	$V_{DD} = 5\text{V}$ , $V_{PIN} = V_{SS}$
D060	<b>Input Leakage Current</b> (Notes 2, 3) I/O ports	$I_{IL}$	-	-	$\pm 1$	$\mu\text{A}$	$V_{SS} \leq V_{PIN} \leq V_{DD}$ , Pin at hi-impedance
D061	$\overline{\text{MCLR}}$ , RA4/T0CKI		-	-	$\pm 5$	$\mu\text{A}$	$V_{SS} \leq V_{PIN} \leq V_{DD}$
D063	OSC1		-	-	$\pm 5$	$\mu\text{A}$	$V_{SS} \leq V_{PIN} \leq V_{DD}$ , XT, HS and LP osc configuration
D080	<b>Output Low Voltage</b> I/O ports	$V_{OL}$	-	-	0.6	V	$I_{OL} = 8.5\text{ mA}$ , $V_{DD} = 4.5\text{V}$ , $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$
D083	OSC2/CLKOUT (RC osc config)		-	-	0.6	V	$I_{OL} = 1.6\text{ mA}$ , $V_{DD} = 4.5\text{V}$ , $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$

† 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 configuration, the OSC1/CLKIN pin is a Schmitt Trigger input. It is not recommended that the PIC16C7X be driven with external clock in RC mode.

- The leakage current on the  $\overline{\text{MCLR}}$  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.
- Negative current is defined as coming out of the pin.

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Standard Operating Conditions (unless otherwise stated)							
<b>DC CHARACTERISTICS</b> Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$ for industrial and $0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$ for commercial Operating voltage $V_{DD}$ range as described in DC spec Section 22.1 and Section 22.2.							
Param No.	Characteristic	Sym	Min	Typ †	Max	Units	Conditions
D090	<b>Output High Voltage</b> I/O ports (Note 3)	$V_{OH}$	$V_{DD} - 0.7$	-	-	V	$I_{OH} = -3.0\text{ mA}$ , $V_{DD} = 4.5\text{V}$ , $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$
D092	OSC2/CLKOUT (RC osc config)		$V_{DD} - 0.7$	-	-	V	$I_{OH} = -1.3\text{ mA}$ , $V_{DD} = 4.5\text{V}$ , $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$
<b>Capacitive Loading Specs on Output Pins</b>							
D100	OSC2 pin	$C_{OSC2}$	-	-	15	pF	In XT, HS and LP modes when external clock is used to drive OSC1.
D101	All I/O pins and OSC2 (in RC mode) SCL, SDA in I <sup>2</sup> C mode	$C_{IO}$	-	-	50	pF	
D102		CB	-	-	400	pF	

† 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 configuration, the OSC1/CLKIN pin is a Schmitt Trigger input. It is not recommended that the PIC16C7X be driven with external clock in RC mode.

2: The leakage current on the  $\overline{\text{MCLR}}$  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 coming out of the pin.

## 22.4 Timing Parameter Symbology

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

- |             |           |  |
|-------------|-----------|--|
| 1. TppS2ppS | 3. TCC:ST | (I <sup>2</sup> C specifications only) |
| 2. TppS     | 4. Ts     | (I <sup>2</sup> C specifications only) |

<b>T</b>			
F	Frequency	T	Time

Lowercase letters (pp) and their meanings:

<b>pp</b>			
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	$\overline{WR}$

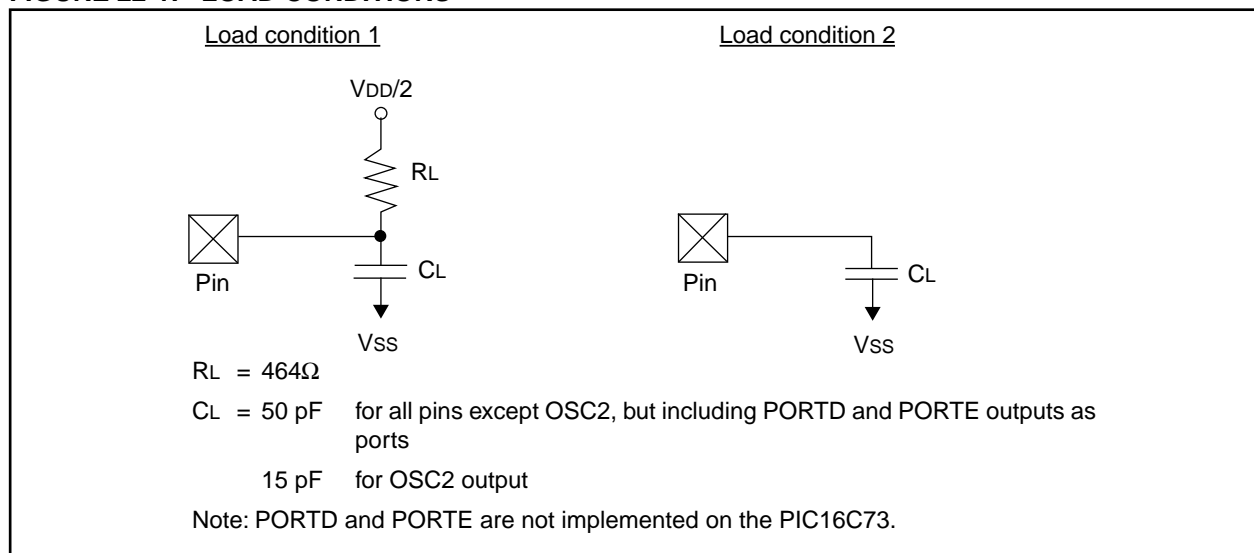
Uppercase letters and their meanings:

<b>S</b>			
F	Fall	P	Period
H	High	R	Rise
I	Invalid (Hi-impedance)	V	Valid
L	Low	Z	Hi-impedance
<b>I<sup>2</sup>C only</b>			
AA	output access	High	High
BUF	Bus free	Low	Low

TCC:ST (I<sup>2</sup>C specifications only)

<b>CC</b>			
HD	Hold	SU	Setup
<b>ST</b>			
DAT	DATA input hold	STO	STOP condition
STA	START condition		

**FIGURE 22-1: LOAD CONDITIONS**



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## 22.5 Timing Diagrams and Specifications

FIGURE 22-2: EXTERNAL CLOCK TIMING

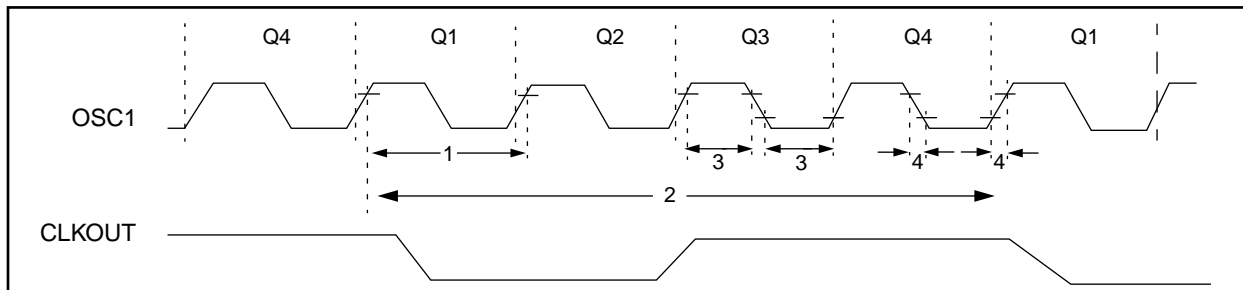


TABLE 22-2: EXTERNAL CLOCK TIMING REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions	
	Fos	<b>External CLKIN Frequency (Note 1)</b>	DC	—	4	MHz	XT and RC osc mode	
			DC	—	4	MHz	HS osc mode (PIC16C73-04, PIC16C74-04)	
			DC	—	20	MHz	HS osc mode (PIC16C73-20, PIC16C74-20)	
			DC	—	200	kHz	LP osc mode	
			<b>Oscillator Frequency (Note 1)</b>	DC	—	4	MHz	RC osc mode
				0.1	—	4	MHz	XT osc mode
				4	—	4	MHz	HS osc mode (PIC16C73-04, PIC16C74-04)
				4	—	10	MHz	HS osc mode (PIC16C73-10, PIC16C74-10)
				4	—	20	MHz	HS osc mode (PIC16C73-20, PIC16C74-20)
				5	—	200	kHz	LP osc mode
1	Tosc	<b>External CLKIN Period (Note 1)</b>	250	—	—	ns	XT and RC osc mode	
			250	—	—	ns	HS osc mode (PIC16C73-04, PIC16C74-04)	
			100	—	—	ns	HS osc mode (PIC16C73-10, PIC16C74-10)	
			50	—	—	ns	HS osc mode (PIC16C73-20, PIC16C74-20)	
			5	—	—	μs	LP osc mode	
					<b>Oscillator Period (Note 1)</b>	250	—	—
	250	—				10,000	ns	XT osc mode
	250	—				250	ns	HS osc mode (PIC16C73-04, PIC16C74-04)
	100	—				250	ns	HS osc mode (PIC16C73-10, PIC16C74-10)
				50	—	250	ns	HS osc mode (PIC16C73-20, PIC16C74-20)
5				—	—	μs	LP osc mode	
2	TCY	<b>Instruction Cycle Time (Note 1)</b>	200	—	DC	ns	TCY = 4/Fosc	

† 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.

**TABLE 22-2: EXTERNAL CLOCK TIMING REQUIREMENTS (Cont.'d)**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
3	TosL, TosH	<b>External Clock in (OSC1) High or Low Time</b>	50	—	—	ns	XT oscillator
			2.5	—	—	μs	LP oscillator
			15	—	—	ns	HS oscillator
4	TosR, TosF	<b>External Clock in (OSC1) Rise or Fall Time</b>	—	—	25	ns	XT oscillator
			—	—	50	ns	LP oscillator
			—	—	15	ns	HS oscillator

† 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 (T<sub>cy</sub>) 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.

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FIGURE 22-3: CLKOUT AND I/O TIMING

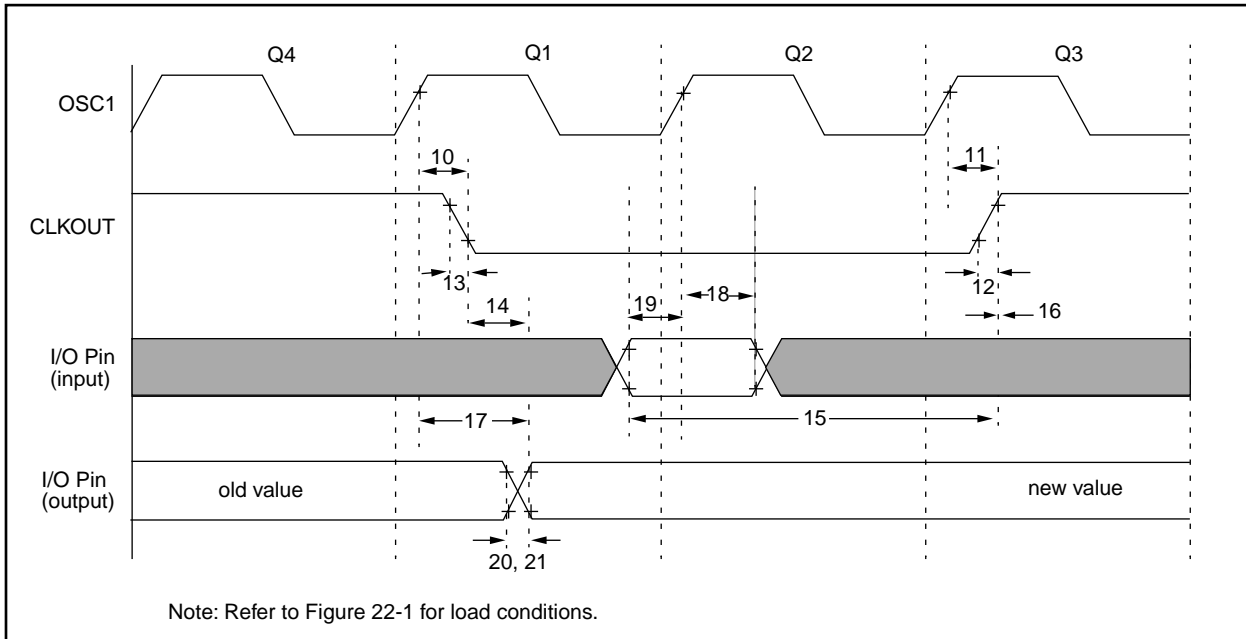


TABLE 22-3: CLKOUT AND I/O TIMING REQUIREMENTS

Parameter 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 ↑	0.25TCY + 25	—	—	ns	Note 1
16*	TckH2iol	Port in hold after CLKOUT ↑	0	—	—	ns	Note 1
17*	TosH2ioV	OSC1↑ (Q1 cycle) to Port out valid	—	50	150	ns	
18*	TosH2iol	OSC1↑ (Q2 cycle) to Port input invalid (I/O in hold time)	PIC16C73/74	100	—	—	ns
			PIC16LC73/74	200	—	—	ns
19*	TioV2osH	Port input valid to OSC1↑ (I/O in setup time)	0	—	—	ns	
20*	TioR	Port output rise time	PIC16C73/74	—	10	25	ns
			PIC16LC73/74	—	—	60	ns
21*	TioF	Port output fall time	PIC16C73/74	—	10	25	ns
			PIC16LC73/74	—	—	60	ns
22††*	Tinp	INT pin high or low time	TCY	—	—	ns	
23††*	Trbp	RB7:RB4 change INT high or low time	TCY	—	—	ns	

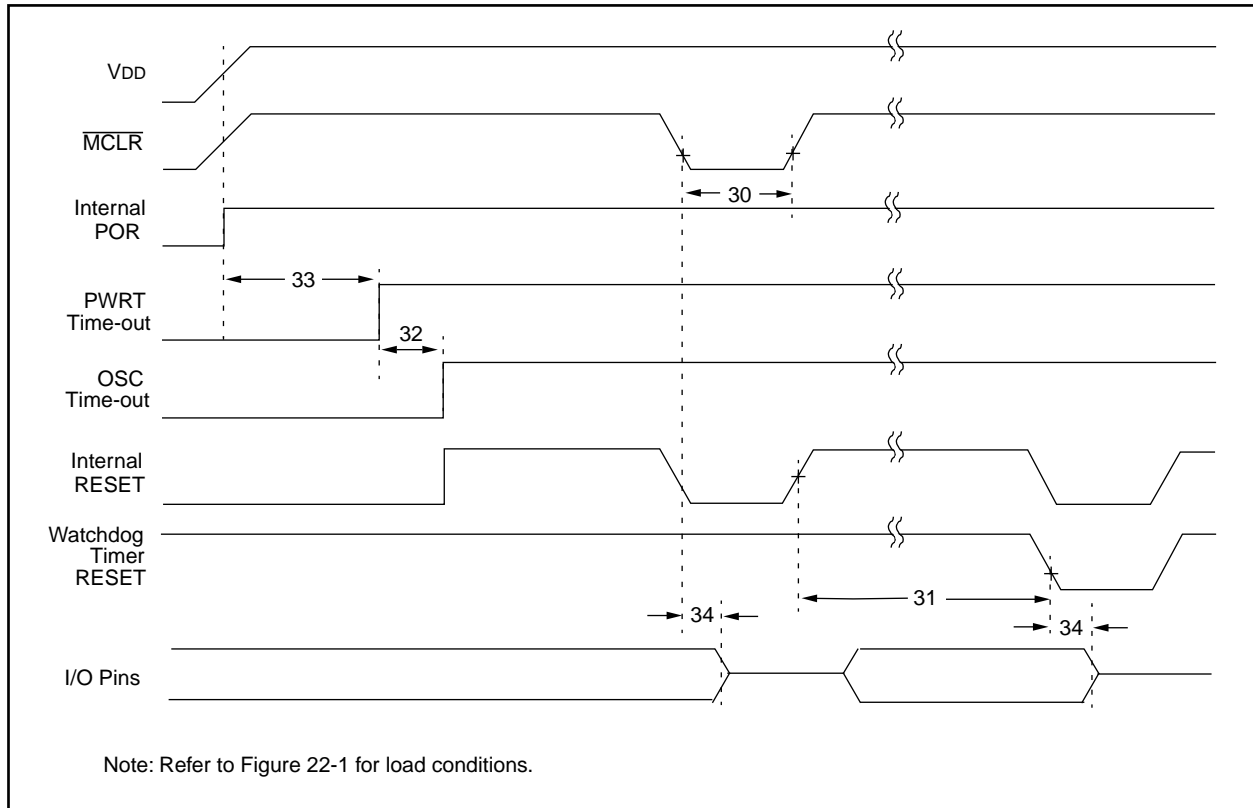
\* These parameters are characterized but not tested.

† 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 edges.

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

**FIGURE 22-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER TIMING**



**TABLE 22-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
30	Tmcl	MCLR Pulse Width (low)	100	—	—	ns	V <sub>DD</sub> = 5V, -40°C to +85°C
31	Twdt	Watchdog Timer Time-out Period (No Prescaler)	7*	18	33*	ms	V <sub>DD</sub> = 5V, -40°C to +85°C
32	Tost	Oscillation Start-up Timer Period	—	1024T <sub>osc</sub>	—	—	T <sub>osc</sub> = OSC1 period
33	Tpwrt	Power up Timer Period	28*	72	132*	ms	V <sub>DD</sub> = 5V, -40°C to +85°C
34	Tioz	I/O Hi-impedance from MCLR Low or Watchdog Timer Reset	—	—	100	ns	

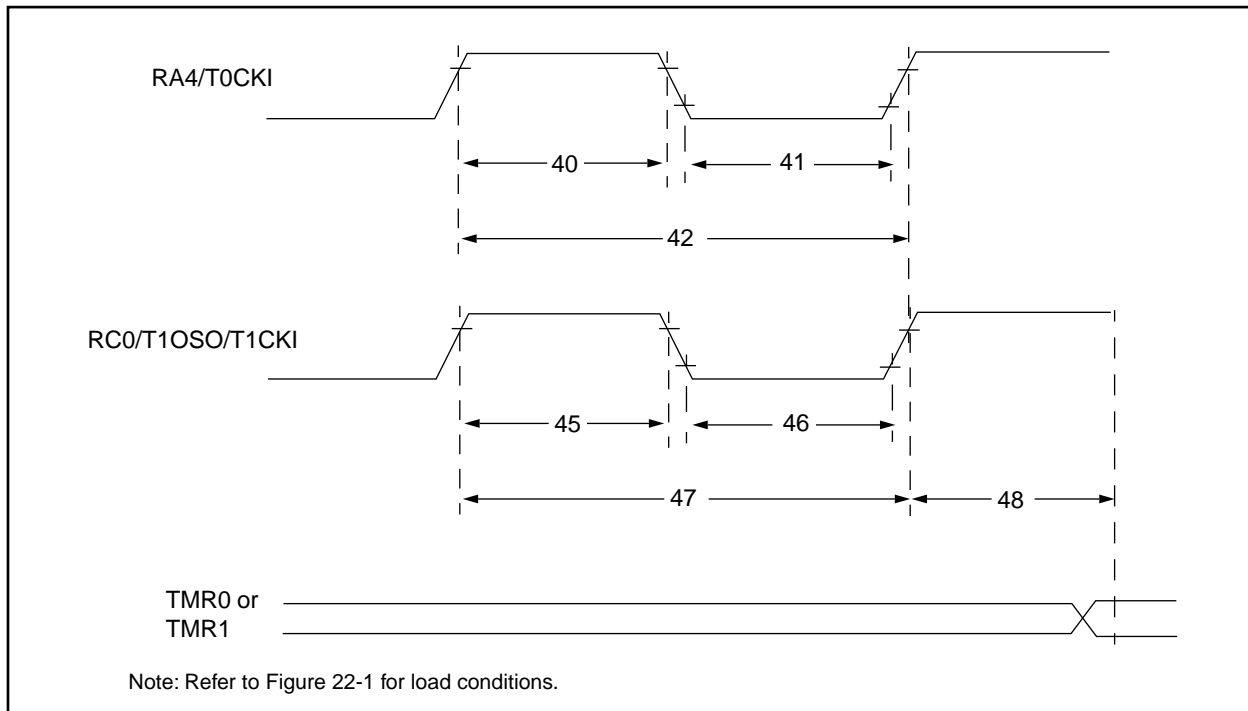
\* These parameters are characterized but not tested.

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

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FIGURE 22-5: TIMER0 AND TIMER1 CLOCK TIMINGS



Note: Refer to Figure 22-1 for load conditions.

TABLE 22-5: TIMER0 AND TIMER1 CLOCK REQUIREMENTS

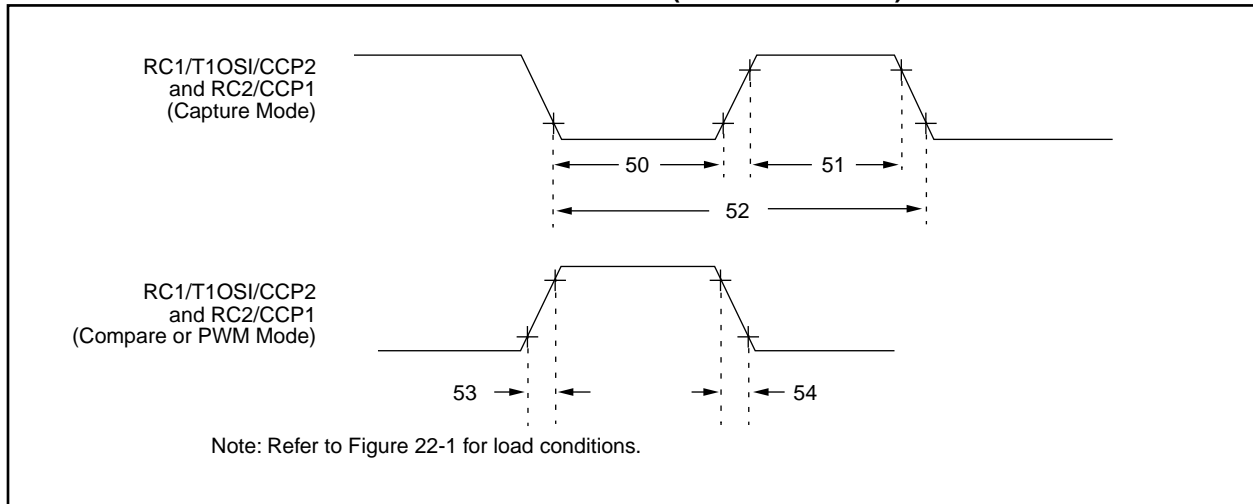
Param No.	Sym	Characteristic		Min	Typ†	Max	Units	Conditions	
40*	Tt0H	T0CKI High Pulse Width	No Prescaler	$0.5T_{CY} + 20$	—	—	ns		
			With Prescaler	10	—	—	ns		
41*	Tt0L	T0CKI Low Pulse Width	No Prescaler	$0.5T_{CY} + 20$	—	—	ns		
			With Prescaler	10*	—	—	ns		
42*	Tt0P	T0CKI Period		Greater of: $20\mu s$ or $\frac{T_{CY} + 40}{N}$	—	—	ns	N = prescale value (1, 2, 4, ..., 256)	
45*	Tt1H	T1CKI High Time	Synchronous, no prescaler		$0.5T_{CY} + 20$	—	—	ns	
			Synchronous, with prescaler	PIC16C73/74	15	—	—	ns	
				PIC16LC73/74	25	—	—	ns	
			Asynchronous		$2T_{CY}$	—	—	ns	
46*	Tt1L	T1CKI Low Time	Synchronous, no prescaler		$0.5T_{CY} + 20$	—	—	ns	
			Synchronous, with prescaler	PIC16C73/74	15	—	—	ns	
				PIC16LC73/74	25	—	—	ns	
			Asynchronous		$2T_{CY}$	—	—	ns	
47*	Tt1P	T1CKI input period	Synchronous		Greater of: $20\mu s$ or $\frac{T_{CY} + 40}{N}$	—	—	ns	N = prescale value (1, 2, 4, 8)
			Asynchronous		Greater of: $20\mu s$ or $4T_{CY}$	—	—	ns	
	Ft1	Timer1 oscillator input frequency range (oscillator enabled by setting the T1OSCEN bit)		DC	—	200	kHz		
48	Tcke2tmr1	Delay from external clock edge to timer increment		$2T_{osc}$	—	$7T_{osc}$	—		

\* 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 22-6: CAPTURE/COMPARE/PWM TIMINGS (CCP1 AND CCP2)**



**TABLE 22-6: CAPTURE/COMPARE/PWM REQUIREMENTS (CCP1 AND CCP2)**

Parameter No.	Sym	Characteristic		Min	Typ†	Max	Units	Conditions	
50*	TccL	CCP1 and CCP2 input low time	No Prescaler	$0.5T_{CY} + 20$	—	—	ns		
			With Prescaler	PIC16C73/74	10	—	—		ns
				PIC16LC73/74	20	—	—		ns
51*	TccH	CCP1 and CCP2 input high time	No Prescaler	$0.5T_{CY} + 20$	—	—	ns		
			With Prescaler	PIC16C73/74	10	—	—		ns
				PIC16LC73/74	20	—	—		ns
52*	TccP	CCP1 and CCP2 input period		$\frac{3T_{CY} + 40}{N}$	—	—	ns	N = prescale value (1,4 or 16)	
53*	TccR	CCP1 and CCP2 output fall time	PIC16C73/74	—	10	25	ns		
			PIC16LC73/74	—	25	45	ns		
54*	TccF	CCP1 and CCP2 output rise time	PIC16C73/74	—	10	25	ns		
			PIC16LC73/74	—	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.

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FIGURE 22-7: PARALLEL SLAVE PORT TIMING (PIC16C74)

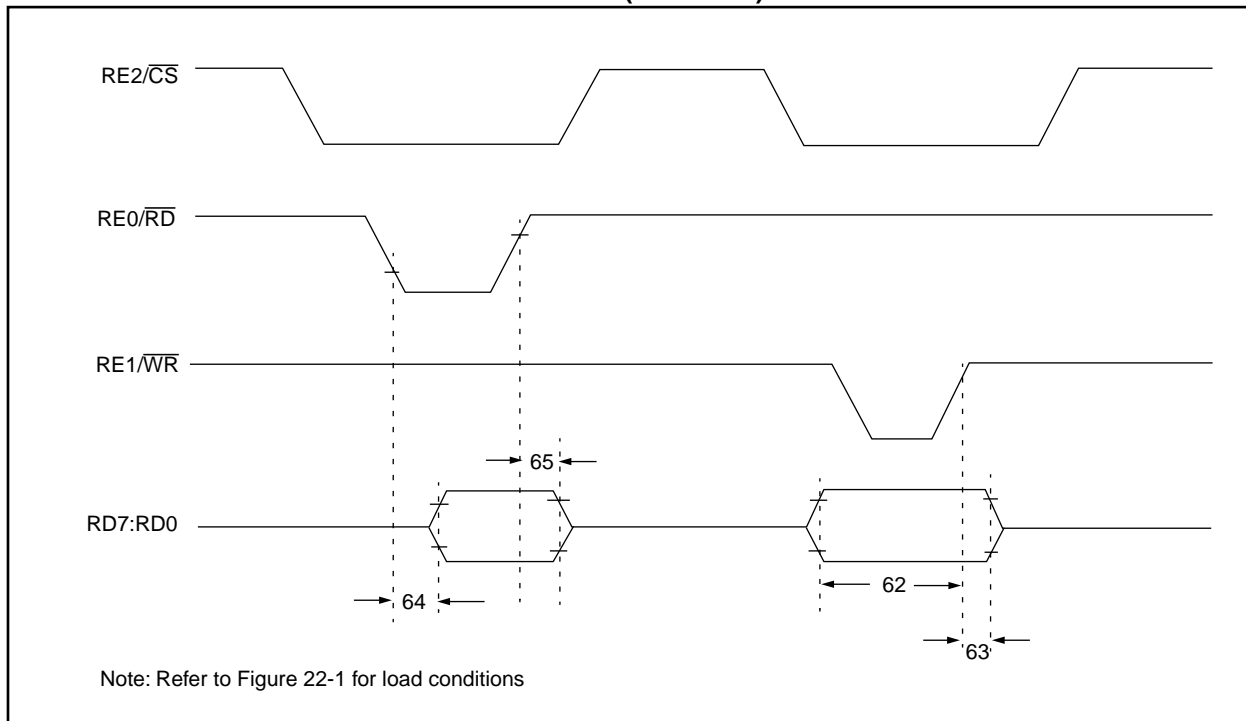
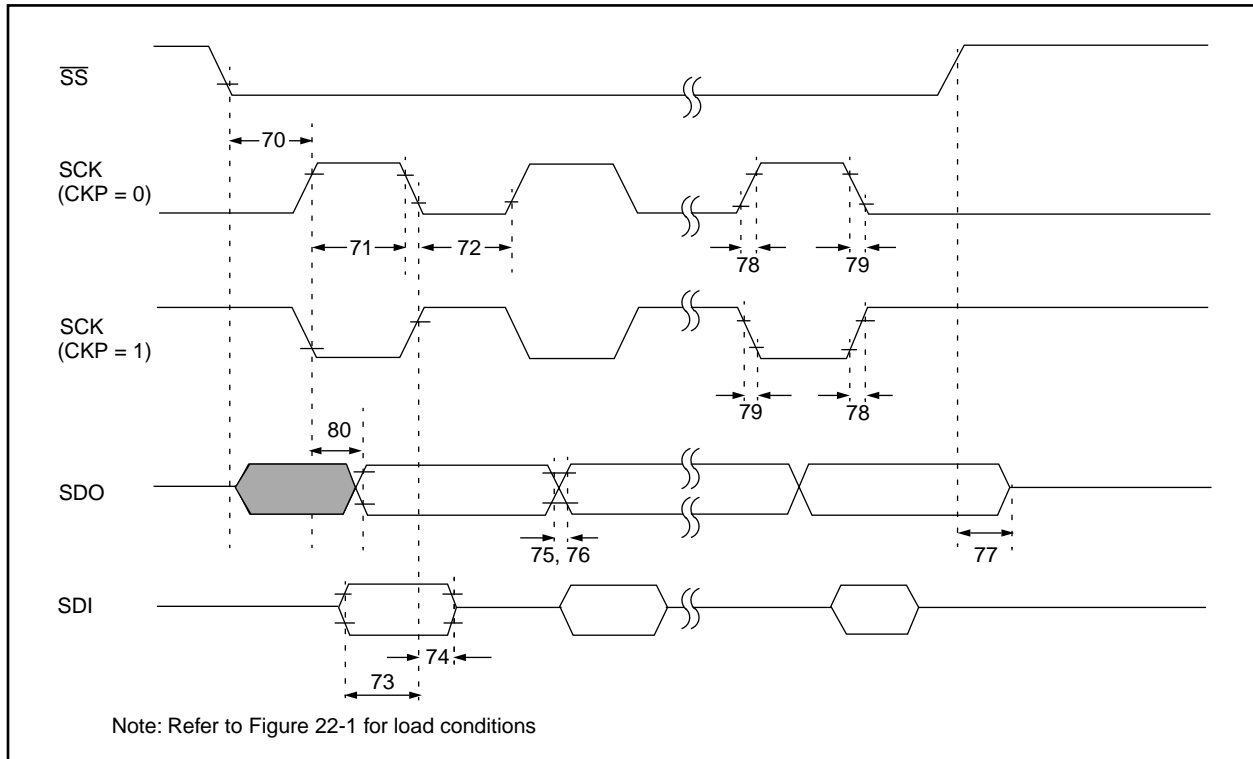


TABLE 22-7: PARALLEL SLAVE PORT REQUIREMENTS (PIC16C74)

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
62	TdtV2wrH	Data in valid before $\overline{WR}\uparrow$ or $\overline{CS}\uparrow$ (setup time)	20	—	—	ns	
63*	TwrH2dtI	$\overline{WR}\uparrow$ or $\overline{CS}\uparrow$ to data-in invalid (hold time)	PIC16C74	20	—	—	ns
			PIC16LC74	35	—	—	ns
64	TrdL2dtV	$\overline{RD}\downarrow$ and $\overline{CS}\downarrow$ to data-out valid	—	—	80	ns	
65	TrdH2dtI	$\overline{RD}\uparrow$ or $\overline{CS}\downarrow$ to data-out invalid	10	—	30	ns	

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

**FIGURE 22-8: SPI MODE TIMING**



**TABLE 22-8: SPI MODE REQUIREMENTS**

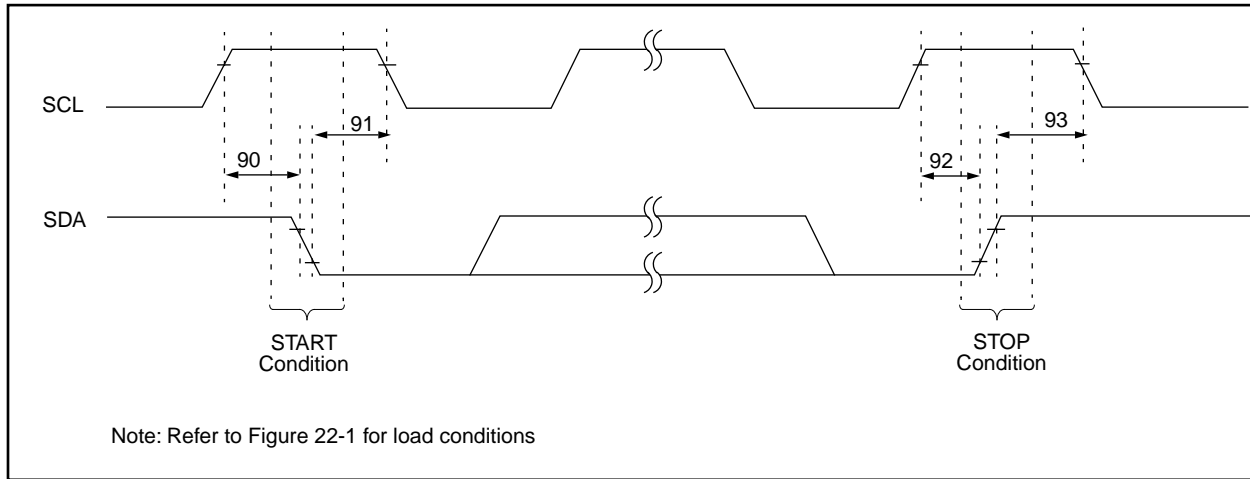
Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
70	TssL2scH, TssL2scL	$\overline{SS}\downarrow$ to SCK $\downarrow$ or SCK $\uparrow$ input	T <sub>CY</sub>	—	—	ns	
71	TscH	SCK input high time (slave mode)	T <sub>CY</sub> + 20	—	—	ns	
72	TscL	SCK input low time (slave mode)	T <sub>CY</sub> + 20	—	—	ns	
73	TdiV2scH, TdiV2scL	Setup time of SDI data input to SCK edge	50	—	—	ns	
74	Tsch2diL, TscL2diL	Hold time of SDI data input to SCK edge	50	—	—	ns	
75	TdoR	SDO data output rise time	—	10	25	ns	
76	TdoF	SDO data output fall time	—	10	25	ns	
77	TssH2doZ	$\overline{SS}\downarrow$ to SDO output hi-impedance	10	—	50	ns	
78	TscR	SCK output rise time (master mode)	—	10	25	ns	
79	TscF	SCK output fall time (master mode)	—	10	25	ns	
80	Tsch2doV, TscL2doV	SDO data output valid after SCK edge	—	—	50	ns	

† 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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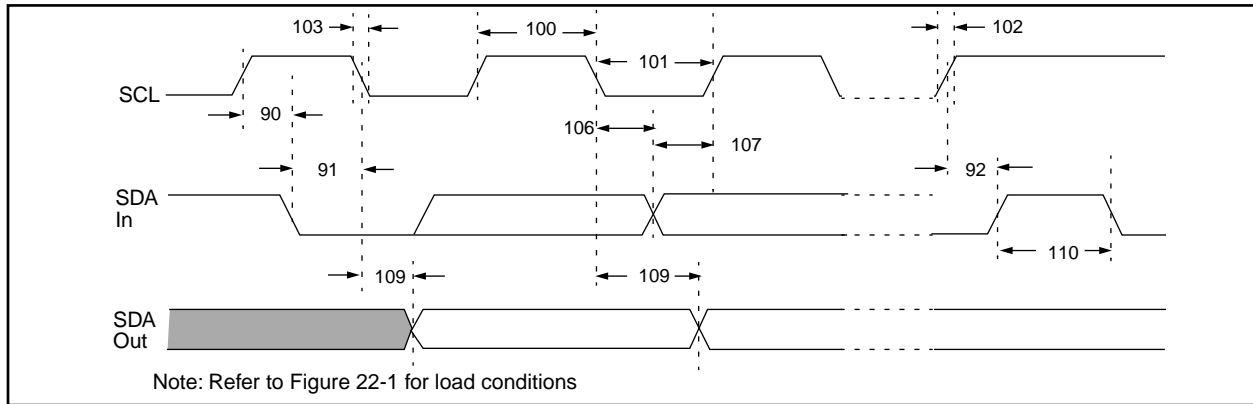
**FIGURE 22-9: I<sup>2</sup>C BUS START/STOP BITS TIMING**



**TABLE 22-9: I<sup>2</sup>C BUS START/STOP BITS REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Typ	Max	Units	Conditions	
90	TSU:STA	START condition	100 kHz mode	4700	—	—	ns	Only relevant for repeated START condition
		Setup time	400 kHz mode	600	—	—		
91	THD:STA	START condition	100 kHz mode	4000	—	—	ns	After this period the first clock pulse is generated
		Hold time	400 kHz mode	600	—	—		
92	TSU:STO	STOP condition	100 kHz mode	4700	—	—	ns	
		Setup time	400 kHz mode	600	—	—		
93	THD:STO	STOP condition	100 kHz mode	4000	—	—	ns	
		Hold time	400 kHz mode	600	—	—		

**FIGURE 22-10: I<sup>2</sup>C BUS DATA TIMING**



**TABLE 22-10: I<sup>2</sup>C BUS DATA REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Max	Units	Conditions		
100	THIGH	Clock high time	100 kHz mode	4.0	—	μs	PIC16C73/74 must operate at a minimum of 1.5 MHz	
			400 kHz mode	0.6	—	μs		PIC16C73/74 must operate at a minimum of 10 MHz
			SSP Module	1.5Tcy	—			
101	TLOW	Clock low time	100 kHz mode	4.7	—	μs	PIC16C73/74 must operate at a minimum of 1.5 MHz	
			400 kHz mode	1.3	—	μs		PIC16C73/74 must operate at a minimum of 10 MHz
			SSP Module	1.5Tcy	—			
102	Tr	SDA and SCL rise time	100 kHz mode	—	1000	ns	Cb is specified to be from 10 to 400 pF	
			400 kHz mode	20 + 0.1Cb	300	ns		
103	TF	SDA and SCL fall time	100 kHz mode	—	300	ns	Cb is specified to be from 10 to 400 pF	
			400 kHz mode	20 + 0.1Cb	300	ns		
90	TSU:STA	START condition setup time	100 kHz mode	4.7	—	μs	Only relevant for repeated START condition	
			400 kHz mode	0.6	—	μs		
91	THD:STA	START condition hold time	100 kHz mode	4.0	—	μs	After this period the first clock pulse is generated	
			400 kHz mode	0.6	—	μs		
106	THD:DAT	Data input hold time	100 kHz mode	0	—	ns		
			400 kHz mode	0	0.9	μs		
107	TSU:DAT	Data input setup time	100 kHz mode	250	—	ns	Note 2	
			400 kHz mode	100	—	ns		
92	TSU:STO	STOP condition setup time	100 kHz mode	4.7	—	μs		
			400 kHz mode	0.6	—	μs		
109	TAA	Output valid from clock	100 kHz mode	—	3500	ns	Note 1	
			400 kHz mode	—	—	ns		
110	TBUF	Bus free time	100 kHz mode	4.7	—	μs	Time the bus must be free before a new transmission can start	
			400 kHz mode	1.3	—	μs		
	Cb	Bus capacitive loading	—	400	pF			

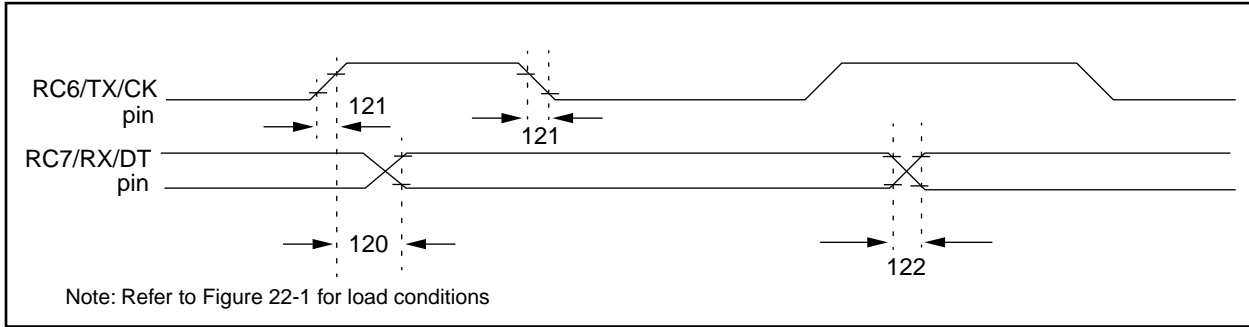
Note 1: As a transmitter, the device must provide this internal minimum delay time to bridge the undefined region (min. 300 ns) of the falling edge of SCL to avoid unintended generation of START or STOP conditions.

2: A fast-mode I<sup>2</sup>C-bus device can be used in a standard-mode I<sup>2</sup>C-bus system, but the requirement tsu;DAT ≥ 250 ns must then be met. This will automatically be the case if the device does not stretch the LOW period of the SCL signal. If such a device does stretch the LOW period of the SCL signal, it must output the next data bit to the SDA line TR max.+tsu;DAT = 1000 + 250 = 1250 ns (according to the standard-mode I<sup>2</sup>C bus specification) before the SCL line is released.

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**FIGURE 22-11: USART SYNCHRONOUS TRANSMISSION (MASTER/SLAVE) TIMING**

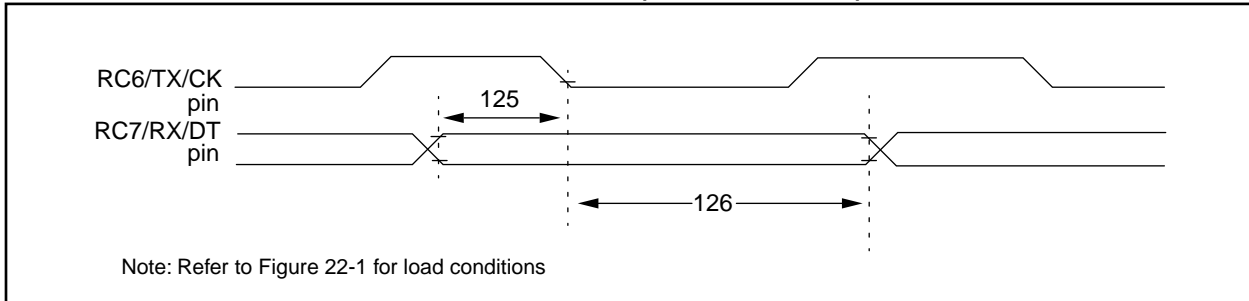


**TABLE 22-11: USART SYNCHRONOUS TRANSMISSION REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions	
120	TckH2dtV	SYNC XMIT (MASTER & SLAVE) Clock high to data out valid	—	—	80	ns		
			—	—	100	ns		
121	Tckrf	Clock out rise time and fall time (Master Mode)	PIC16C73/74	—	—	45	ns	
			PIC16LC73/74	—	—	50	ns	
122	TdtV	Data out rise time and fall time	PIC16C73/74	—	—	45	ns	
			PIC16LC73/74	—	—	50	ns	

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

**FIGURE 22-12: USART SYNCHRONOUS RECEIVE (MASTER/SLAVE) TIMING**



**TABLE 22-12: USART SYNCHRONOUS RECEIVE REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
125	TdtV2ckl	SYNC RCV (MASTER & SLAVE) Data hold before CK ↓ (DT hold time)	15	—	—	ns	
126	TckL2dtl	Data hold after CK ↓ (DT hold time)	15	—	—	ns	

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

**TABLE 22-13: A/D CONVERTER CHARACTERISTICS:**  
**PIC16C73-04 (COMMERCIAL, INDUSTRIAL)**  
**PIC16C74-04 (COMMERCIAL, INDUSTRIAL)**  
**PIC16C73-10 (COMMERCIAL, INDUSTRIAL)**  
**PIC16C74-10 (COMMERCIAL, INDUSTRIAL)**  
**PIC16C73-20 (COMMERCIAL, INDUSTRIAL)**  
**PIC16C74-20 (COMMERCIAL, INDUSTRIAL)**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
	NR	Resolution	—	—	8-bits	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NINT	Integral error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NDIF	Differential error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NFS	Full scale error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NOFF	Offset error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	—	Monotonicity	—	guaranteed	—	—	$V_{SS} \leq A_{IN} \leq V_{REF}$
	VREF	Reference voltage	3.0V	—	$V_{DD} + 0.3$	V	
	VAIN	Analog input voltage	$V_{SS} - 0.3$	—	$V_{REF} + 0.3$	V	
	ZAIN	Recommended impedance of analog voltage source	—	—	10.0	k $\Omega$	
	IAD	A/D conversion current ( $V_{DD}$ )	—	180	—	$\mu A$	Average current consumption when A/D is on. (Note 1)
	IREF	$V_{REF}$ input current (Note 2)	—	—	1 10	mA $\mu A$	During sampling All other times

\* 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: When A/D is off, it will not consume any current other than minor leakage current. The power-down current spec includes any such leakage from the A/D module.

2:  $V_{REF}$  current is from RA3 pin or  $V_{DD}$  pin, whichever is selected as reference input.

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Applicable Devices 710 71 711 72 73 73A 74 74A

**TABLE 22-14: A/D CONVERTER CHARACTERISTICS:  
PIC16LC73-04 (COMMERCIAL, INDUSTRIAL)  
PIC16LC74-04 (COMMERCIAL, INDUSTRIAL)**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
	NR	Resolution	—	—	8-bits	—	VREF = VDD = 3.0V (Note 1)
	NINT	Integral error	—	—	less than ±1 LSb	—	VREF = VDD = 3.0V (Note 1)
	NDIF	Differential error	—	—	less than ±1 LSb	—	VREF = VDD = 3.0V (Note 1)
	NFS	Full scale error	—	—	less than ±1 LSb	—	VREF = VDD = 3.0V (Note 1)
	NOFF	Offset error	—	—	less than ±1 LSb	—	VREF = VDD = 3.0V (Note 1)
	—	Monotonicity	—	guaranteed	—	—	VSS ≤ AIN ≤ VREF
	VREF	Reference voltage	3.0V	—	VDD + 0.3	V	
	VAIN	Analog input voltage	VSS - 0.3	—	VREF + 0.3	V	
	ZAIN	Recommended impedance of analog voltage source	—	—	10.0	kΩ	
	IAD	A/D conversion current (VDD)	—	90	—	μA	Average current consumption when A/D is on. (Note 2)
	IREF	VREF input current (Note 3)	—	—	1 10	mA μA	During sampling All other times

\* 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.

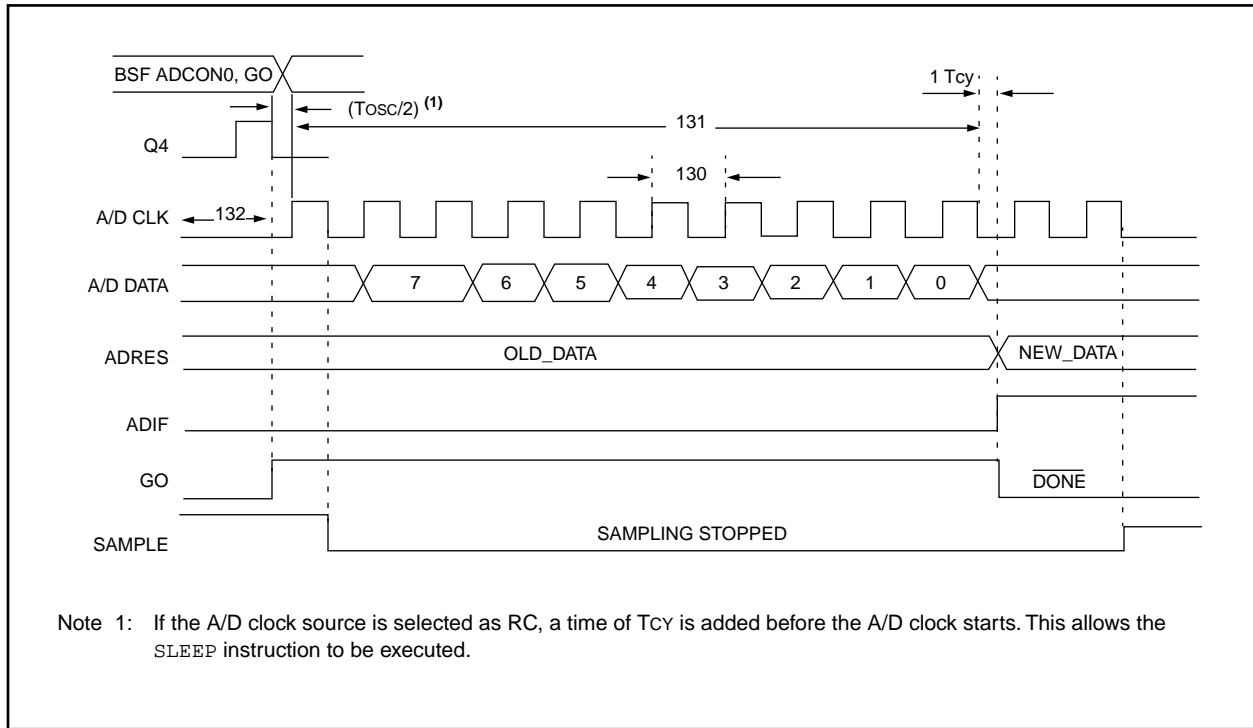
Note 1: These specifications apply if VREF = 3.0V and if VDD ≥ 3.0V. VIN must be between VSS and VREF

2: When A/D is off, it will not consume any current other than minor leakage current. The power-down current spec includes any such leakage from the A/D module.

3: VREF current is from RA3 pin or VDD pin, whichever is selected as reference input.



**FIGURE 22-13: A/D CONVERSION TIMING**



**TABLE 22-15: A/D CONVERSION REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions	
130	TAD	A/D clock period	PIC16C73/74	1.6	—	—	$\mu s$	TOSC based, $V_{REF} \geq 3.0V$
			PIC16LC73/74	2.0	—	—	$\mu s$	TOSC based, $V_{REF}$ full range
			PIC16C73/74	2.0	4.0	6.0	$\mu s$	A/D RC Mode
			PIC16LC73/74	3.0	6.0	9.0	$\mu s$	A/D RC Mode
131	TCNV	Conversion time (not including S/H time) (Note 1)	—	9.5TAD	—	—		
132	TACQ	Acquisition time	Note 2	20	—	$\mu s$		

\* 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  $T_{cy}$  cycle.

Note 2: See Section 13.1 for min conditions.

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Applicable Devices	710	71	711	72	73	73A	74	74A
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NOTES:

## 23.0 ELECTRICAL CHARACTERISTICS FOR PIC16C73A/74A

### Absolute Maximum Ratings †

Ambient temperature under bias.....	-55 to +125°C
Storage temperature .....	-65°C to +150°C
Voltage on any pin with respect to VSS (except VDD and $\overline{\text{MCLR}}$ ) .....	-0.3V to (VDD + 0.3V)
Voltage on VDD with respect to VSS .....	0 to +7.5V
Voltage on $\overline{\text{MCLR}}$ with respect to VSS (Note 2) .....	0 to +14V
Total power dissipation (Note 1).....	1.0W
Maximum current out of VSS pin .....	300 mA
Maximum current into VDD pin .....	250 mA
Input clamp current, I <sub>IK</sub> (V <sub>I</sub> < 0 or V <sub>I</sub> > VDD) .....	± 20 mA
Output clamp current, I <sub>OK</sub> (V <sub>O</sub> < 0 or V <sub>O</sub> > VDD) .....	± 20 mA
Maximum output current sunk by any I/O pin.....	25 mA
Maximum output current sourced by any I/O pin .....	25 mA
Maximum current sunk by PORTA, PORTB, and PORTE (combined) (Note 3) .....	200 mA
Maximum current sourced by PORTA, PORTB, and PORTE (combined) (Note 3) .....	200 mA
Maximum current sunk by PORTC and PORTD (combined) (Note 3).....	200 mA
Maximum current sourced by PORTC and PORTD (combined) (Note 3).....	200 mA

**Note 1:** Power dissipation is calculated as follows:  $P_{dis} = V_{DD} \times \{I_{DD} - \sum I_{OH}\} + \sum \{(V_{DD} - V_{OH}) \times I_{OH}\} + \sum (V_{OL} \times I_{OL})$

**Note 2:** Voltage spikes below VSS at the  $\overline{\text{MCLR}}$  pin, inducing currents greater than 80 mA, may cause latch-up. Thus, a series resistor of 50-100Ω should be used when applying a “low” level to the  $\overline{\text{MCLR}}$  pin rather than pulling this pin directly to VSS.

**Note 3:** PORTD and PORTE are not implemented on the PIC16C73A.

† NOTICE: 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 those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

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Applicable Devices	710	71	711	72	73	73A	74	74A
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**TABLE 23-1: CROSS REFERENCE OF DEVICE SPECS FOR OSCILLATOR CONFIGURATIONS AND FREQUENCIES OF OPERATION (COMMERCIAL DEVICES)**

OSC	PIC16C73A-04 PIC16C74A-04	PIC16C73A-10 PIC16C74A-10	PIC16C73A-20 PIC16C74A-20	PIC16LC73A-04 PIC16LC74A-04	JW Devices
RC	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 16 $\mu$ A max. at 4V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 2.7 mA typ. at 5.5V IPD: 1.5 $\mu$ A typ. at 4V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 2.7 mA typ. at 5.5V IPD: 1.5 $\mu$ A typ. at 4V Freq: 4 MHz max.	VDD: 2.5V to 6.0V IDD: 3.8 mA max. at 3.0V IPD: 5 $\mu$ A max. at 3V Freq: 4 MHz max.	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 16 $\mu$ A max. at 4V Freq: 4 MHz max.
XT	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 16 $\mu$ A max. at 4V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 2.7 mA typ. at 5.5V IPD: 1.5 $\mu$ A typ. at 4V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 2.7 mA typ. at 5.5V IPD: 1.5 $\mu$ A typ. at 4V Freq: 4 MHz max.	VDD: 2.5V to 6.0V IDD: 3.8 mA max. at 3.0V IPD: 5 $\mu$ A max. at 3V Freq: 4 MHz max.	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 16 $\mu$ A max. at 4V Freq: 4 MHz max.
HS	VDD: 4.5V to 5.5V IDD: 13.5 mA typ. at 5.5V IPD: 1.5 $\mu$ A typ. at 4.5V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 10 mA max. at 5.5V IPD: 1.5 $\mu$ A typ. at 4.5V Freq: 10 MHz max.	VDD: 4.5V to 5.5V IDD: 20 mA max. at 5.5V IPD: 1.5 $\mu$ A typ. at 4.5V Freq: 20 MHz max.	Do not use in HS mode	VDD: 4.5V to 5.5V IDD: 20 mA max. at 5.5V IPD: 1.5 $\mu$ A typ. at 4.5V Freq: 20 MHz max.
LP	VDD: 4.0V to 6.0V IDD: 52.5 $\mu$ A typ. at 32 kHz, 4.0V IPD: 0.9 $\mu$ A typ. at 4.0V Freq: 200 kHz max.	Do not use in LP mode	Do not use in LP mode	VDD: 2.5V to 6.0V IDD: 48 $\mu$ A max. at 32 kHz, 3.0V IPD: 5.0 $\mu$ A max. at 3.0V Freq: 200 kHz max.	VDD: 2.5V to 6.0V IDD: 48 $\mu$ A max. at 32 kHz, 3.0V IPD: 5.0 $\mu$ A max. at 3.0V Freq: 200 kHz max.

The shaded sections indicate oscillator selections which are tested for functionality, but not for MIN/MAX specifications. It is recommended that the user select the device type that ensures the specifications required.

**23.1 DC Characteristics:** PIC16C73A-04 (Commercial, Industrial, Automotive)  
 PIC16C74A-04 (Commercial, Industrial, Automotive)  
 PIC16C73A-10 (Commercial, Industrial, Automotive)  
 PIC16C74A-10 (Commercial, Industrial, Automotive)  
 PIC16C73A-20 (Commercial, Industrial, Automotive)  
 PIC16C74A-20 (Commercial, Industrial, Automotive)

DC CHARACTERISTICS		Standard Operating Conditions (unless otherwise stated)					
		Operating temperature -40°C ≤ TA ≤ +125°C for automotive, -40°C ≤ TA ≤ +85°C for industrial and 0°C ≤ TA ≤ +70°C for commercial					
Param No.	Characteristic	Sym	Min	Typ†	Max	Units	Conditions
D001 D001A	Supply Voltage	VDD	4.0 4.5	- -	6.0 5.5	V V	XT, RC and LP osc configuration HS osc configuration
D002*	RAM Data Retention Voltage (Note 1)	VDR	-	1.5	-	V	Device in SLEEP mode
D003	VDD start voltage to ensure internal Power-on Reset signal	VPOR	-	VSS	-	V	See section on Power-on Reset for details
D004*	VDD rise rate to ensure internal Power-on Reset signal	SVDD	0.05	-	-	V/ms	See section on Power-on Reset for details
D005	Brown-out Reset Voltage	BVDD	3.7 3.7	4.0 4.0	4.3 4.4	V V	BODEN bit in configuration word enabled Automotive Range Only
D010  D013	Supply Current (Note 2,5)	IDD	- -	2.7 10	5 20	mA mA	XT, RC osc configuration (PIC16C73A-04) FOSC = 4 MHz, VDD = 5.5V (Note 4)  HS osc configuration (PIC16C73A-20) FOSC = 20 MHz, VDD = 5.5V
D015*	Brown-out Reset Current (Note 6)	ΔIBOR	-	350	425	μA	BOR enabled VDD = 5.0V
D020 D021 D021A D021B	Power-down Current (Note 3,5)	IPD	- - - -	10.5 1.5 1.5 2.5	42 16 19 19	μA μA μA μA	VDD = 4.0V, WDT enabled, -40°C to +85°C VDD = 4.0V, WDT disabled, -0°C to +70°C VDD = 4.0V, WDT disabled, -40°C to +85°C VDD = 4.0V, WDT disabled, -40°C to +125°C
D023*	Brown-out Reset Current (Note 6)	ΔIBOR	-	350	425	μA	BOR enabled 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 in SLEEP mode 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 configuration, current through Rext is not included. The current through the resistor can be estimated by the formula  $I_r = V_{DD}/2R_{ext}$  (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.

# PIC16C7X

Applicable Devices 710 71 711 72 73 73A 74 74A

## 23.2 DC Characteristics: PIC16LC73A-04 (Commercial, Industrial) PIC16LC74A-04 (Commercial, Industrial)

DC CHARACTERISTICS		Standard Operating Conditions (unless otherwise stated)						
		Operating temperature -40°C ≤ TA ≤ +85°C for industrial and 0°C ≤ TA ≤ +70°C for commercial						
Param No.	Characteristic	Sym	Min	Typ†	Max	Units	Conditions	
D001	Supply Voltage	VDD	2.5	-	6.0	V	LP, XT, RC osc configuration (DC - 4 MHz)	
D002*	RAM Data Retention Voltage (Note 1)	VDR	-	1.5	-	V	Device in SLEEP mode	
D003	VDD start voltage to ensure internal Power-on Reset signal	VPOR	-	VSS	-	V	See section on Power-on Reset for details	
D004*	VDD rise rate to ensure internal Power-on Reset signal	SVDD	0.05	-	-	V/ms	See section on Power-on Reset for details	
D005	Brown-out Reset Voltage	BVDD	3.7	4.0	4.3	V	BODEN bit in configuration word enabled	
D010	Supply Current (Note 2,5)	IDD	-	2.0	3.8	mA	XT, RC osc configuration FOSC = 4 MHz, VDD = 3.0V (Note 4)	
D010A				-	22.5	48	μA	LP osc configuration FOSC = 32 kHz, VDD = 3.0V, WDT disabled
D015*				ΔIBOR	-	350	425	μA
D020	Power-down Current (Note 3,5)	IPD	-	7.5	30	μA	VDD = 3.0V, WDT enabled, -40°C to +85°C	
D021				-	0.9	5	μA	VDD = 3.0V, WDT disabled, 0°C to +70°C
D021A				-	0.9	5	μA	VDD = 3.0V, WDT disabled, -40°C to +85°C
D023*	Brown-out Reset Current (Note 6)	ΔIBOR	-	350	425	μA	BOR enabled VDD = 3.0V	

\* 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 in SLEEP mode 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 configuration, current through Rext is not included. The current through the resistor can be estimated by the formula  $I_r = V_{DD}/2R_{ext}$  (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.

- 23.3 DC Characteristics:** PIC16C73A-04 (Commercial, Industrial, Automotive)  
 PIC16C74A-04 (Commercial, Industrial, Automotive)  
 PIC16C73A-10 (Commercial, Industrial, Automotive)  
 PIC16C74A-10 (Commercial, Industrial, Automotive)  
 PIC16C73A-20 (Commercial, Industrial, Automotive)  
 PIC16C74A-20 (Commercial, Industrial, Automotive)  
 PIC16LC73A-04 (Commercial, Industrial)  
 PIC16LC74A-04 (Commercial, Industrial)

Standard Operating Conditions (unless otherwise stated)							
<b>DC CHARACTERISTICS</b> Operating temperature -40°C ≤ TA ≤ +125°C for automotive, -40°C ≤ TA ≤ +85°C for industrial and 0°C ≤ TA ≤ +70°C for commercial Operating voltage VDD range as described in DC spec Section 23.1 and Section 23.2.							
Param No.	Characteristic	Sym	Min	Typ †	Max	Units	Conditions
D030	<b>Input Low Voltage</b> I/O ports with TTL buffer	VIL	VSS	-	0.5V	V	
D031	with Schmitt Trigger buffer		VSS	-	0.2VDD	V	
D032	MCLR, RA4/T0CKI, OSC1 (in RC mode)		VSS	-	0.2VDD	V	
D033	OSC1 (in XT, HS and LP)		VSS	-	0.3VDD	V	Note1
D040	<b>Input High Voltage</b> I/O ports with TTL buffer	VIH	2.0	-	VDD	V	4.5V ≤ VDD ≤ 5.5V
D040A			0.8VDD	-	VDD	V	For VDD > 5.5V or VDD < 4.5V
D041	with Schmitt Trigger buffer		0.8VDD	-	VDD	V	For entire VDD range
D042	MCLR, RA4/T0CKI, RC7:RC4, RD7:RD4, RB0/INT		0.8VDD	-	VDD	V	
D042A	RE2:RE0, OSC1 (XT, HS and LP)		0.7VDD	-	VDD	V	Note1
D043	OSC1 (in RC mode)		0.9VDD	-	VDD	V	
D070	PORTB weak pull-up current	IPURB	50	250	400	μA	VDD = 5V, VPIN = VSS
D060	<b>Input Leakage Current</b> (Notes 2, 3) I/O ports	IIL	-	-	±1	μA	VSS ≤ VPIN ≤ VDD, Pin at hi-impedance
D061	MCLR, RA4/T0CKI		-	-	±5	μA	VSS ≤ VPIN ≤ VDD
D063	OSC1		-	-	±5	μA	VSS ≤ VPIN ≤ VDD, XT, HS and LP osc configuration

† 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 configuration, the OSC1/CLKIN pin is a Schmitt Trigger input. It is not recommended that the PIC16C7X be driven with external clock in RC mode.

2: The leakage current on the MCLR 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 coming out of the pin.

# PIC16C7X

Applicable Devices 710 71 711 72 73 73A 74 74A

Standard Operating Conditions (unless otherwise stated)							
Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$ for automotive, $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$ for industrial and $0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$ for commercial Operating voltage $V_{DD}$ range as described in DC spec Section 23.1 and Section 23.2.							
Param No.	Characteristic	Sym	Min	Typ †	Max	Units	Conditions
<b>DC CHARACTERISTICS</b>							
<b>Output Low Voltage</b>							
D080	I/O ports	$V_{OL}$	-	-	0.6	V	$I_{OL} = 8.5\text{ mA}$ , $V_{DD} = 4.5\text{V}$ , $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$
D080A			-	-	0.6	V	$I_{OL} = 7.0\text{ mA}$ , $V_{DD} = 4.5\text{V}$ , $-40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$
D083	OSC2/CLKOUT (RC osc config)		-	-	0.6	V	$I_{OL} = 1.6\text{ mA}$ , $V_{DD} = 4.5\text{V}$ , $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$
D083A			-	-	0.6	V	$I_{OL} = 1.2\text{ mA}$ , $V_{DD} = 4.5\text{V}$ , $-40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$
<b>Output High Voltage</b>							
D090	I/O ports (Note 3)	$V_{OH}$	$V_{DD} - 0.7$	-	-	V	$I_{OH} = -3.0\text{ mA}$ , $V_{DD} = 4.5\text{V}$ , $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$
D090A			$V_{DD} - 0.7$	-	-	V	$I_{OH} = -2.5\text{ mA}$ , $V_{DD} = 4.5\text{V}$ , $-40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$
D092	OSC2/CLKOUT (RC osc config)		$V_{DD} - 0.7$	-	-	V	$I_{OH} = -1.3\text{ mA}$ , $V_{DD} = 4.5\text{V}$ , $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$
D092A			$V_{DD} - 0.7$	-	-	V	$I_{OH} = -1.0\text{ mA}$ , $V_{DD} = 4.5\text{V}$ , $-40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$
<b>Capacitive Loading Specs on Output Pins</b>							
D100	OSC2 pin	$C_{OSC2}$	-	-	15	pF	In XT, HS and LP modes when external clock is used to drive OSC1.
D101	All I/O pins and OSC2 (in RC mode)	$C_{IO}$	-	-	50	pF	
D102	SCL, SDA in I <sup>2</sup> C mode	CB	-	-	400	pF	

† 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 configuration, the OSC1/CLKIN pin is a Schmitt Trigger input. It is not recommended that the PIC16C7X be driven with external clock in RC mode.

2: The leakage current on the  $\overline{\text{MCLR}}$  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 coming out of the pin.



## 23.4 Timing Parameter Symbology

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

- |             |           |  |
|-------------|-----------|--|
| 1. TppS2ppS | 3. TCC:ST | (I <sup>2</sup> C specifications only) |
| 2. TppS     | 4. Ts     | (I <sup>2</sup> C specifications only) |

<b>T</b>			
F	Frequency	T	Time

Lowercase letters (pp) and their meanings:

<b>pp</b>			
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	$\overline{WR}$

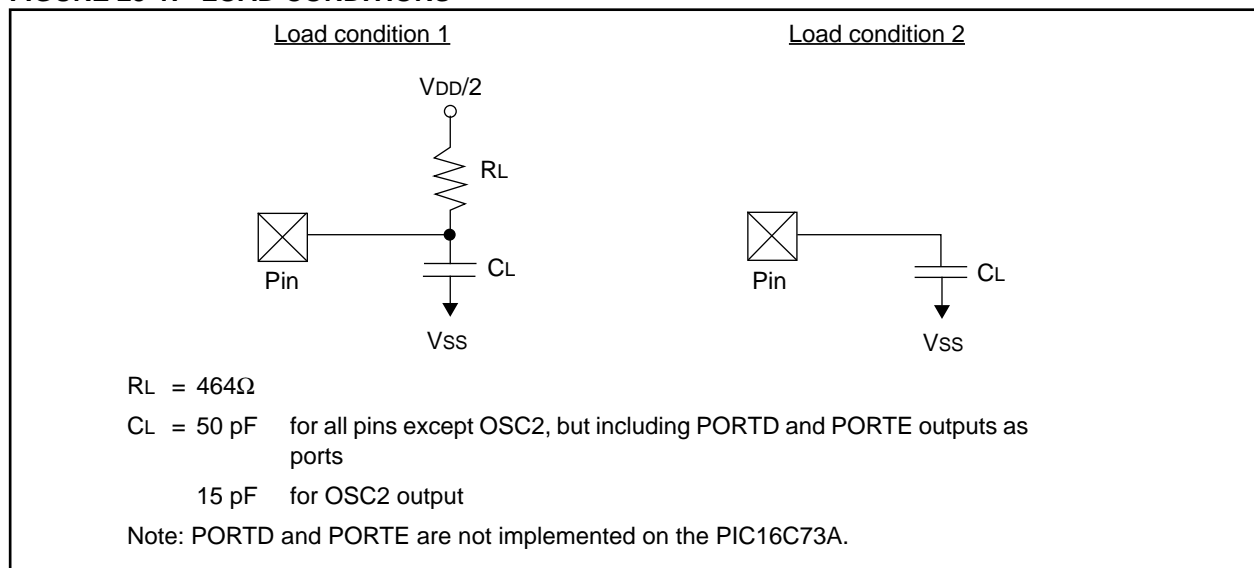
Uppercase letters and their meanings:

<b>S</b>			
F	Fall	P	Period
H	High	R	Rise
I	Invalid (Hi-impedance)	V	Valid
L	Low	Z	Hi-impedance
<b>I<sup>2</sup>C only</b>		High	High
AA	output access	Low	Low
BUF	Bus free		

TCC:ST (I<sup>2</sup>C specifications only)

<b>CC</b>			
HD	Hold	SU	Setup
<b>ST</b>		STO	STOP condition
DAT	DATA input hold		
STA	START condition		

**FIGURE 23-1: LOAD CONDITIONS**



# PIC16C7X

Applicable Devices 710 71 711 72 73 73A 74 74A

## 23.5 Timing Diagrams and Specifications

FIGURE 23-2: EXTERNAL CLOCK TIMING

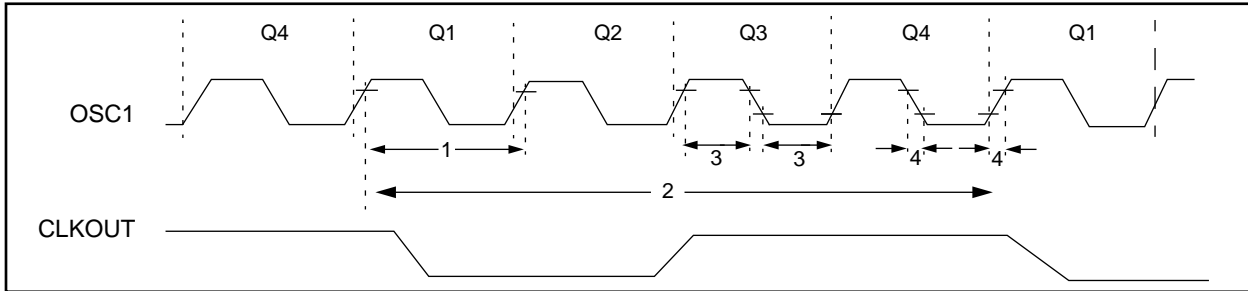


TABLE 23-2: CLOCK TIMING REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
	Fos	External CLKIN Frequency (Note 1)	DC	—	4	MHz	XT and RC osc mode
			DC	—	4	MHz	HS osc mode (PIC16C73A-04, PIC16C74A-04)
			DC	—	20	MHz	HS osc mode (PIC16C73A-20, PIC16C74A-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	—	4	MHz	HS osc mode (PIC16C73A-04, PIC16C74A-04)	
		4	—	10	MHz	HS osc mode (PIC16C73A-10, PIC16C74A-10)	
		4	—	20	MHz	HS osc mode (PIC16C73A-20, PIC16C74A-20)	
		5	—	200	kHz	LP osc mode	
1	Tosc	External CLKIN Period (Note 1)	250	—	—	ns	XT and RC osc mode
			250	—	—	ns	HS osc mode (PIC16C73A-04, PIC16C74A-04)
			100	—	—	ns	HS osc mode (PIC16C73A-10, PIC16C74A-10)
			50	—	—	ns	HS osc mode (PIC16C73A-20, PIC16C74A-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 (PIC16C73A-04, PIC16C74A-04)	
		100	—	250	ns	HS osc mode (PIC16C73A-10, PIC16C74A-10)	
		50	—	250	ns	HS osc mode (PIC16C73A-20, PIC16C74A-20)	
5	—	—	μs	LP osc mode			
2	TCY	Instruction Cycle Time (Note 1)	200	—	DC	ns	TCY = 4/FOSC

† 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.

**TABLE 23-2: CLOCK TIMING REQUIREMENTS (Cont.'d)**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
3	TosL, TosH	<b>External Clock in (OSC1) High or Low Time</b>	100	—	—	ns	XT oscillator
			2.5	—	—	μs	LP oscillator
			15	—	—	ns	HS oscillator
4	TosR, TosF	<b>External Clock in (OSC1) Rise or Fall Time</b>	—	—	25	ns	XT oscillator
			—	—	50	ns	LP oscillator
			—	—	15	ns	HS oscillator

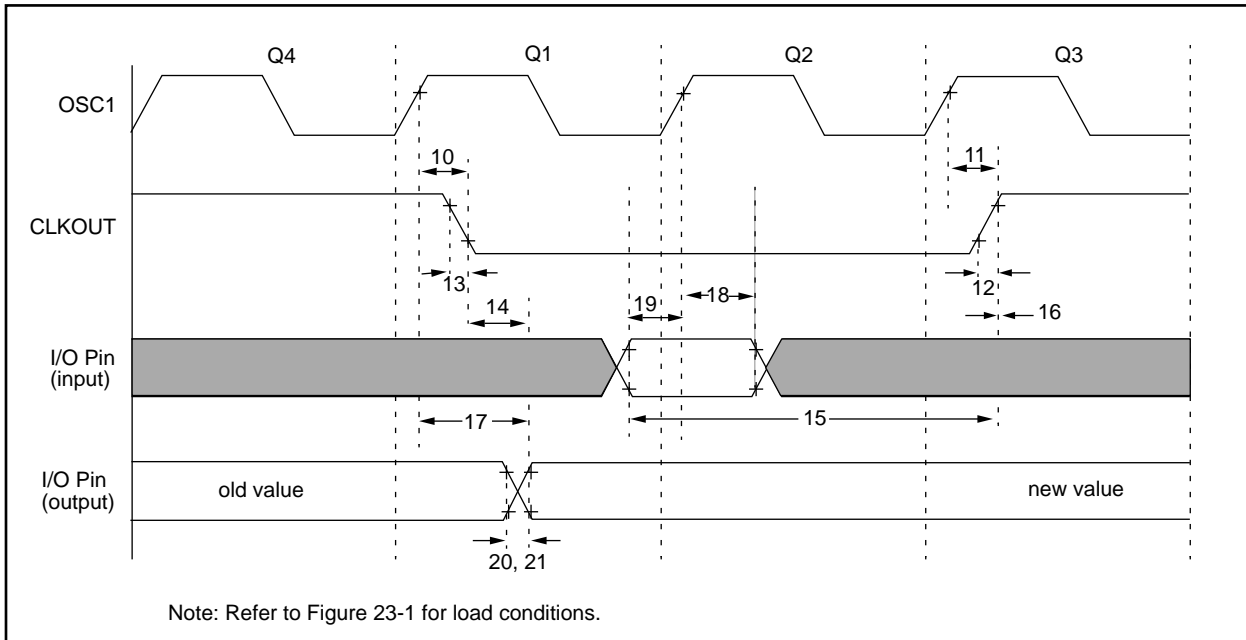
† Data in "Typ" column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

Note 1: Instruction cycle period (T<sub>cy</sub>) 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.

# PIC16C7X

Applicable Devices 710 71 711 72 73 73A 74 74A

**FIGURE 23-3: CLKOUT AND I/O TIMING**



**TABLE 23-3: CLKOUT AND I/O TIMING REQUIREMENTS**

Parameter 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	—	—	0.5T <sub>cy</sub> + 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)	PIC16C73A/74A	100	—	—	ns
			PIC16LC73A/74A	200	—	—	ns
19*	TioV2osH	Port input valid to OSC1↑ (I/O in setup time)	0	—	—	ns	
20*	TioR	Port output rise time	PIC16C73A/74A	—	10	40	ns
			PIC16LC73A/74A	—	—	80	ns
21*	TioF	Port output fall time	PIC16C73A/74A	—	10	40	ns
			PIC16LC73A/74A	—	—	80	ns
22††*	Tinp	INT pin high or low time	T <sub>cy</sub>	—	—	ns	
23††*	Trbp	RB7:RB4 change INT high or low time	T <sub>cy</sub>	—	—	ns	

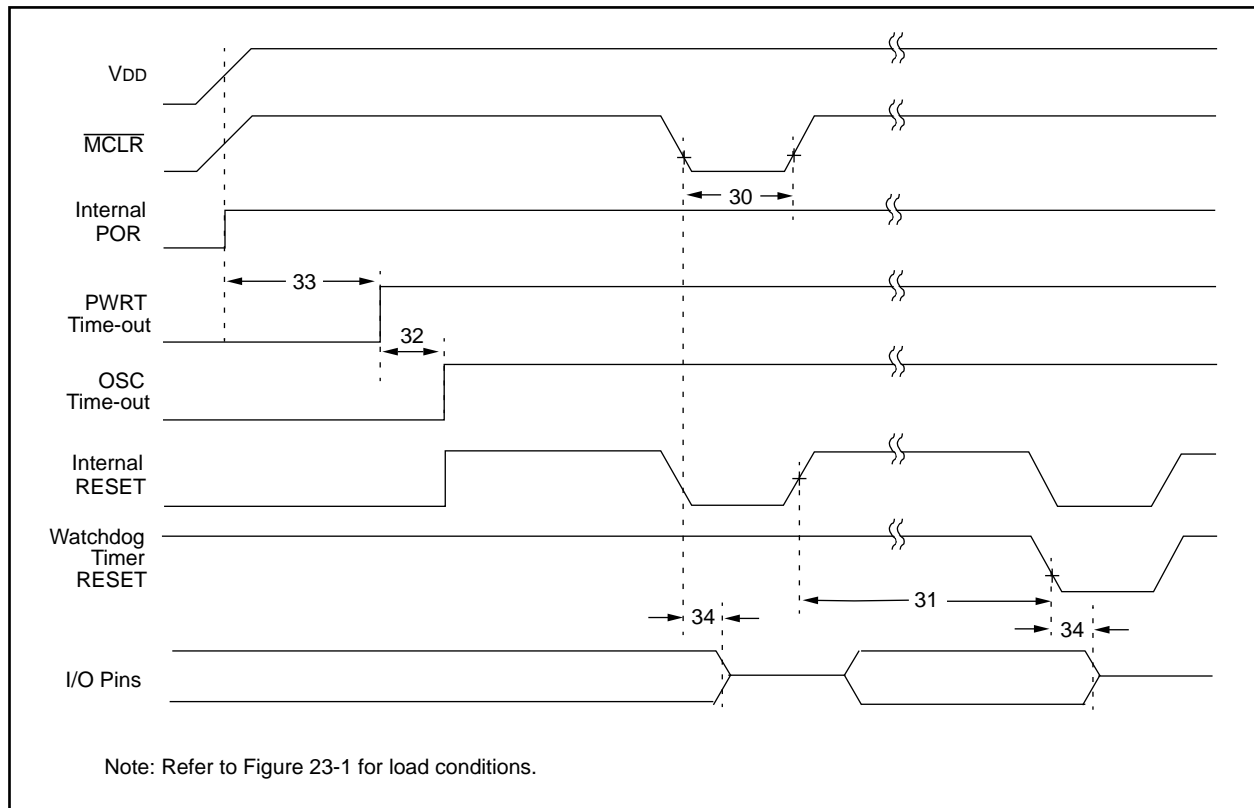
\* These parameters are characterized but not tested.

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

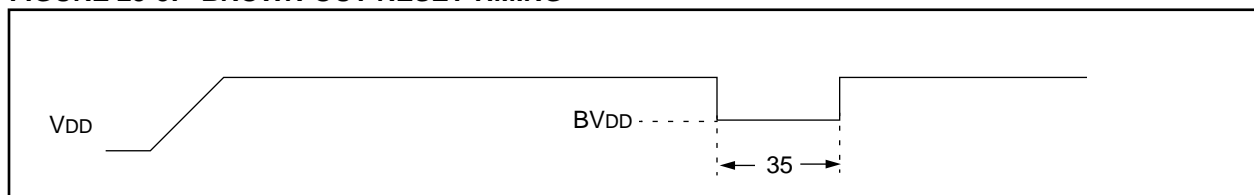
†† These parameters are asynchronous events not related to any internal clock edges.

Note 1: Measurements are taken in RC Mode where CLKOUT output is 4 x T<sub>osc</sub>.

**FIGURE 23-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER TIMING**



**FIGURE 23-5: BROWN-OUT RESET TIMING**



**TABLE 23-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER, POWER-UP TIMER, AND BROWN-OUT RESET REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
30	Tmcl	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	Oscillation Start-up Timer Period	—	1024Tosc	—	—	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 MCLR Low or Watchdog Timer 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 23-6: TIMER0 AND TIMER1 CLOCK TIMINGS

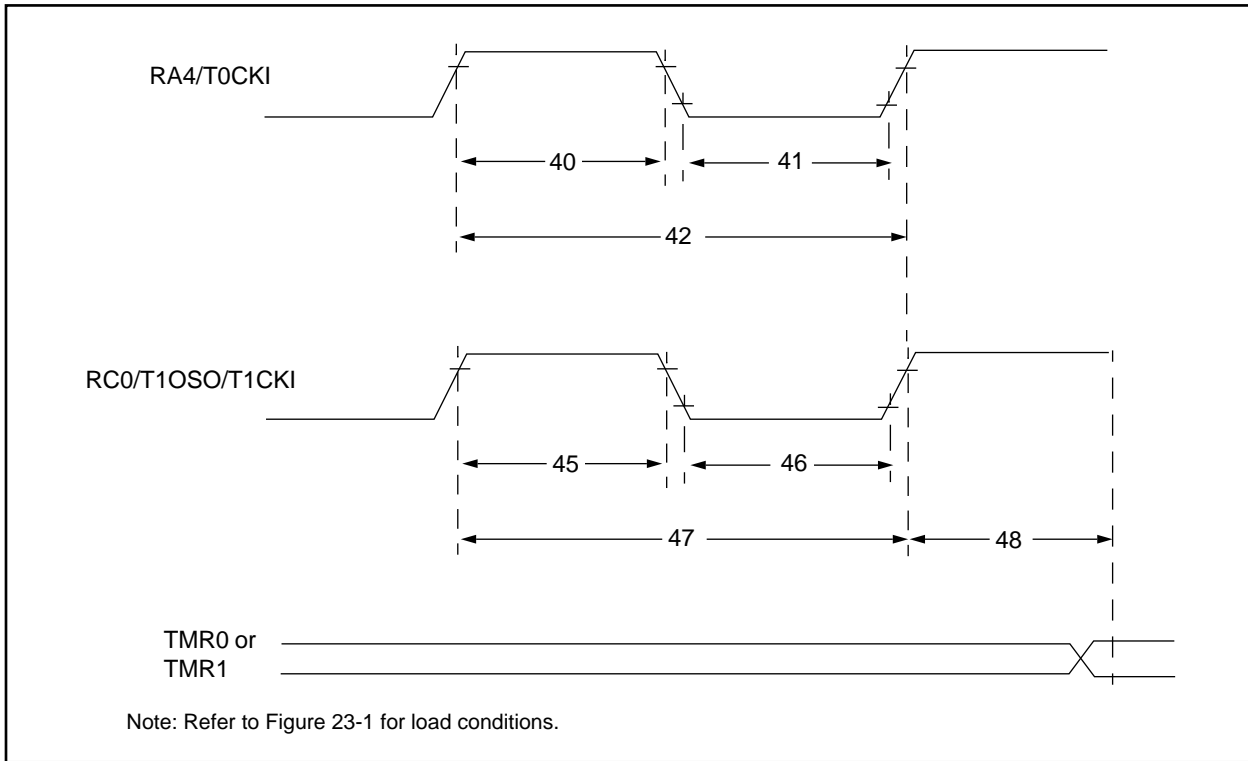


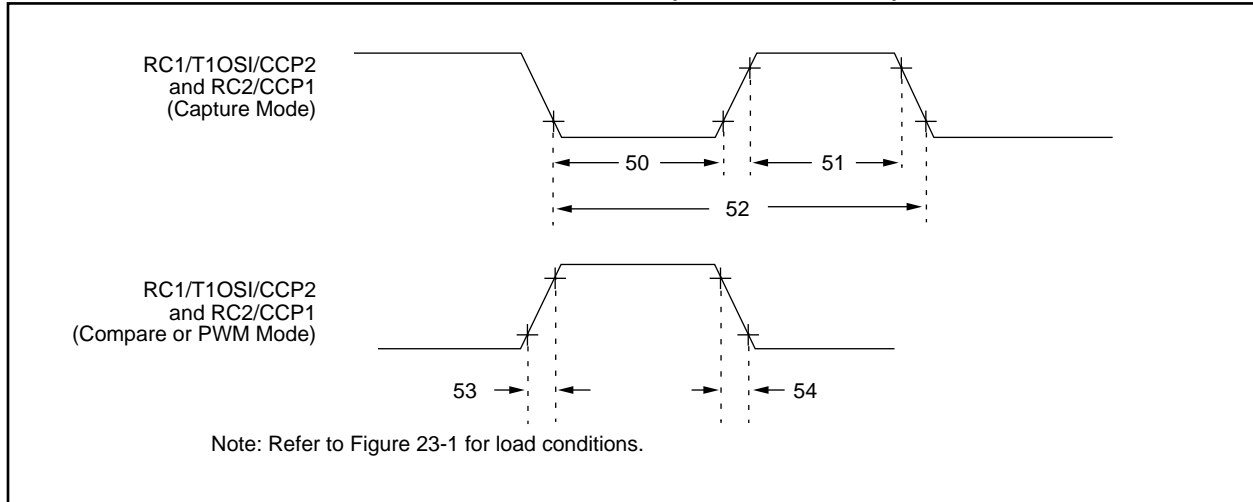
TABLE 23-5: TIMER0 AND TIMER1 CLOCK REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions	
40*	Tt0H	T0CKI High Pulse Width	No Prescaler	$0.5T_{CY} + 20$	—	—	ns	
			With Prescaler	10	—	—	ns	
41*	Tt0L	T0CKI Low Pulse Width	No Prescaler	$0.5T_{CY} + 20$	—	—	ns	
			With Prescaler	10	—	—	ns	
42*	Tt0P	T0CKI Period	$\frac{T_{CY} + 40}{N}$	—	—	ns	N = prescale value (1, 2, 4, ..., 256)	
45*	Tt1H	T1CKI High Time	Synchronous, no prescaler	$0.5T_{CY} + 20$	—	—	ns	
			Synchronous, with prescaler	PIC16C73A/74A	15	—	—	ns
				PIC16LC73A/74A	25	—	—	ns
Asynchronous	$2T_{CY}$	—	—	ns				
46*	Tt1L	T1CKI Low Time	Synchronous, no prescaler	$0.5T_{CY} + 20$	—	—	ns	
			Synchronous, with prescaler	PIC16C73A/74A	15	—	—	ns
				PIC16LC73A/74A	25	—	—	ns
Asynchronous	$2T_{CY}$	—	—	ns				
47*	Tt1P	T1CKI input period	Synchronous	$\frac{T_{CY} + 40}{N}$	—	—	ns	N = prescale value (1, 2, 4, 8)
			Asynchronous	$4T_{CY}$	—	—	ns	
	Ft1	Timer1 oscillator input frequency range (oscillator enabled by setting the T1OSCEN bit)	DC	—	200	kHz		
48	Tcke2tmr1	Delay from external clock edge to timer increment	$2T_{osc}$	—	$7T_{osc}$	—		

\* 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 23-7: CAPTURE/COMPARE/PWM TIMINGS (CCP1 AND CCP2)**



**TABLE 23-6: CAPTURE/COMPARE/PWM REQUIREMENTS (CCP1 AND CCP2)**

Param No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
50*	TccL	CCP1 and CCP2 input low time	No Prescaler	$0.5T_{CY} + 20$	—	—	ns
			With Prescaler	PIC16C73A/74A: 10 PIC16LC73A/74A: 20	—	—	ns
51*	TccH	CCP1 and CCP2 input high time	No Prescaler	$0.5T_{CY} + 20$	—	—	ns
			With Prescaler	PIC16C73A/74A: 10 PIC16LC73A/74A: 20	—	—	ns
52*	TccP	CCP1 and CCP2 input period	$\frac{3T_{CY} + 40}{N}$	—	—	ns	N = prescale value (1, 4 or 16)
53*	TccR	CCP1 and CCP2 output rise time	PIC16C73A/74A	10	25	ns	
			PIC16LC73A/74A	25	45	ns	
54*	TccF	CCP1 and CCP2 output fall time	PIC16C73A/74A	10	25	ns	
			PIC16LC73A/74A	25	45	ns	

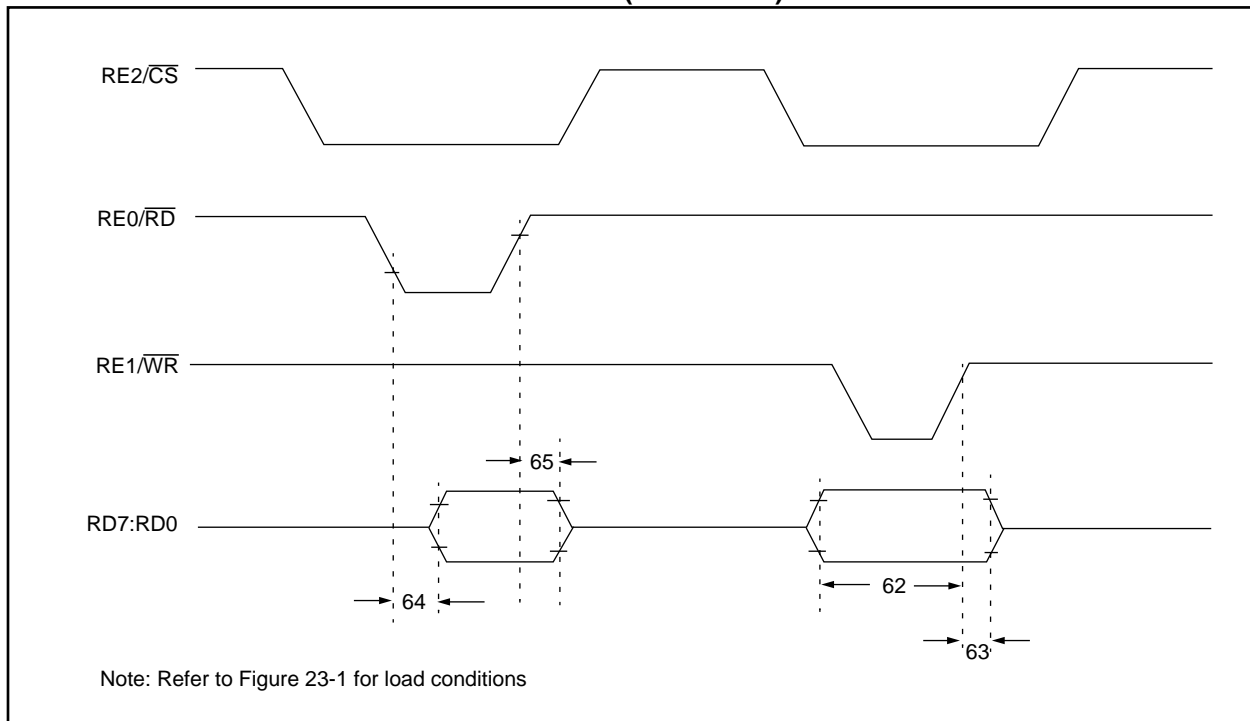
\* These parameters are characterized but not tested.

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

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**FIGURE 23-8: PARALLEL SLAVE PORT TIMING (PIC16C74A)**



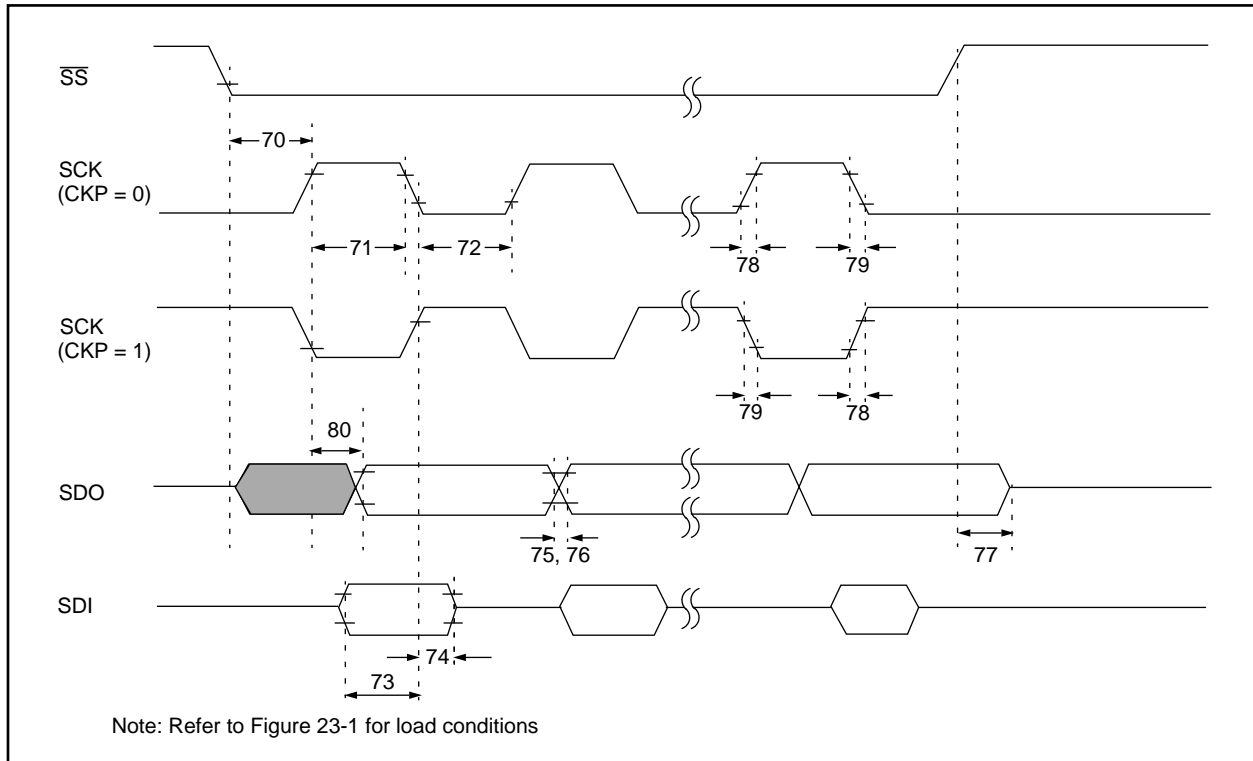
**TABLE 23-7: PARALLEL SLAVE PORT REQUIREMENTS (PIC16C74A)**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions	
62	TdtV2wrH	Data in valid before $\overline{WR}\uparrow$ or $\overline{CS}\uparrow$ (setup time)	20	—	—	ns		
63*	TwrH2dtI	$\overline{WR}\uparrow$ or $\overline{CS}\uparrow$ to data-in invalid (hold time)	PIC16C74A	20	—	—	ns	
			PIC16LC74A	35	—	—	ns	
64	TrdL2dtV	$\overline{RD}\downarrow$ and $\overline{CS}\downarrow$ to data-out valid	—	—	80	ns		
65	TrdH2dtI	$\overline{RD}\uparrow$ or $\overline{CS}\downarrow$ to data-out invalid	10	—	30	ns		

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



**FIGURE 23-9: SPI MODE TIMING**



**TABLE 23-8: SPI MODE REQUIREMENTS**

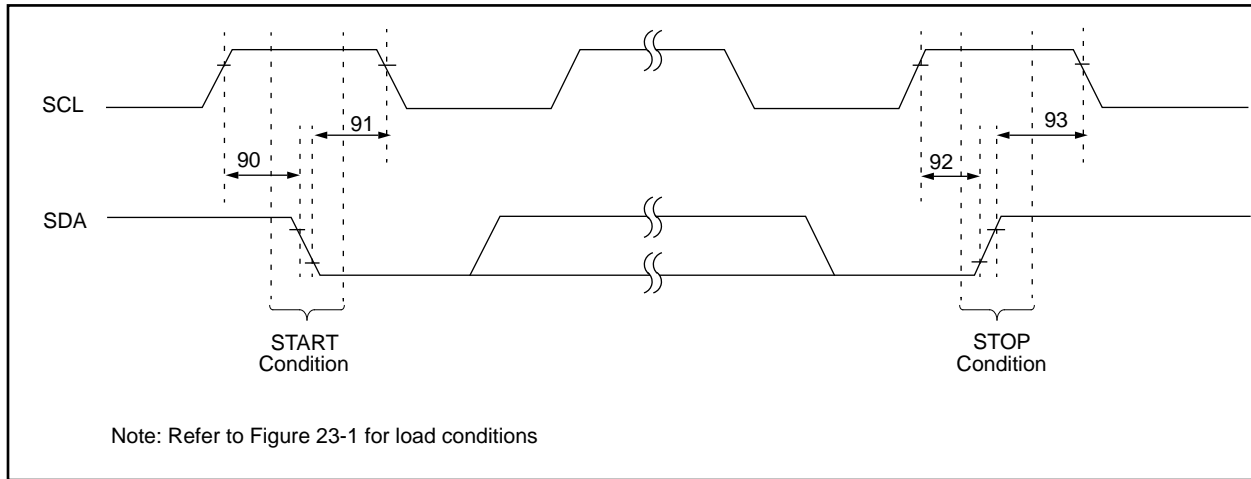
Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
70	TssL2scH, TssL2scL	$\overline{SS}\downarrow$ to SCK $\downarrow$ or SCK $\uparrow$ input	T <sub>CY</sub>	—	—	ns	
71	TscH	SCK input high time (slave mode)	T <sub>CY</sub> + 20	—	—	ns	
72	TscL	SCK input low time (slave mode)	T <sub>CY</sub> + 20	—	—	ns	
73	TdiV2scH, TdiV2scL	Setup time of SDI data input to SCK edge	50	—	—	ns	
74	TscH2diL, TscL2diL	Hold time of SDI data input to SCK edge	50	—	—	ns	
75	TdoR	SDO data output rise time	—	10	25	ns	
76	TdoF	SDO data output fall time	—	10	25	ns	
77	TssH2doZ	$\overline{SS}\downarrow$ to SDO output hi-impedance	10	—	50	ns	
78	TscR	SCK output rise time (master mode)	—	10	25	ns	
79	TscF	SCK output fall time (master mode)	—	10	25	ns	
80	TscH2doV, TscL2doV	SDO data output valid after SCK edge	—	—	50	ns	

† 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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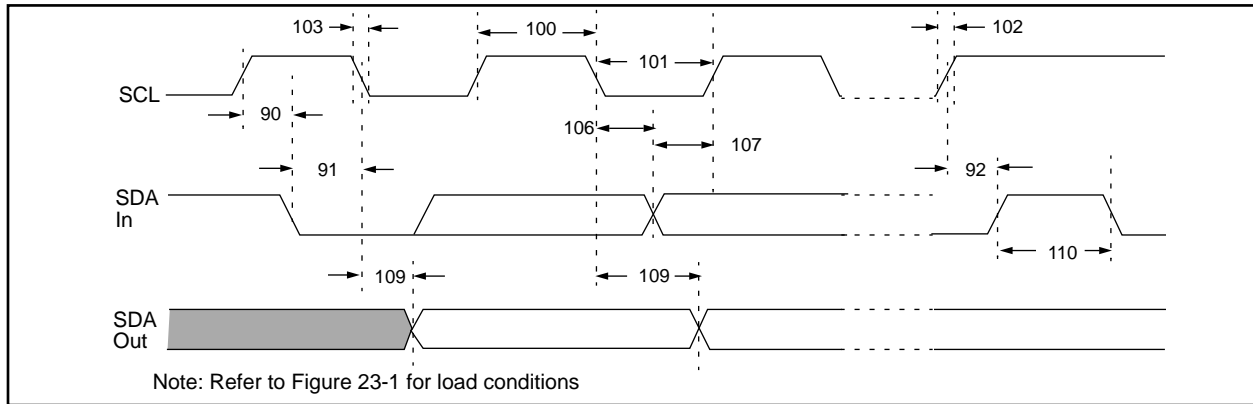
**FIGURE 23-10: I<sup>2</sup>C BUS START/STOP BITS TIMING**



**TABLE 23-9: I<sup>2</sup>C BUS START/STOP BITS REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Typ	Max	Units	Conditions	
90	T <sub>SU:STA</sub>	START condition Setup time	100 kHz mode	4700	—	—	ns	Only relevant for repeated START condition
			400 kHz mode	600	—	—		
91	T <sub>HD:STA</sub>	START condition Hold time	100 kHz mode	4000	—	—	ns	After this period the first clock pulse is generated
			400 kHz mode	600	—	—		
92	T <sub>SU:STO</sub>	STOP condition Setup time	100 kHz mode	4700	—	—	ns	
			400 kHz mode	600	—	—		
93	T <sub>HD:STO</sub>	STOP condition Hold time	100 kHz mode	4000	—	—	ns	
			400 kHz mode	600	—	—		

**FIGURE 23-11: I<sup>2</sup>C BUS DATA TIMING**



**TABLE 23-10: I<sup>2</sup>C BUS DATA REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Max	Units	Conditions	
100	THIGH	Clock high time	100 kHz mode	4.0	—	μs	PIC16C73A/74A must operate at a minimum of 1.5 MHz
			400 kHz mode	0.6	—	μs	PIC16C73A/74A must operate at a minimum of 10 MHz
			SSP Module	1.5T <sub>CY</sub>	—		
101	TLOW	Clock low time	100 kHz mode	4.7	—	μs	PIC16C73A/74A must operate at a minimum of 1.5 MHz
			400 kHz mode	1.3	—	μs	PIC16C73A/74A must operate at a minimum of 10 MHz
			SSP Module	1.5T <sub>CY</sub>	—		
102	TR	SDA and SCL rise time	100 kHz mode	—	1000	ns	
			400 kHz mode	20 + 0.1C <sub>b</sub>	300	ns	C <sub>b</sub> is specified to be from 10 to 400 pF
103	TF	SDA and SCL fall time	100 kHz mode	—	300	ns	
			400 kHz mode	20 + 0.1C <sub>b</sub>	300	ns	C <sub>b</sub> is specified to be from 10 to 400 pF
90	TSU:STA	START condition setup time	100 kHz mode	4.7	—	μs	Only relevant for repeated START condition
			400 kHz mode	0.6	—	μs	
91	THD:STA	START condition hold time	100 kHz mode	4.0	—	μs	After this period the first clock pulse is generated
			400 kHz mode	0.6	—	μs	
106	THD:DAT	Data input hold time	100 kHz mode	0	—	ns	
			400 kHz mode	0	0.9	μs	
107	TSU:DAT	Data input setup time	100 kHz mode	250	—	ns	Note 2
			400 kHz mode	100	—	ns	
92	TSU:STO	STOP condition setup time	100 kHz mode	4.7	—	μs	
			400 kHz mode	0.6	—	μs	
109	TAA	Output valid from clock	100 kHz mode	—	3500	ns	Note 1
			400 kHz mode	—	—	ns	
110	TBUF	Bus free time	100 kHz mode	4.7	—	μs	Time the bus must be free before a new transmission can start
			400 kHz mode	1.3	—	μs	
	C <sub>b</sub>	Bus capacitive loading	—	400	pF		

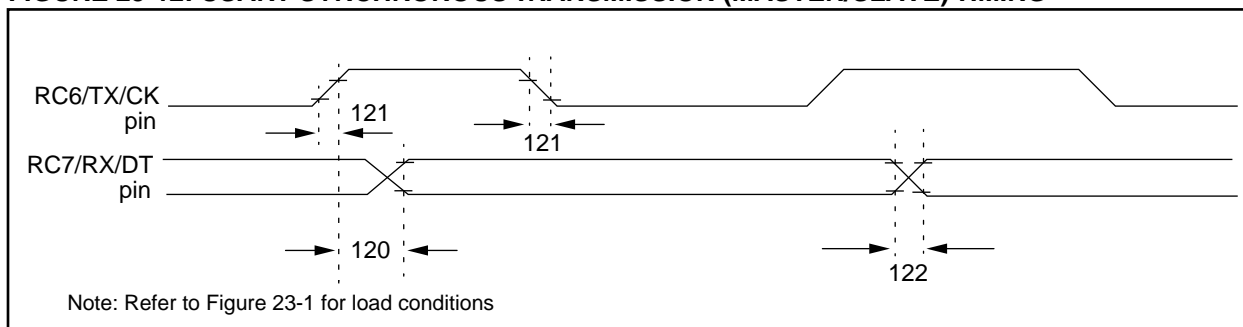
Note 1: As a transmitter, the device must provide this internal minimum delay time to bridge the undefined region (min. 300 ns) of the falling edge of SCL to avoid unintended generation of START or STOP conditions.

2: A fast-mode I<sup>2</sup>C-bus device can be used in a standard-mode I<sup>2</sup>C-bus system, but the requirement tsu;DAT ≥ 250 ns must then be met. This will automatically be the case if the device does not stretch the LOW period of the SCL signal. If such a device does stretch the LOW period of the SCL signal, it must output the next data bit to the SDA line TR max.+tsu;DAT = 1000 + 250 = 1250 ns (according to the standard-mode I<sup>2</sup>C bus specification) before the SCL line is released.

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**FIGURE 23-12: USART SYNCHRONOUS TRANSMISSION (MASTER/SLAVE) TIMING**

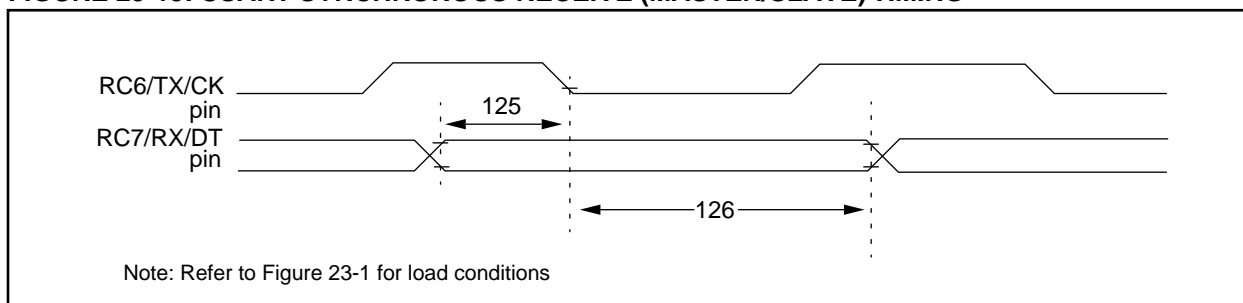


**TABLE 23-11: USART SYNCHRONOUS TRANSMISSION REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
120	TckH2dtV	<u>SYNC XMIT (MASTER &amp; SLAVE)</u> Clock high to data out valid	PIC16C73A/74A	—	—	80	ns
		PIC16LC73A/74A	—	—	100	ns	
121	Tckrf	Clock out rise time and fall time (Master Mode)	PIC16C73A/74A	—	—	45	ns
			PIC16LC73A/74A	—	—	50	ns
122	Tdtrf	Data out rise time and fall time	PIC16C73A/74A	—	—	45	ns
			PIC16LC73A/74A	—	—	50	ns

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

**FIGURE 23-13: USART SYNCHRONOUS RECEIVE (MASTER/SLAVE) TIMING**



**TABLE 23-12: USART SYNCHRONOUS RECEIVE REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
125	TdtV2ckl	<u>SYNC RCV (MASTER &amp; SLAVE)</u> Data hold before CK ↓ (DT hold time)	15	—	—	ns	
126	TckL2dtl	Data hold after CK ↓ (DT hold time)	15	—	—	ns	

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

**TABLE 23-13: A/D CONVERTER CHARACTERISTICS:**  
**PIC16C73A-04 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE)**  
**PIC16C74A-04 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE)**  
**PIC16C73A-10 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE)**  
**PIC16C74A-10 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE)**  
**PIC16C73A-20 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE)**  
**PIC16C74A-20 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE)**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
	NR	Resolution	—	—	8-bits	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq AIN \leq V_{REF}$
	NINT	Integral error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq AIN \leq V_{REF}$
	NDIF	Differential error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq AIN \leq V_{REF}$
	NFS	Full scale error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq AIN \leq V_{REF}$
	NOFF	Offset error	—	—	less than $\pm 1$ LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq AIN \leq V_{REF}$
	—	Monotonicity	—	guaranteed	—	—	$V_{SS} \leq AIN \leq V_{REF}$
	VREF	Reference voltage	3.0V	—	$V_{DD} + 0.3$	V	
	VAIN	Analog input voltage	$V_{SS} - 0.3$	—	$V_{REF} + 0.3$	V	
	ZAIN	Recommended impedance of analog voltage source	—	—	10.0	k $\Omega$	
	IAD	A/D conversion current ( $V_{DD}$ )	—	180	—	$\mu A$	Average current consumption when A/D is on. (Note 1)
	IREF	VREF input current (Note 2)	—	—	1 10	mA $\mu A$	During sampling All other times

\* 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: When A/D is off, it will not consume any current other than minor leakage current. The power-down current spec includes any such leakage from the A/D module.

2: VREF current is from RA3 pin or VDD pin, whichever is selected as reference input.

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**TABLE 23-14: A/D CONVERTER CHARACTERISTICS:  
PIC16LC73A-04 (COMMERCIAL, INDUSTRIAL)  
PIC16LC74A-04 (COMMERCIAL, INDUSTRIAL)**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
	NR	Resolution	—	—	8-bits	—	VREF = VDD = 3.0V (Note 1)
	NINT	Integral error	—	—	less than ±1 LSb	—	VREF = VDD = 3.0V (Note 1)
	NDIF	Differential error	—	—	less than ±1 LSb	—	VREF = VDD = 3.0V (Note 1)
	NFS	Full scale error	—	—	less than ±1 LSb	—	VREF = VDD = 3.0V (Note 1)
	NOFF	Offset error	—	—	less than ±1 LSb	—	VREF = VDD = 3.0V (Note 1)
	—	Monotonicity	—	guaranteed	—	—	VSS ≤ AIN ≤ VREF
	VREF	Reference voltage	3.0V	—	VDD + 0.3	V	
	VAIN	Analog input voltage	VSS - 0.3	—	VREF + 0.3	V	
	ZAIN	Recommended impedance of analog voltage source	—	—	10.0	kΩ	
	IAD	A/D conversion current (VDD)	—	180	—	μA	Average current consumption when A/D is on. (Note 2)
	IREF	VREF input current (Note 3)	—	—	1 10	mA μA	During sampling All other times

\* These parameters are characterized but not tested.

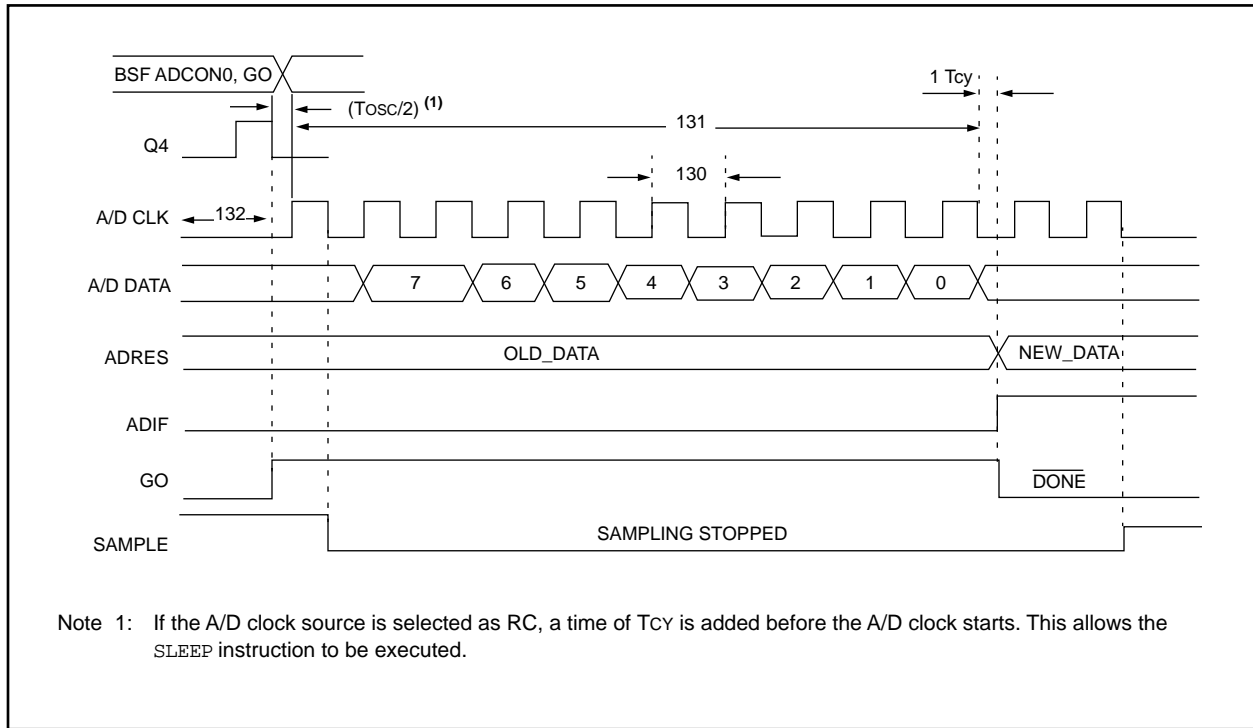
† Data in "Typ" column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

Note 1: These specifications apply if VREF = 3.0V and if VDD ≥ 3.0V. VIN must be between VSS and VREF

2: When A/D is off, it will not consume any current other than minor leakage current. The power-down current spec includes any such leakage from the A/D module.

3: VREF current is from RA3 pin or VDD pin, whichever is selected as reference input.

**FIGURE 23-14: A/D CONVERSION TIMING**



**TABLE 23-15: A/D CONVERSION REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions	
130	TAD	A/D clock period	PIC16C73/74	1.6	—	—	$\mu s$	TOSC based, $V_{REF} \geq 3.0V$
			PIC16LC73/74	2.0	—	—	$\mu s$	TOSC based, $V_{REF}$ full range
			PIC16C73/74	2.0	4.0	6.0	$\mu s$	A/D RC Mode
			PIC16LC73/74	3.0	6.0	9.0	$\mu s$	A/D RC Mode
131	TCNV	Conversion time (not including S/H time) (Note 1)	—	$9.5TAD$	—	—		
132	TACQ	Acquisition time	Note 2	20	—	$\mu s$		

\* 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  $T_{cy}$  cycle.

Note 2: See Section 13.1 for min conditions.

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Applicable Devices	710	71	711	72	73	73A	74	74A
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NOTES:



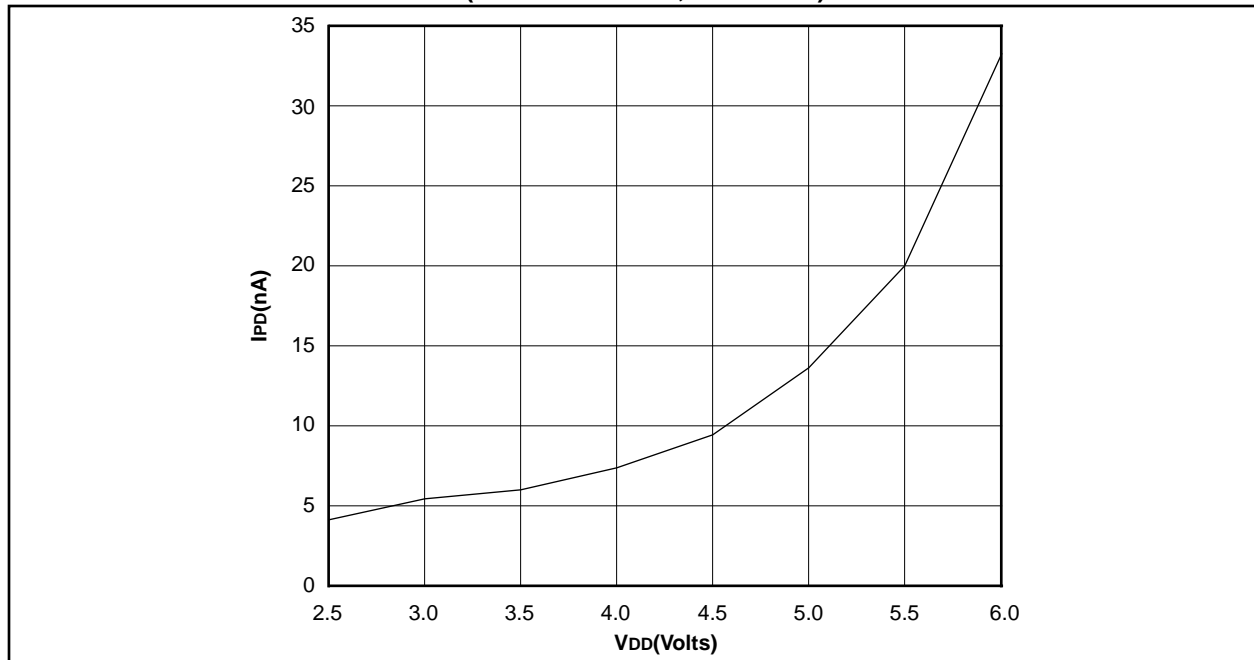
## 24.0 DC AND AC CHARACTERISTICS GRAPHS AND TABLES FOR: PIC16C72, PIC16C73, PIC16C73A, PIC16C74, PIC16C74A

The graphs and tables provided in this section are for design guidance and are not tested or guaranteed.

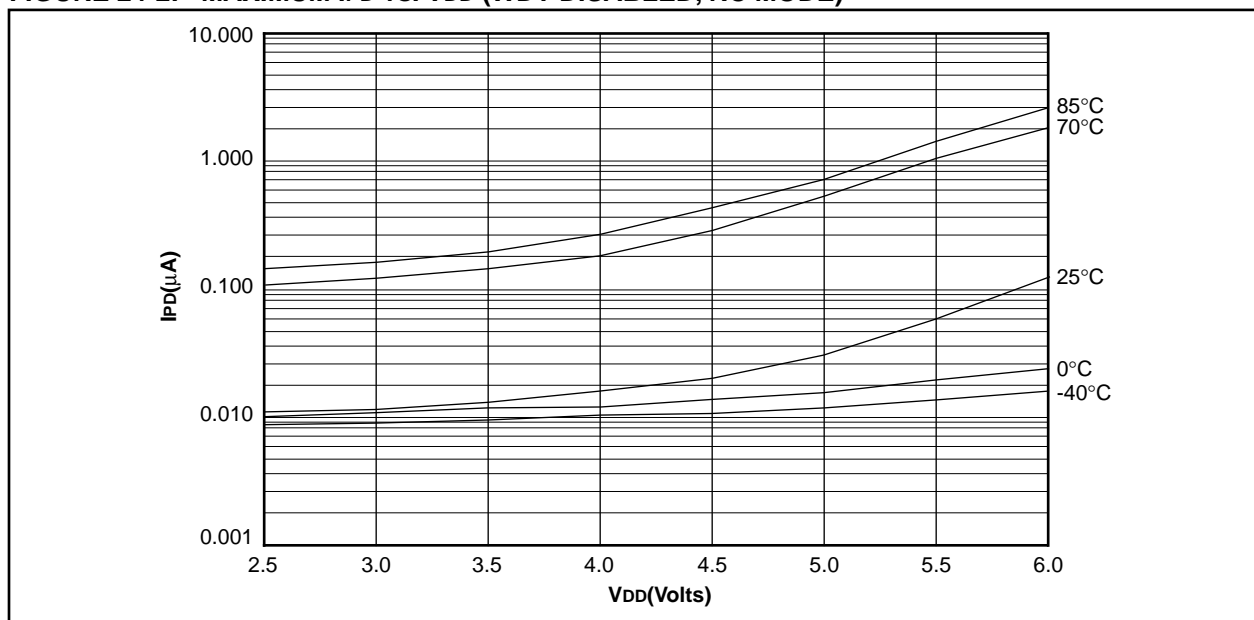
In some graphs or tables the data presented are outside specified operating range (i.e., outside specified  $V_{DD}$  range). This is for information only and devices are guaranteed to operate properly only within the specified range.

**Note:** The data presented in this section is a statistical summary of data collected on units from different lots over a period of time and matrix samples. 'Typical' represents the mean of the distribution at, 25°C, while 'max' or 'min' represents (mean +3 $\sigma$ ) and (mean -3 $\sigma$ ) respectively where  $\sigma$  is standard deviation.

**FIGURE 24-1: TYPICAL  $I_{PD}$  vs.  $V_{DD}$  (WDT DISABLED, RC MODE)**



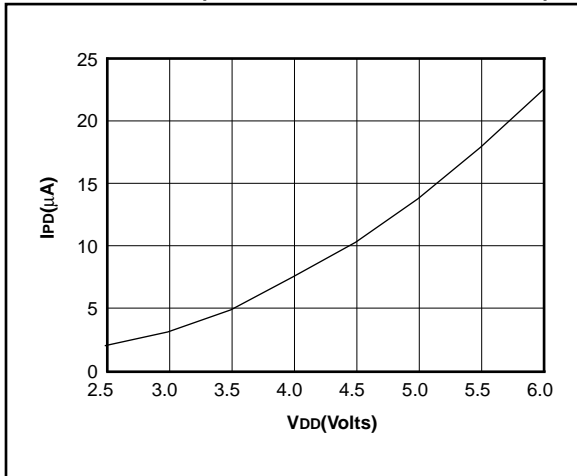
**FIGURE 24-2: MAXIMUM  $I_{PD}$  vs.  $V_{DD}$  (WDT DISABLED, RC MODE)**



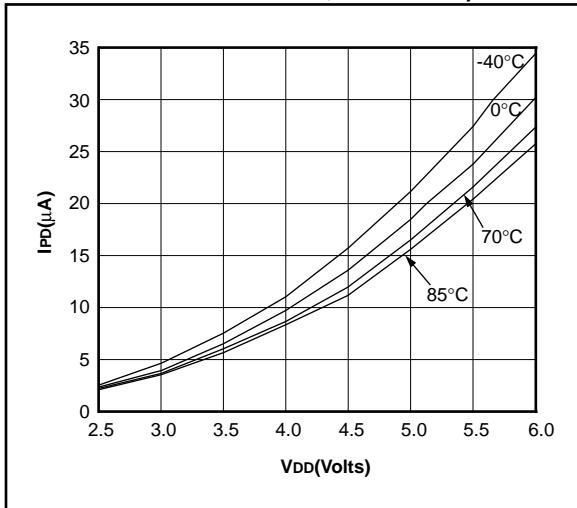
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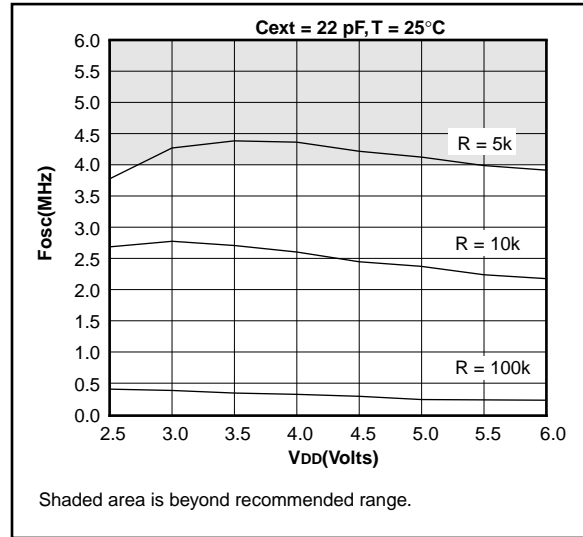
**FIGURE 24-3: TYPICAL IPD vs. VDD @ 25°C (WDT ENABLED, RC MODE)**



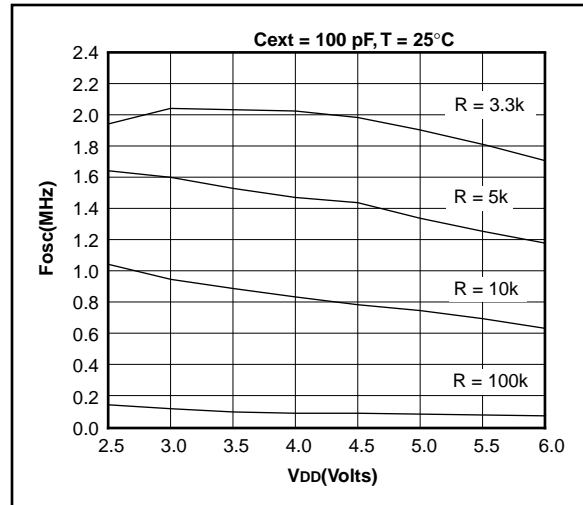
**FIGURE 24-4: MAXIMUM IPD vs. VDD (WDT ENABLED, RC MODE)**



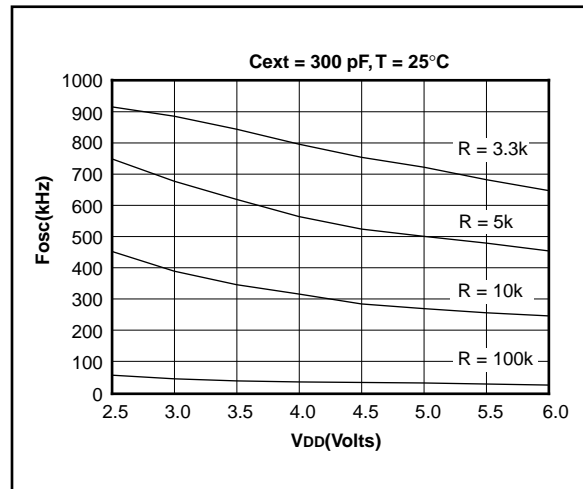
**FIGURE 24-5: TYPICAL RC OSCILLATOR FREQUENCY vs. VDD**



**FIGURE 24-6: TYPICAL RC OSCILLATOR FREQUENCY vs. VDD**

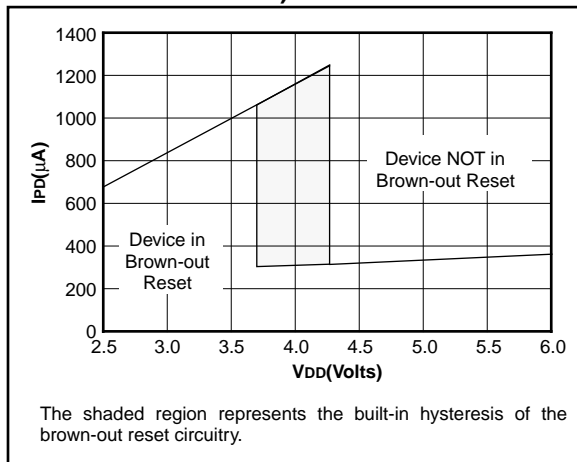


**FIGURE 24-7: TYPICAL RC OSCILLATOR FREQUENCY vs. VDD**

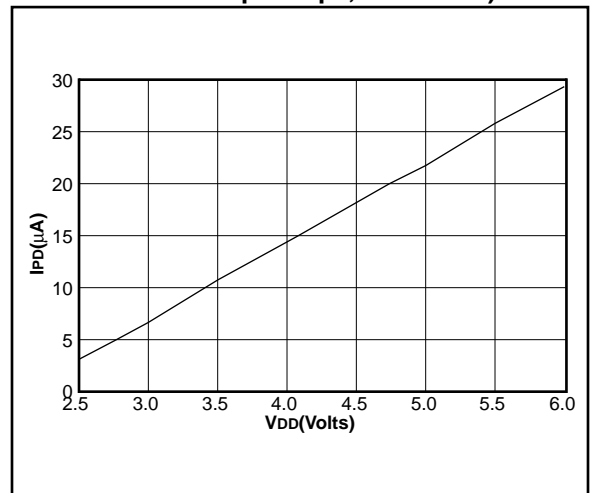


Data based on matrix samples. See first page of this section for details.

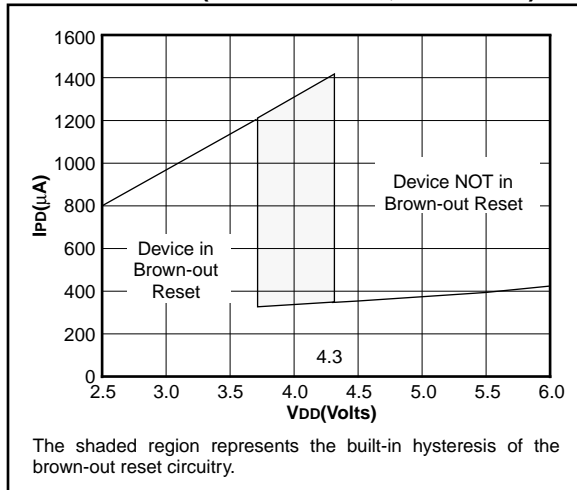
**FIGURE 24-8: TYPICAL  $I_{PD}$  vs.  $V_{DD}$  BROWN-OUT DETECT ENABLED (RC MODE)**



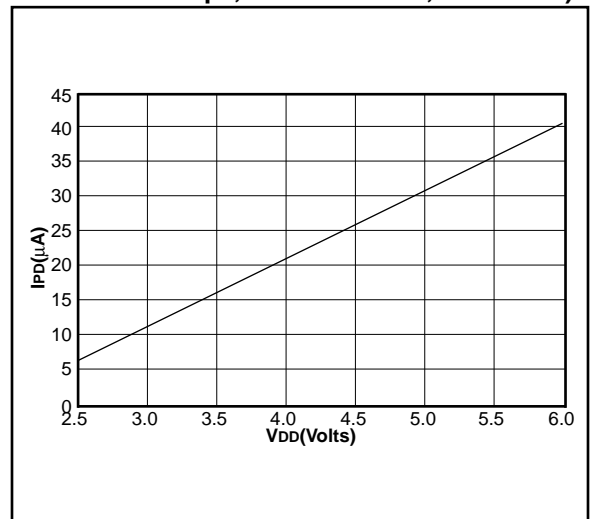
**FIGURE 24-10: TYPICAL  $I_{PD}$  vs. TIMER1 ENABLED (32 kHz, RC0/RC1 = 33 pF/33 pF, RC MODE)**



**FIGURE 24-9: MAXIMUM  $I_{PD}$  vs.  $V_{DD}$  BROWN-OUT DETECT ENABLED (85°C TO -40°C, RC MODE)**



**FIGURE 24-11: MAXIMUM  $I_{PD}$  vs. TIMER1 ENABLED (32 kHz, RC0/RC1 = 33 pF/33 pF, 85°C TO -40°C, RC MODE)**

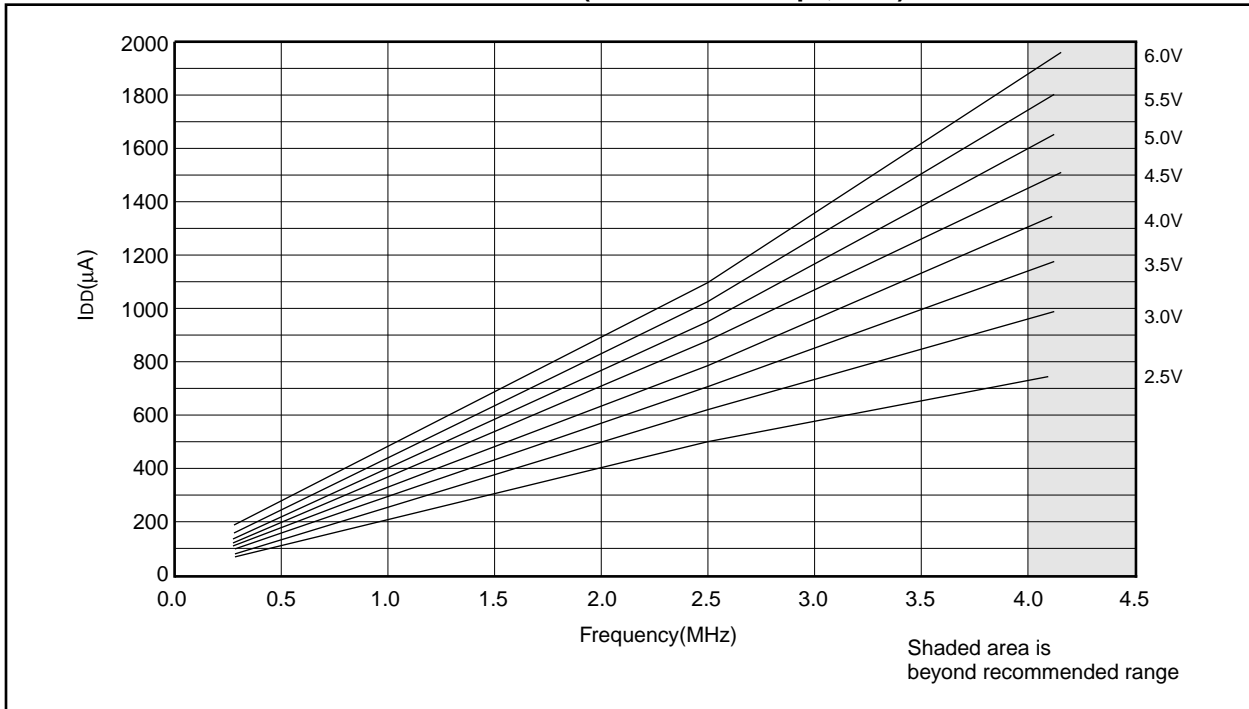


Data based on matrix samples. See first page of this section for details.

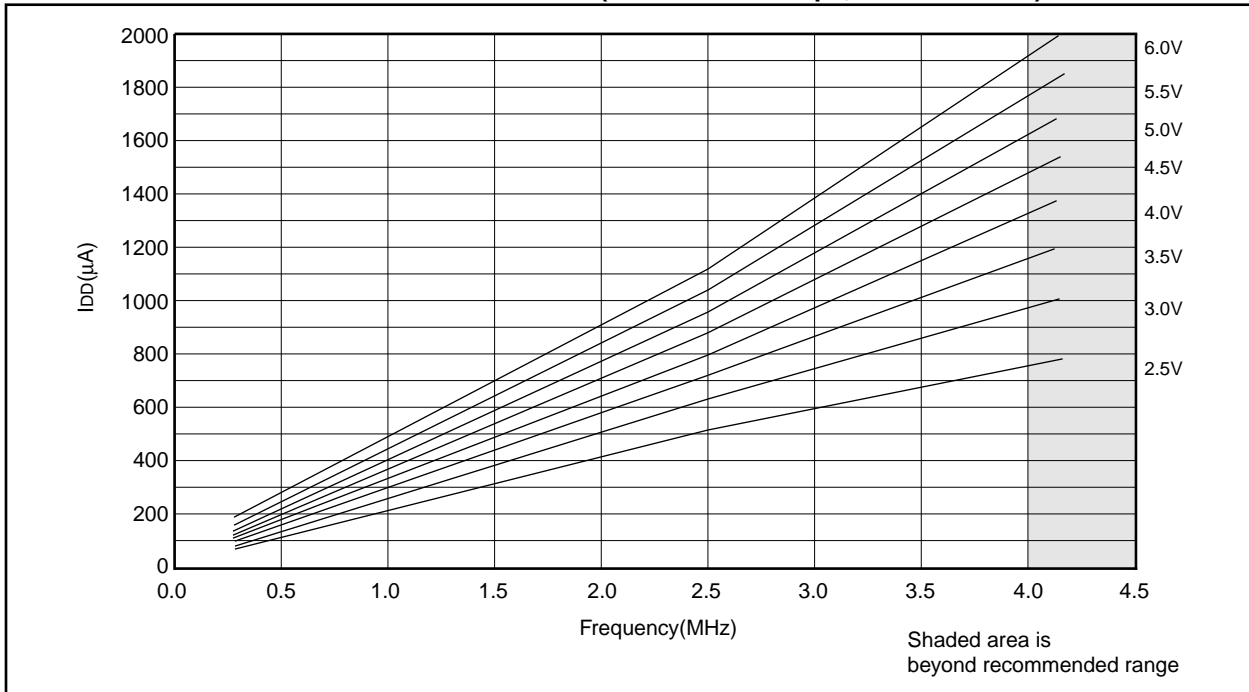
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Applicable Devices 710 71 711 72 73 73A 74 74A

**FIGURE 24-12: TYPICAL  $I_{DD}$  vs. FREQUENCY (RC MODE @ 22 pF, 25°C)**

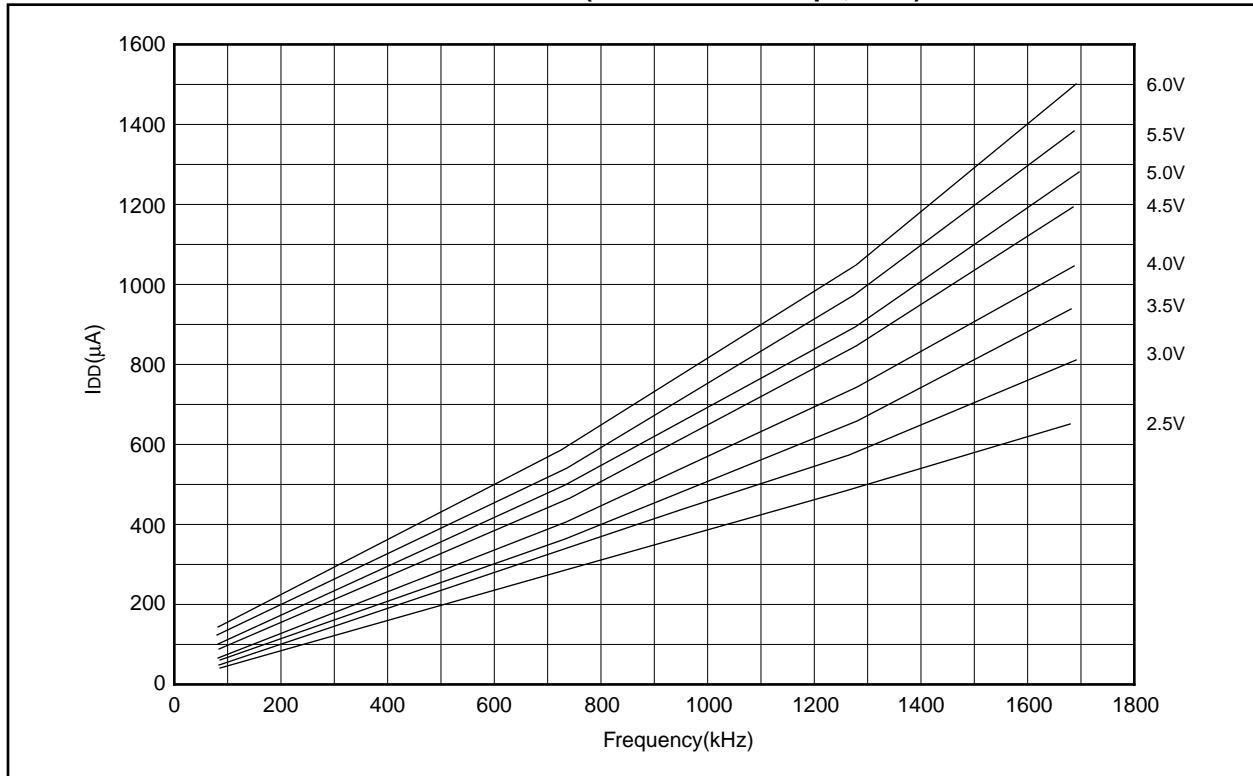


**FIGURE 24-13: MAXIMUM  $I_{DD}$  vs. FREQUENCY (RC MODE @ 22 pF, -40°C TO 85°C)**

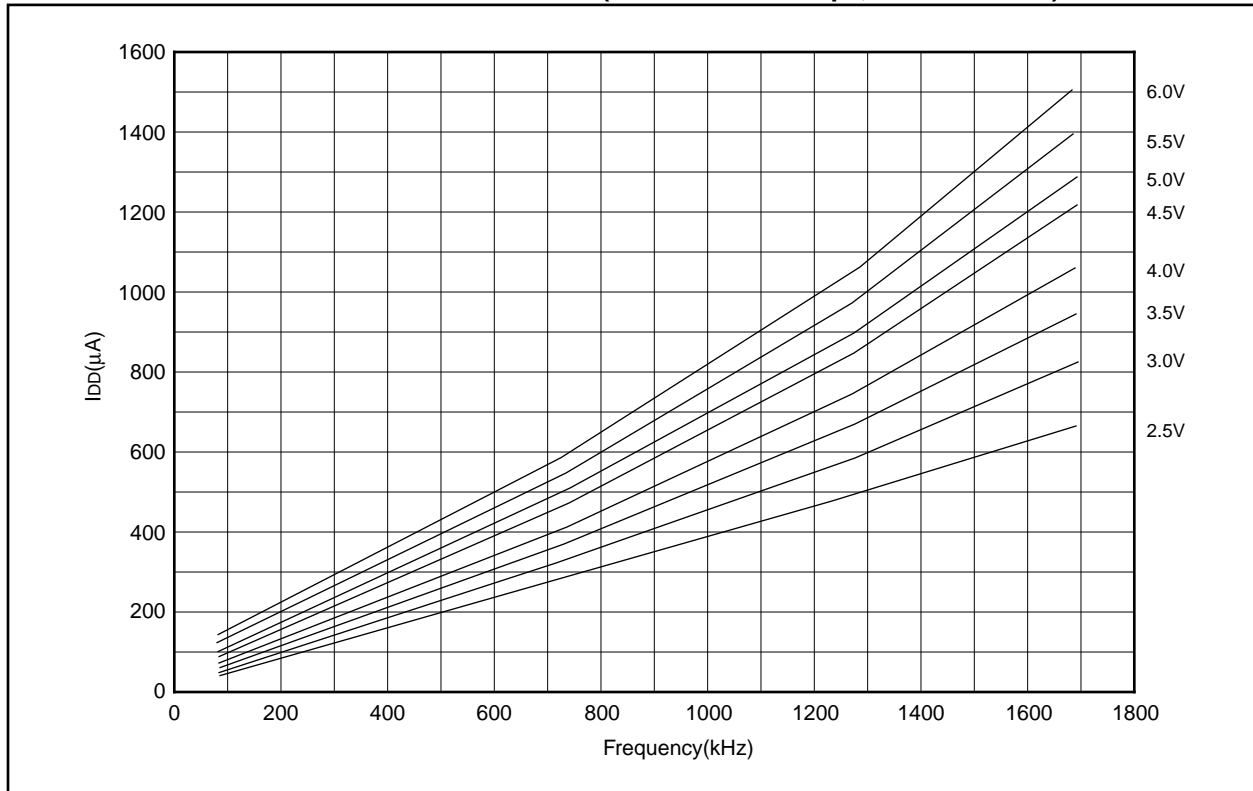


Data based on matrix samples. See first page of this section for details.

**FIGURE 24-14: TYPICAL  $I_{DD}$  vs. FREQUENCY (RC MODE @ 100 pF, 25°C)**



**FIGURE 24-15: MAXIMUM  $I_{DD}$  vs. FREQUENCY (RC MODE @ 100 pF, -40°C TO 85°C)**



Data based on matrix samples. See first page of this section for details.

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Applicable Devices 710 71 711 72 73 73A 74 74A

FIGURE 24-16: TYPICAL  $I_{DD}$  vs. FREQUENCY (RC MODE @ 300 pF, 25°C)

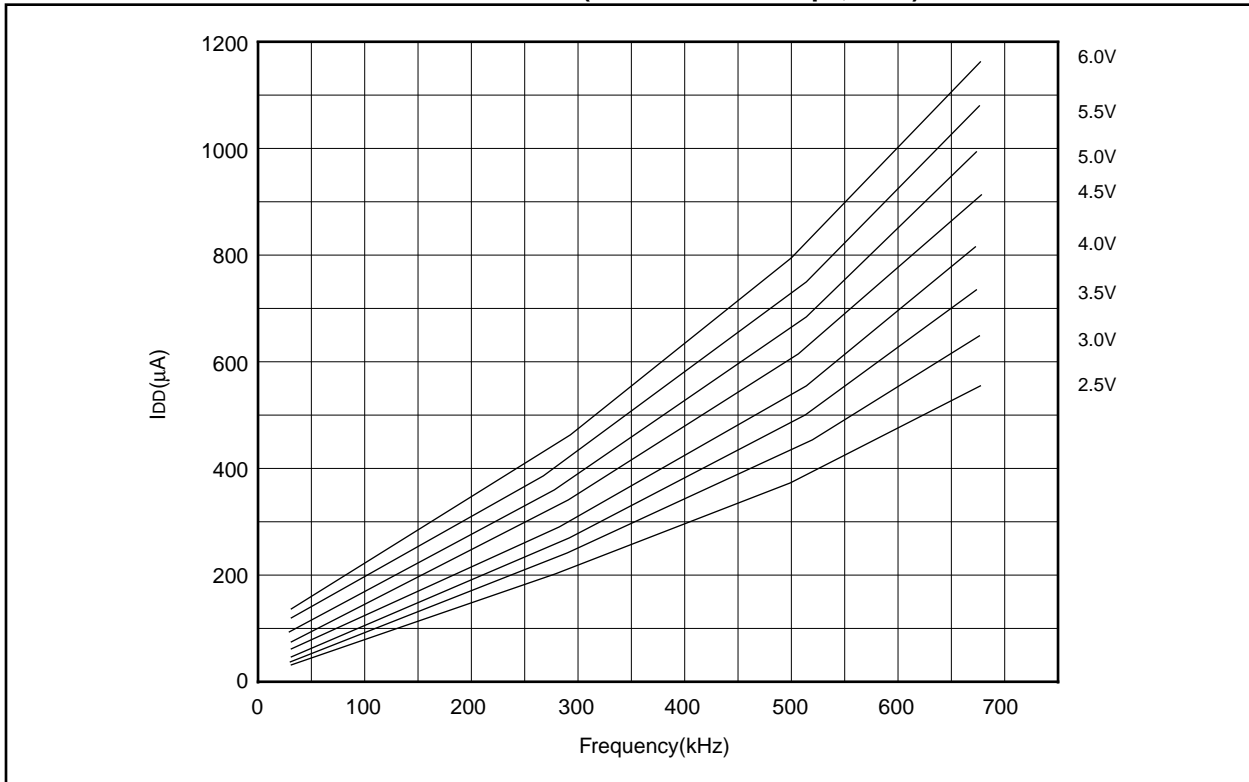
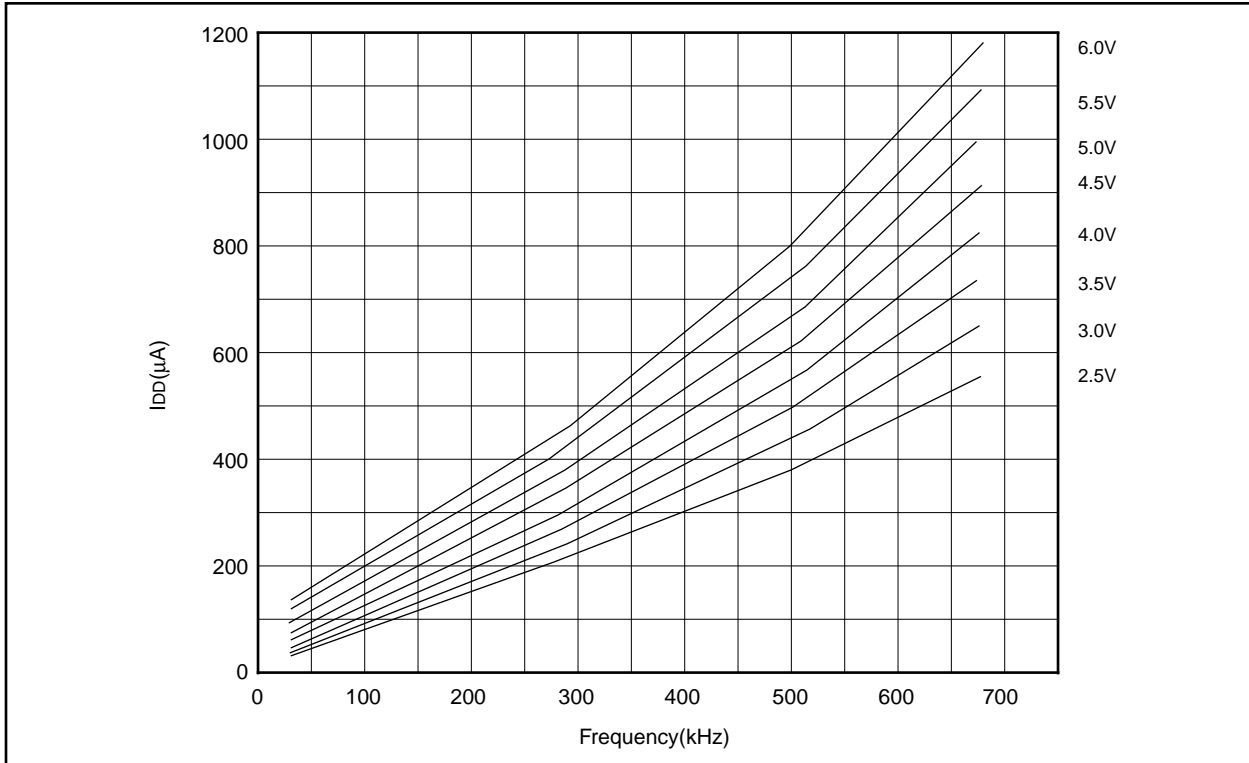
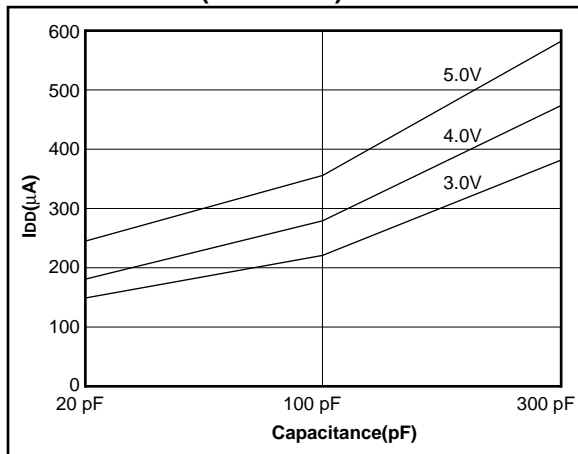


FIGURE 24-17: MAXIMUM  $I_{DD}$  vs. FREQUENCY (RC MODE @ 300 pF, -40°C TO 85°C)



Data based on matrix samples. See first page of this section for details.

**FIGURE 24-18: TYPICAL I<sub>DD</sub> vs. CAPACITANCE @ 500 kHz (RC MODE)**

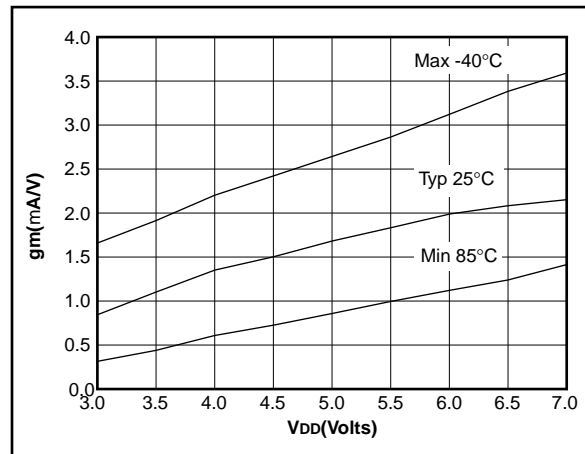


**TABLE 24-1: RC OSCILLATOR FREQUENCIES**

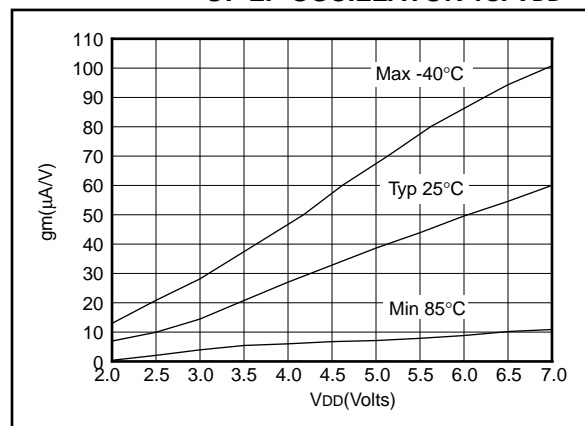
Cext	Rext	Average Fosc @ 5V, 25°C	
		Fosc	% Variation
22 pF	5k	4.12 MHz	± 1.4%
	10k	2.35 MHz	± 1.4%
	100k	268 kHz	± 1.1%
100 pF	3.3k	1.80 MHz	± 1.0%
	5k	1.27 MHz	± 1.0%
	10k	688 kHz	± 1.2%
300 pF	100k	77.2 kHz	± 1.0%
	3.3k	707 kHz	± 1.4%
	5k	501 kHz	± 1.2%
	10k	269 kHz	± 1.6%
	100k	28.3 kHz	± 1.1%

The percentage variation indicated here is part to part variation due to normal process distribution. The variation indicated is ±3 standard deviation from average value for VDD = 5V.

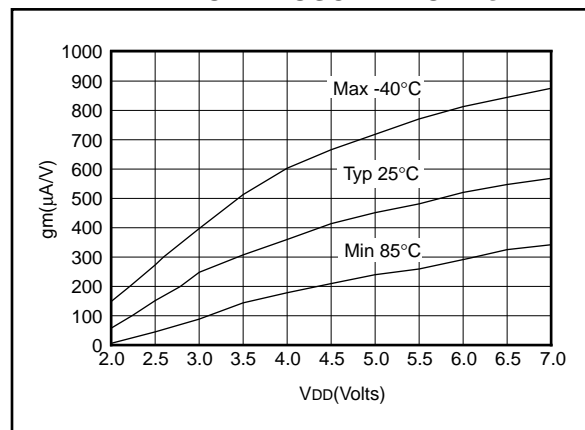
**FIGURE 24-19: TRANSCONDUCTANCE(gm) OF HS OSCILLATOR vs. VDD**



**FIGURE 24-20: TRANSCONDUCTANCE(gm) OF LP OSCILLATOR vs. VDD**



**FIGURE 24-21: TRANSCONDUCTANCE(gm) OF XT OSCILLATOR vs. VDD**

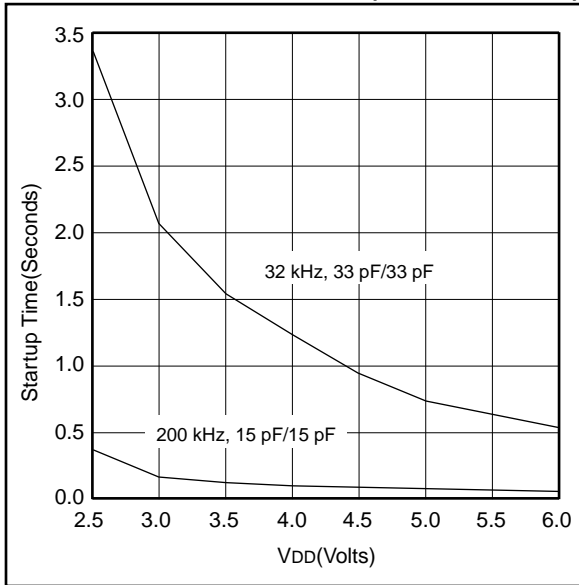


Data based on matrix samples. See first page of this section for details.

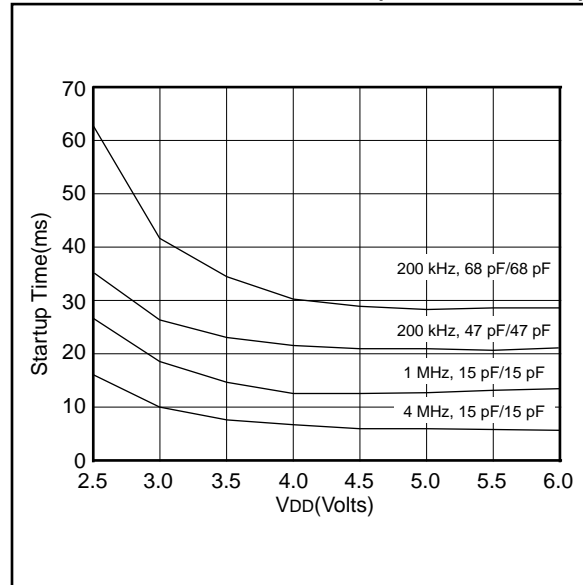
# PIC16C7X

Applicable Devices 710 71 711 72 73 73A 74 74A

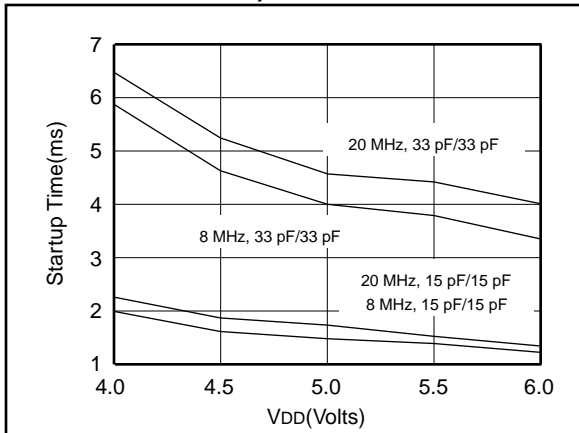
**FIGURE 24-22: TYPICAL XTAL STARTUP TIME vs. VDD (LP MODE, 25°C)**



**FIGURE 24-24: TYPICAL XTAL STARTUP TIME vs. VDD (XT MODE, 25°C)**



**FIGURE 24-23: TYPICAL XTAL STARTUP TIME vs. VDD (HS MODE, 25°C)**



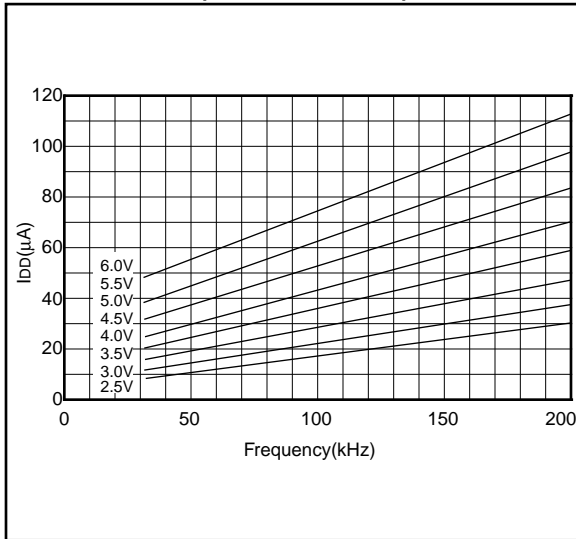
**TABLE 24-2: CAPACITOR SELECTION FOR CRYSTAL OSCILLATORS**

Osc Type	Crystal Freq	Cap. Range C1	Cap. Range C2
LP	32 kHz	33 pF	33 pF
	200 kHz	15 pF	15 pF
XT	200 kHz	47-68 pF	47-68 pF
	1 MHz	15 pF	15 pF
	4 MHz	15 pF	15 pF
HS	4 MHz	15 pF	15 pF
	8 MHz	15-33 pF	15-33 pF
	20 MHz	15-33 pF	15-33 pF
<b>Crystals Used</b>			
32 kHz	Epson C-001R32.768K-A		± 20 PPM
200 kHz	STD XTL 200.000KHz		± 20 PPM
1 MHz	ECS ECS-10-13-1		± 50 PPM
4 MHz	ECS ECS-40-20-1		± 50 PPM
8 MHz	EPSON CA-301 8.000M-C		± 30 PPM
20 MHz	EPSON CA-301 20.000M-C		± 30 PPM

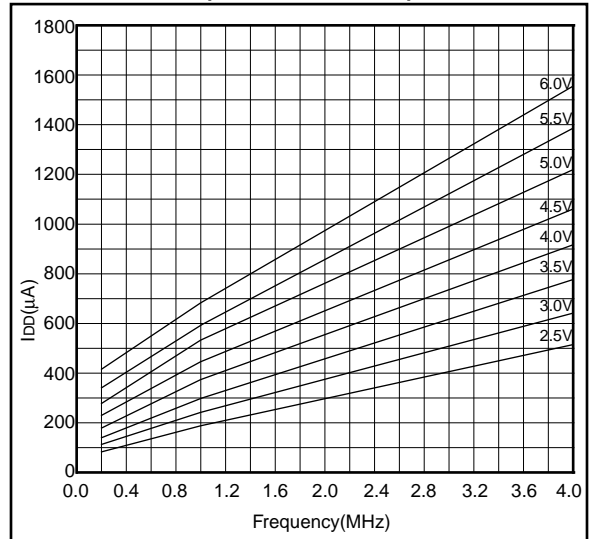
Data based on matrix samples. See first page of this section for details.



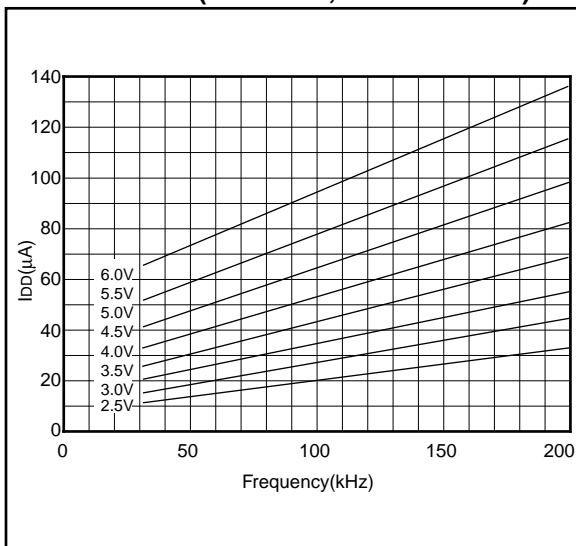
**FIGURE 24-25: TYPICAL I<sub>DD</sub> vs. FREQUENCY (LP MODE, 25°C)**



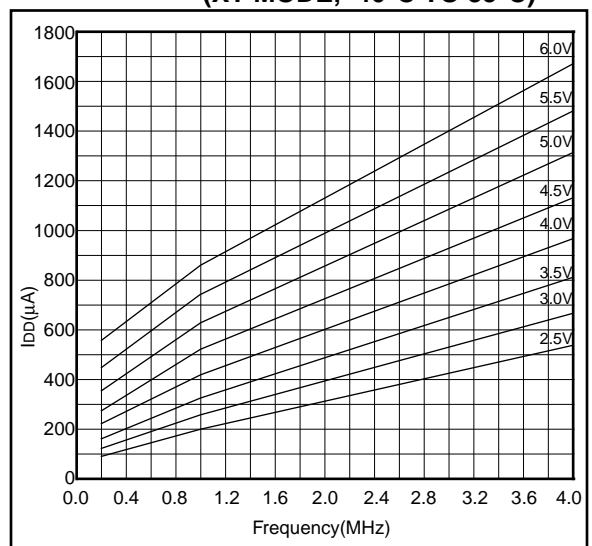
**FIGURE 24-27: TYPICAL I<sub>DD</sub> vs. FREQUENCY (XT MODE, 25°C)**



**FIGURE 24-26: MAXIMUM I<sub>DD</sub> vs. FREQUENCY (LP MODE, 85°C TO -40°C)**



**FIGURE 24-28: MAXIMUM I<sub>DD</sub> vs. FREQUENCY (XT MODE, -40°C TO 85°C)**



Data based on matrix samples. See first page of this section for details.

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FIGURE 24-29: TYPICAL  $I_{DD}$  vs. FREQUENCY  
(HS MODE, 25°C)

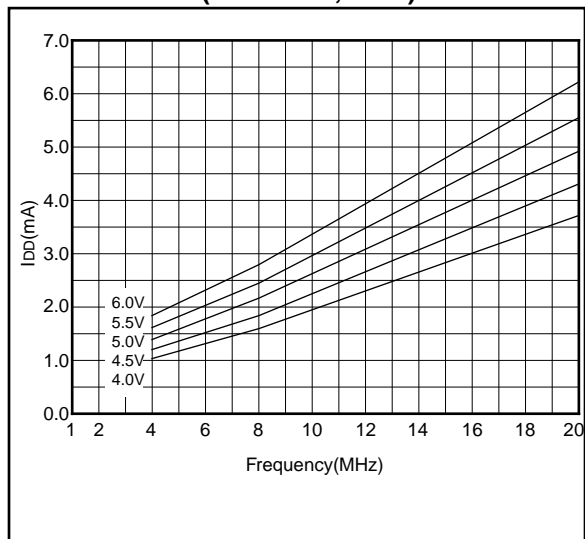
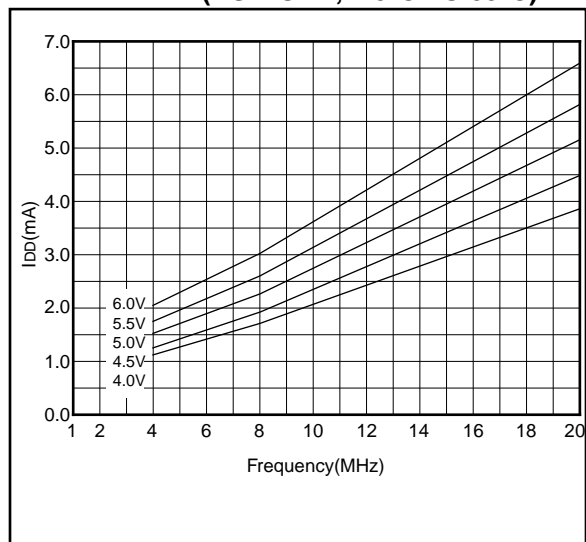


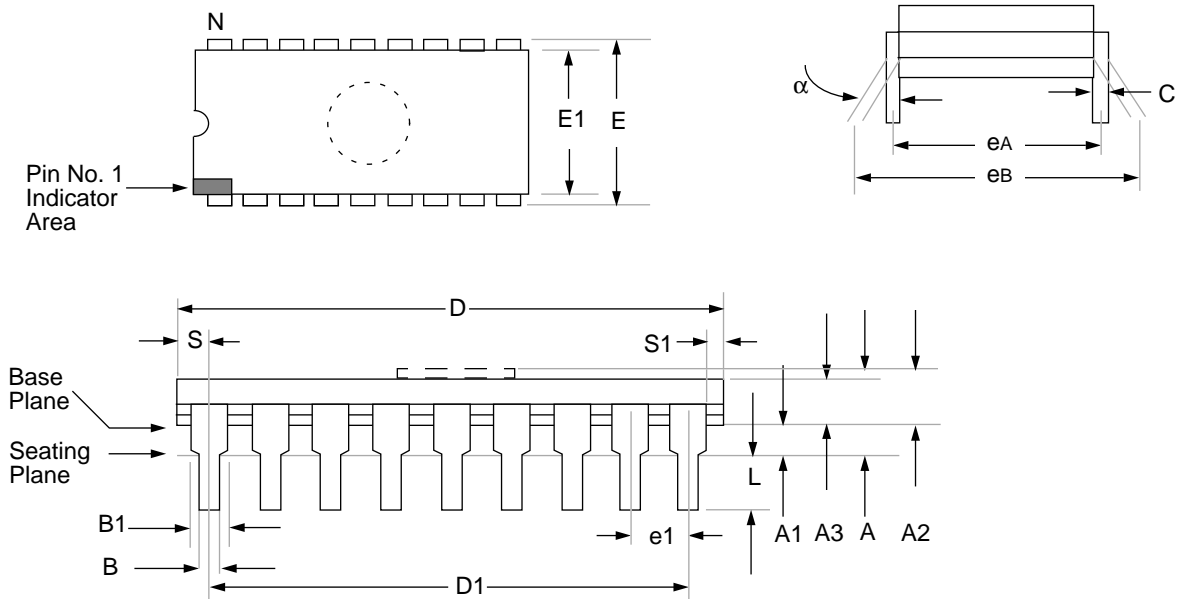
FIGURE 24-30: MAXIMUM  $I_{DD}$  vs.  
FREQUENCY  
(HS MODE, -40°C TO 85°C)



Data based on matrix samples. See first page of this section for details.

## 25.0 PACKAGING INFORMATION

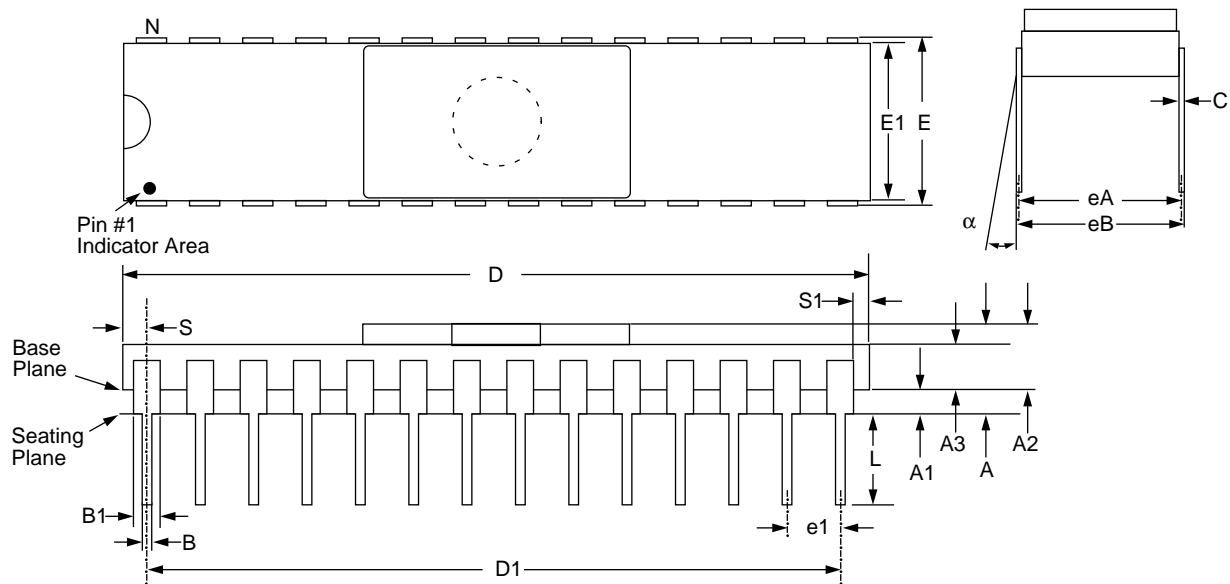
### 25.1 18-Lead Ceramic CERDIP Dual In-line with Window (300 mil)



Package Group: Ceramic CERDIP Dual In-Line (CDP)						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
$\alpha$	0°	10°		0°	10°	
A	—	5.080		—	0.200	
A1	0.381	1.7780		0.015	0.070	
A2	3.810	4.699		0.150	0.185	
A3	3.810	4.445		0.150	0.175	
B	0.355	0.585		0.014	0.023	
B1	1.270	1.651	Typical	0.050	0.065	Typical
C	0.203	0.381	Typical	0.008	0.015	Typical
D	22.352	23.622		0.880	0.930	
D1	20.320	20.320	Reference	0.800	0.800	Reference
E	7.620	8.382		0.300	0.330	
E1	5.588	7.874		0.220	0.310	
e1	2.540	2.540	Reference	0.100	0.100	Reference
eA	7.366	8.128	Typical	0.290	0.320	Typical
eB	7.620	10.160		0.300	0.400	
L	3.175	3.810		0.125	0.150	
N	18	18		18	18	
S	0.508	1.397		0.020	0.055	
S1	0.381	1.270		0.015	0.050	

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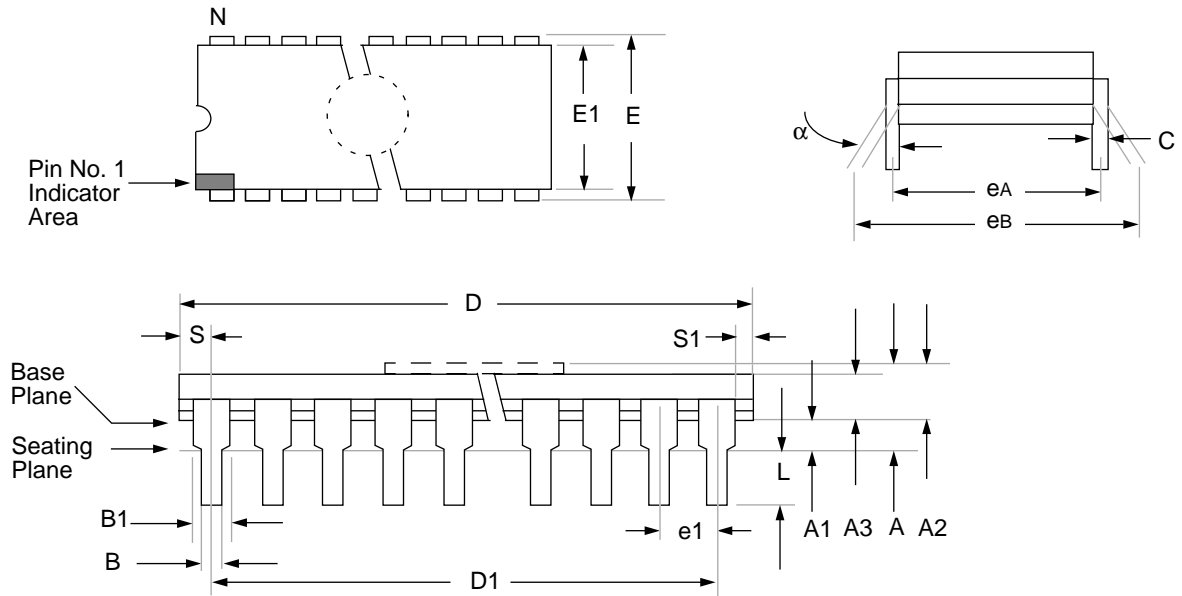
## 25.2 28-Lead Ceramic Side Brazed Dual In-Line with Window (300 mil)



Package Group: Ceramic Side Brazed Dual In-Line (CER)

Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
$\alpha$	0°	10°		0°	10°	
A	3.937	5.030		0.155	0.198	
A1	1.016	1.524		0.040	0.060	
A2	2.921	3.506		0.115	0.138	
A3	1.930	2.388		0.076	0.094	
B	0.406	0.508		0.016	0.020	
B1	1.219	1.321	Typical	0.048	0.052	
C	0.228	0.305	Typical	0.009	0.012	
D	35.204	35.916		1.386	1.414	
D1	32.893	33.147	Reference	1.295	1.305	
E	7.620	8.128		0.300	0.320	
E1	7.366	7.620		0.290	0.300	
e1	2.413	2.667	Typical	0.095	0.105	
eA	7.366	7.874	Reference	0.290	0.310	
eB	7.594	8.179		0.299	0.322	
L	3.302	4.064		0.130	0.160	
N	28	28		28	28	
S	1.143	1.397		0.045	0.055	
S1	0.533	0.737		0.021	0.029	

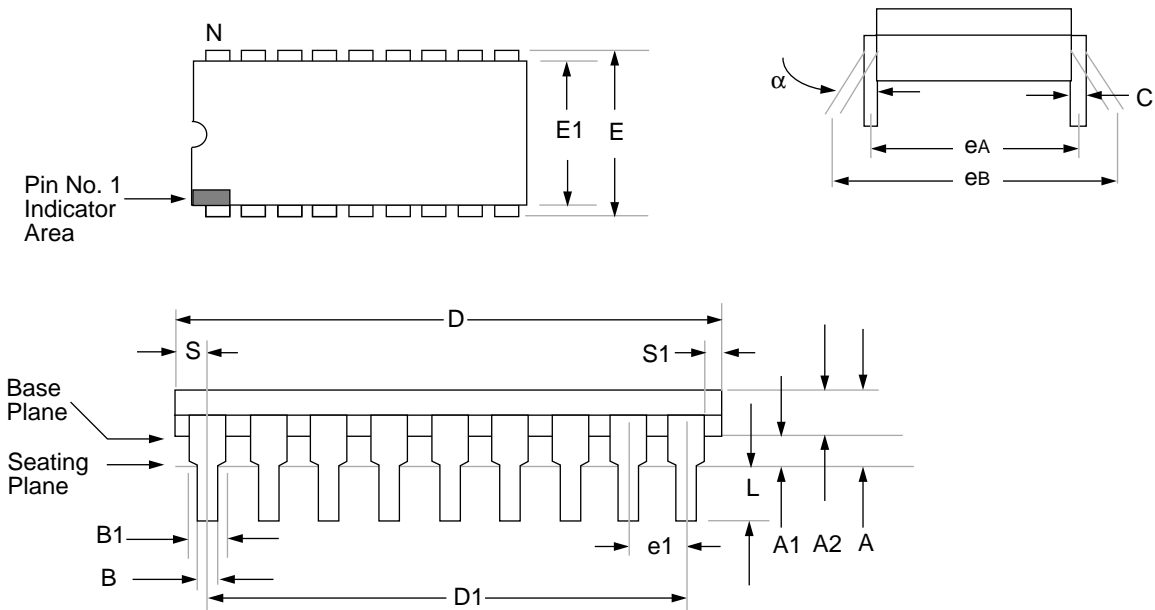
## 25.3 40-Lead Ceramic CERDIP Dual In-line with Window (600 mil)



Package Group: Ceramic CERDIP Dual In-Line (CDP)						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
$\alpha$	0°	10°		0°	10°	
A	4.318	5.715		0.170	0.225	
A1	0.381	1.778		0.015	0.070	
A2	3.810	4.699		0.150	0.185	
A3	3.810	4.445		0.150	0.175	
B	0.355	0.585		0.014	0.023	
B1	1.270	1.651	Typical	0.050	0.065	Typical
C	0.203	0.381	Typical	0.008	0.015	Typical
D	51.435	52.705		2.025	2.075	
D1	48.260	48.260	Reference	1.900	1.900	Reference
E	15.240	15.875		0.600	0.625	
E1	12.954	15.240		0.510	0.600	
e1	2.540	2.540	Reference	0.100	0.100	Reference
eA	14.986	16.002	Typical	0.590	0.630	Typical
eB	15.240	18.034		0.600	0.710	
L	3.175	3.810		0.125	0.150	
N	40	40		40	40	
S	1.016	2.286		0.040	0.090	
S1	0.381	1.778		0.015	0.070	

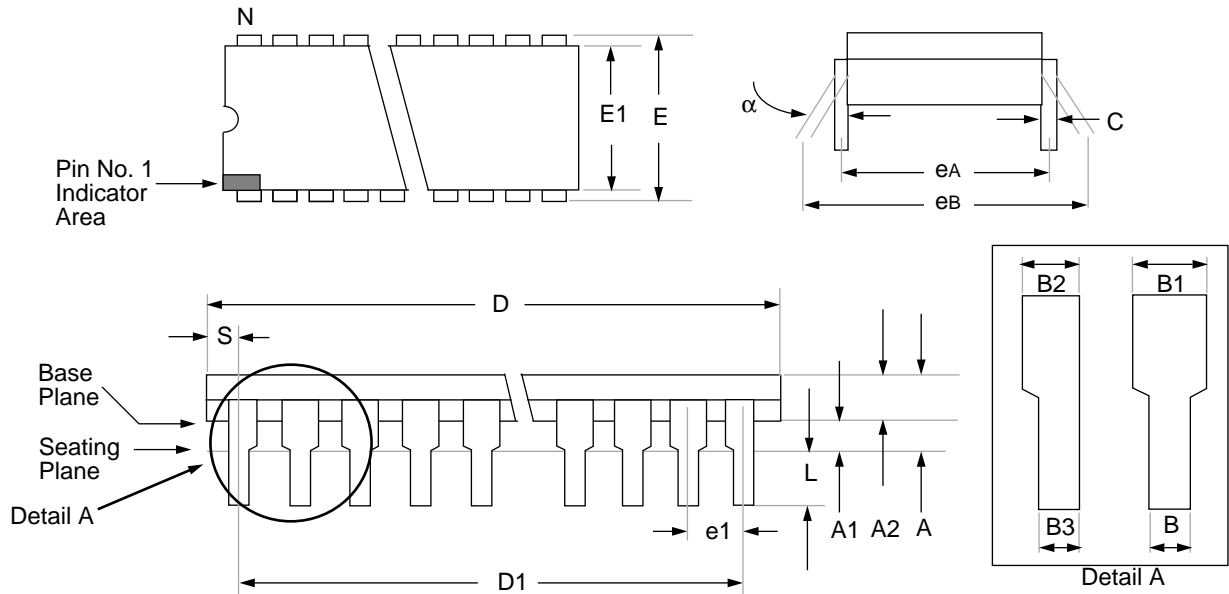
# PIC16C7X

## 25.4 18-Lead Plastic Dual In-line (300 mil)



Package Group: Plastic Dual In-Line (PLA)						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
$\alpha$	0°	10°		0°	10°	
A	—	4.064		—	0.160	
A1	0.381	—		0.015	—	
A2	3.048	3.810		0.120	0.150	
B	0.355	0.559		0.014	0.022	
B1	1.524	1.524	Reference	0.060	0.060	Reference
C	0.203	0.381	Typical	0.008	0.015	Typical
D	22.479	23.495		0.885	0.925	
D1	20.320	20.320	Reference	0.800	0.800	Reference
E	7.620	8.255		0.300	0.325	
E1	6.096	7.112		0.240	0.280	
e1	2.489	2.591	Typical	0.098	0.102	Typical
eA	7.620	7.620	Reference	0.300	0.300	Reference
eB	7.874	9.906		0.310	0.390	
L	3.048	3.556		0.120	0.140	
N	18	18		18	18	
S	0.889	—		0.035	—	
S1	0.127	—		0.005	—	

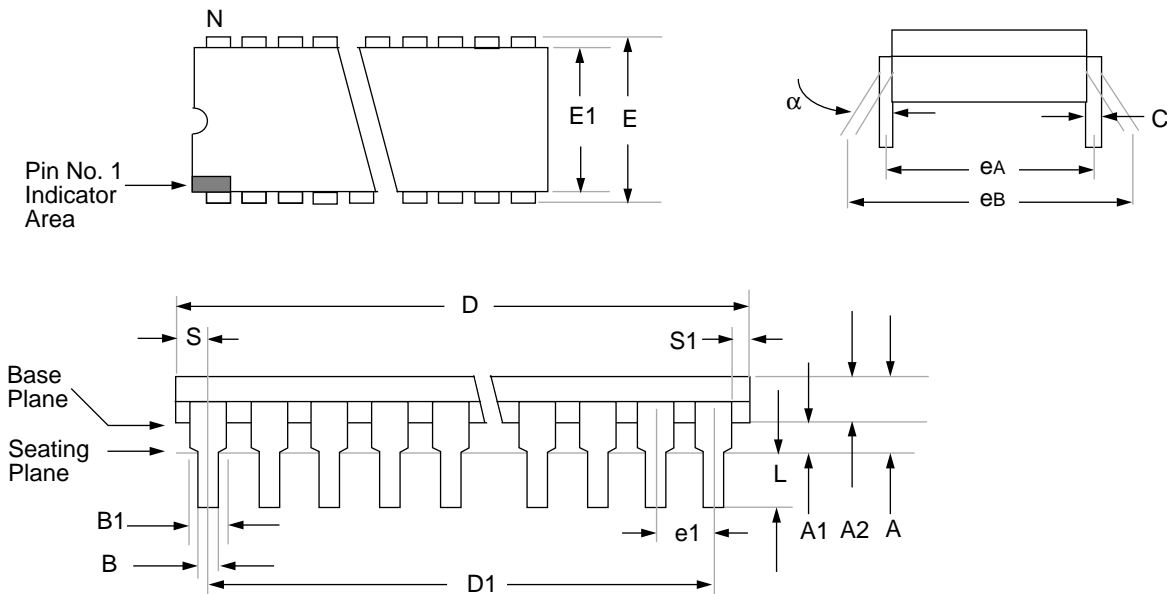
## 25.5 28-Lead Plastic Dual In-line (300 mil)



Package Group: Plastic Dual In-Line (PLA)						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
$\alpha$	0°	10°		0°	10°	
A	3.632	4.572		0.143	0.180	
A1	0.381	–		0.015	–	
A2	3.175	3.556		0.125	0.140	
B	0.406	0.559		0.016	0.022	
B1	1.016	1.651	<b>Typical</b>	0.040	0.065	<b>Typical</b>
B2	0.762	1.016	<b>4 places</b>	0.030	0.040	<b>4 places</b>
B3	0.203	0.508	<b>4 places</b>	0.008	0.020	<b>4 places</b>
C	0.203	0.331	<b>Typical</b>	0.008	0.013	<b>Typical</b>
D	34.163	35.179		1.385	1.395	
D1	33.020	33.020	<b>Reference</b>	1.300	1.300	<b>Reference</b>
E	7.874	8.382		0.310	0.330	
E1	7.112	7.493		0.280	0.295	
e1	2.540	2.540	<b>Typical</b>	0.100	0.100	<b>Typical</b>
eA	7.874	7.874	<b>Reference</b>	0.310	0.310	<b>Reference</b>
eB	8.128	9.652		0.320	0.380	
L	3.175	3.683		0.125	0.145	
N	28	–		28	–	
S	0.584	1.220		0.023	0.048	

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## 25.6 40-Lead Plastic Dual In-line (600 mil)

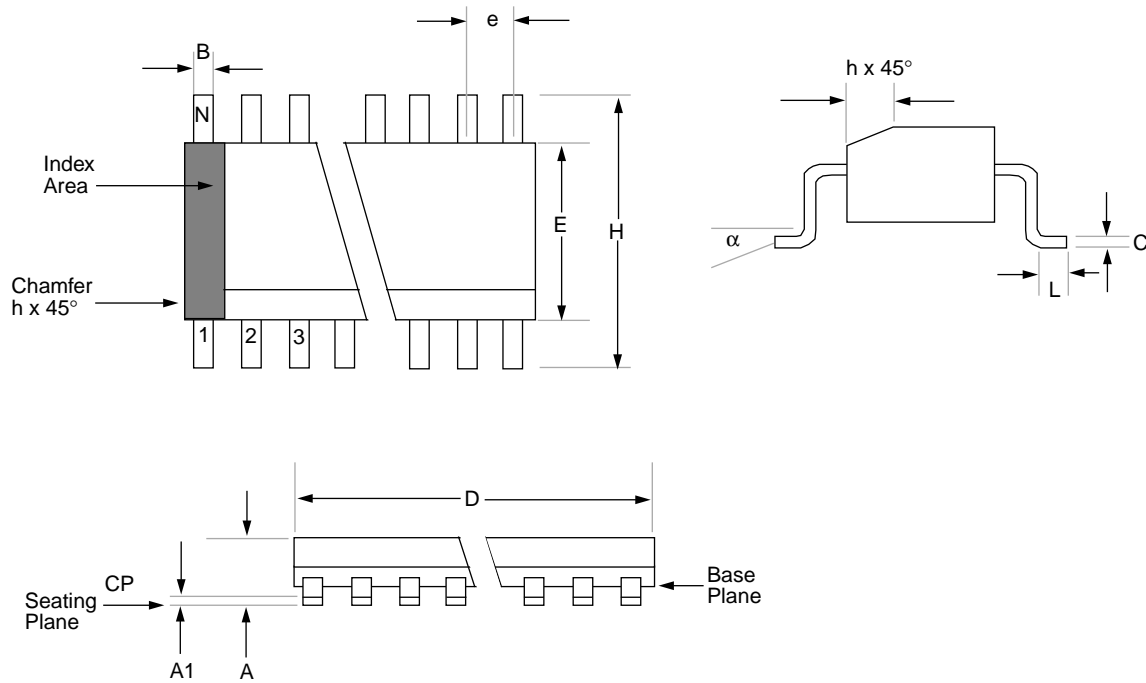


Package Group: Plastic Dual In-Line (PLA)

Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
$\alpha$	0°	10°		0°	10°	
A	–	5.080		–	0.200	
A1	0.381	–		0.015	–	
A2	3.175	4.064		0.125	0.160	
B	0.355	0.559		0.014	0.022	
B1	1.270	1.778	Typical	0.050	0.070	Typical
C	0.203	0.381	Typical	0.008	0.015	Typical
D	51.181	52.197		2.015	2.055	
D1	48.260	48.260	Reference	1.900	1.900	Reference
E	15.240	15.875		0.600	0.625	
E1	13.462	13.970		0.530	0.550	
e1	2.489	2.591	Typical	0.098	0.102	Typical
eA	15.240	15.240	Reference	0.600	0.600	Reference
eB	15.240	17.272		0.600	0.680	
L	2.921	3.683		0.115	0.145	
N	40	40		40	40	
S	1.270	–		0.050	–	
S1	0.508	–		0.020	–	



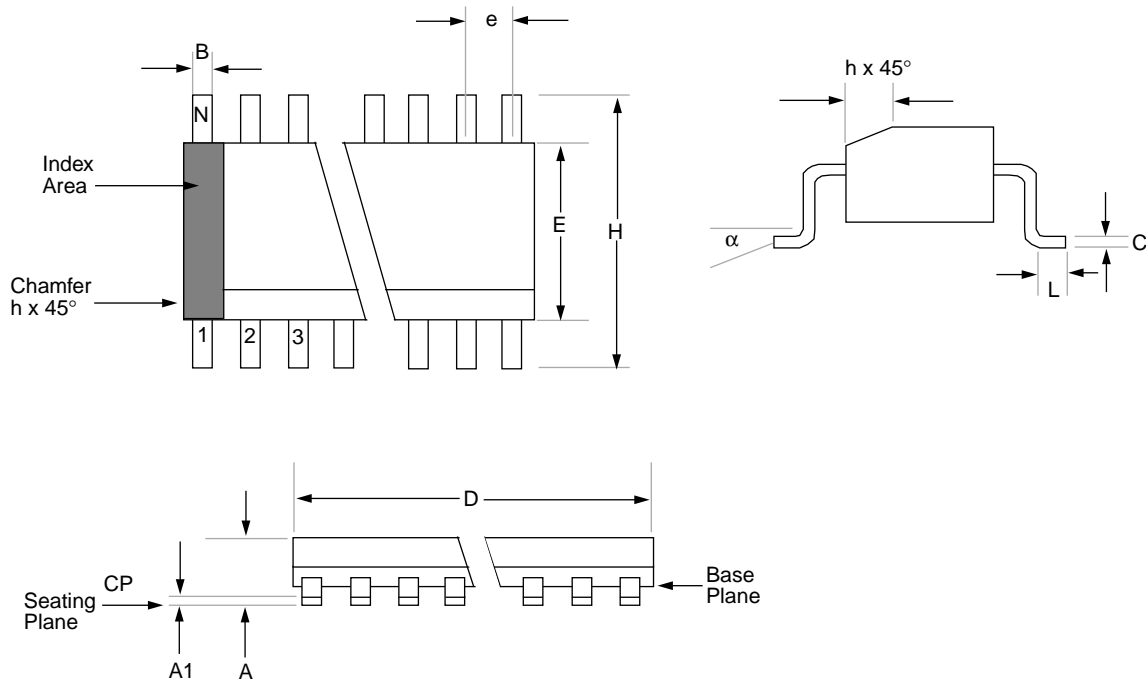
## 25.7 18-Lead Plastic Surface Mount (SOIC - Wide, 300 mil Body)



Package Group: Plastic SOIC (SO)						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
$\alpha$	0°	8°		0°	8°	
A	2.362	2.642		0.093	0.104	
A1	0.101	0.300		0.004	0.012	
B	0.355	0.483		0.014	0.019	
C	0.241	0.318		0.009	0.013	
D	11.353	11.735		0.447	0.462	
E	7.416	7.595		0.292	0.299	
e	1.270	1.270	Reference	0.050	0.050	Reference
H	10.007	10.643		0.394	0.419	
h	0.381	0.762		0.015	0.030	
L	0.406	1.143		0.016	0.045	
N	18	18		18	18	
CP	–	0.102		–	0.004	

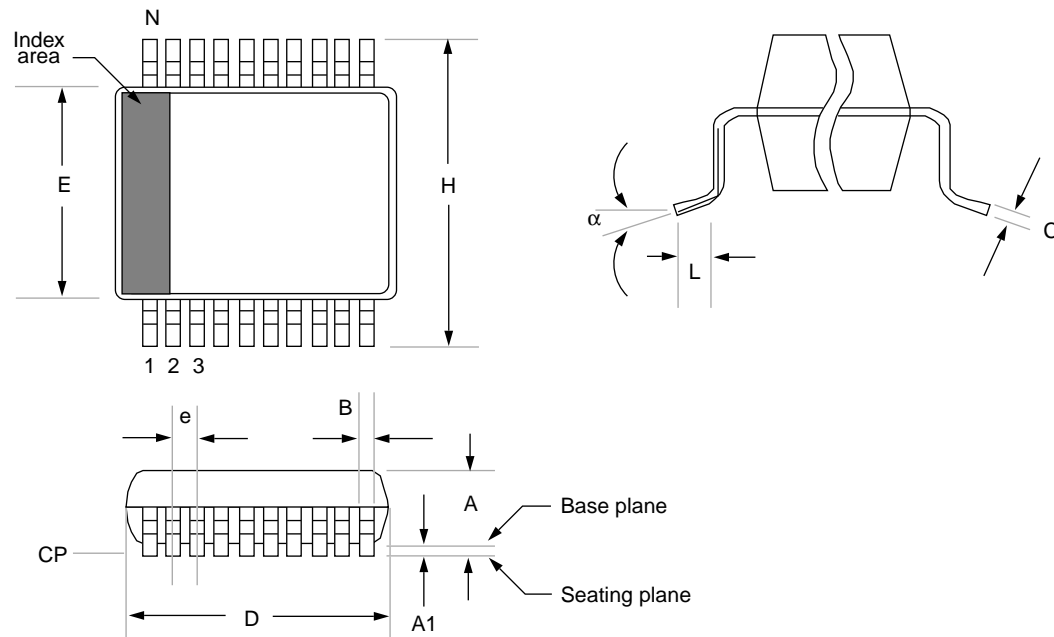
# PIC16C7X

## 25.8 28-Lead Plastic Surface Mount (SOIC - Wide, 300 mil Body)



Package Group: Plastic SOIC (SO)						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
$\alpha$	0°	8°		0°	8°	
A	2.362	2.642		0.093	0.104	
A1	0.101	0.300		0.004	0.012	
B	0.355	0.483		0.014	0.019	
C	0.241	0.318		0.009	0.013	
D	17.703	18.085		0.697	0.712	
E	7.416	7.595		0.292	0.299	
e	1.270	1.270	<b>Typical</b>	0.050	0.050	<b>Typical</b>
H	10.007	10.643		0.394	0.419	
h	0.381	0.762		0.015	0.030	
L	0.406	1.143		0.016	0.045	
N	28	28		28	28	
CP	—	0.102		—	0.004	

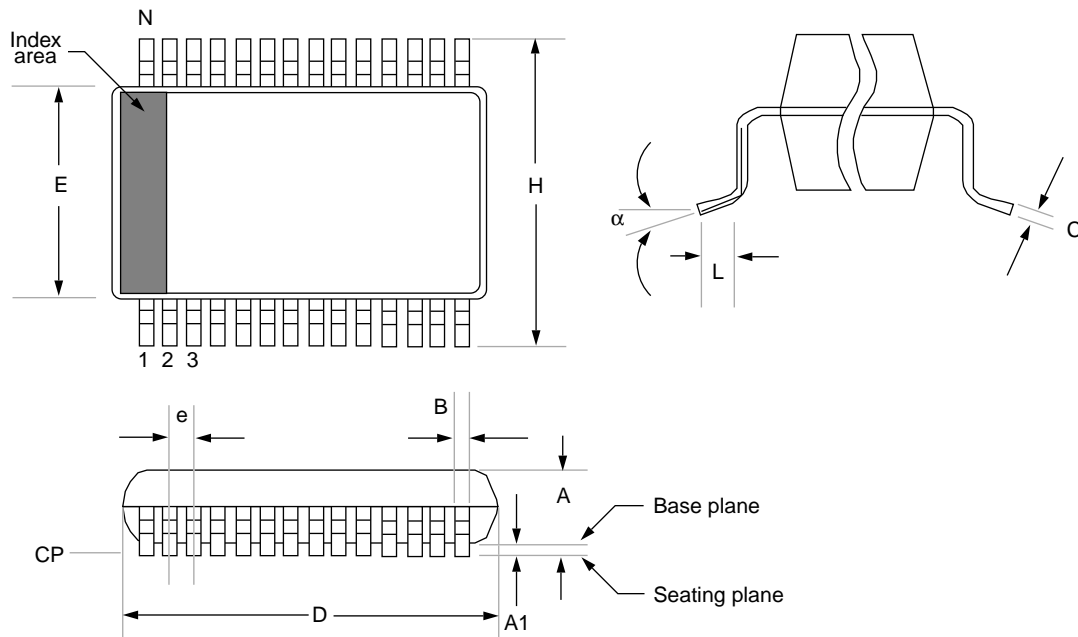
## 25.9 20-Lead Plastic Surface Mount (SSOP - 209 mil Body 5.30 mm)



Package Group: Plastic SSOP						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
$\alpha$	0°	8°		0°	8°	
A	1.730	1.990		0.068	0.078	
A1	0.050	0.210		0.002	0.008	
B	0.250	0.380		0.010	0.015	
C	0.130	0.220		0.005	0.009	
D	7.070	7.330		0.278	0.289	
E	5.200	5.380		0.205	0.212	
e	0.650	0.650	Reference	0.026	0.026	Reference
H	7.650	7.900		0.301	0.311	
L	0.550	0.950		0.022	0.037	
N	20	20		20	20	
CP	-	0.102		-	0.004	

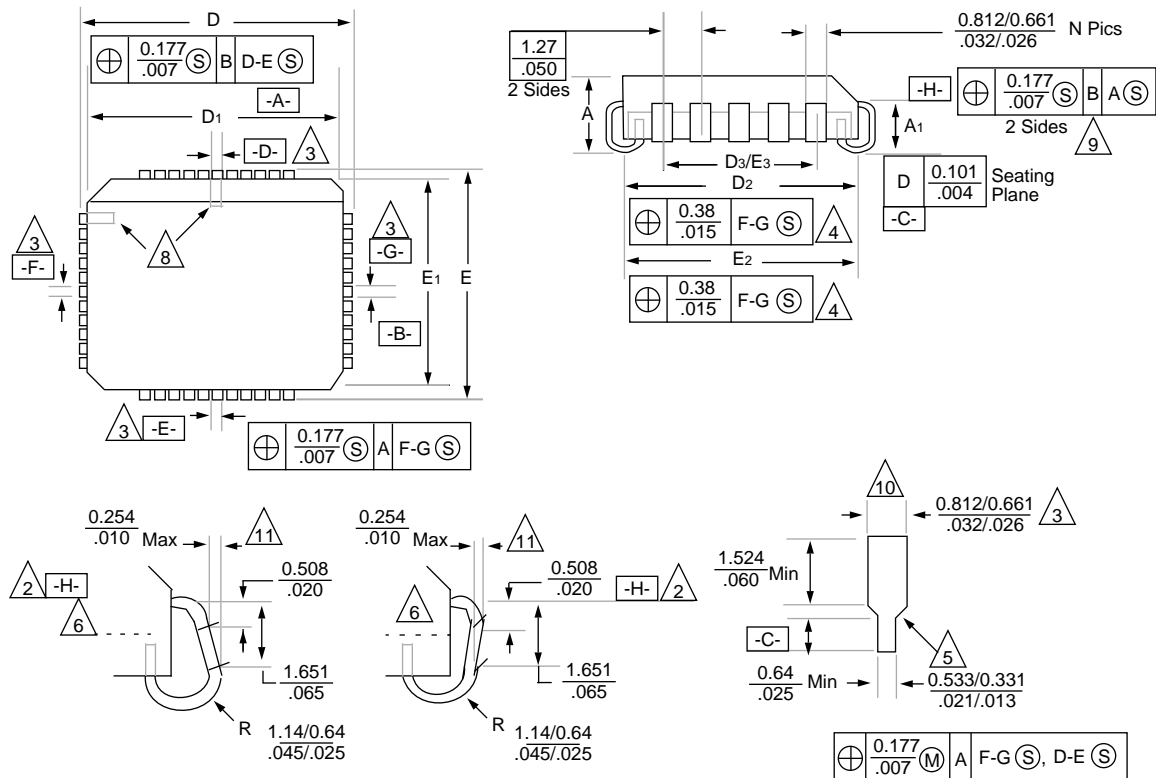
# PIC16C7X

## 25.10 28-Lead Plastic Surface Mount (SSOP - 209 mil Body 5.30 mm)



Package Group: Plastic SSOP						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
$\alpha$	0°	8°		0°	8°	
A	1.730	1.990		0.068	0.078	
A1	0.050	0.210		0.002	0.008	
B	0.250	0.380		0.010	0.015	
C	0.130	0.220		0.005	0.009	
D	10.070	10.330		0.396	0.407	
E	5.200	5.380		0.205	0.212	
e	0.650	0.650	Reference	0.026	0.026	Reference
H	7.650	7.900		0.301	0.311	
L	0.550	0.950		0.022	0.037	
N	28	28		28	28	
CP	-	0.102		-	0.004	

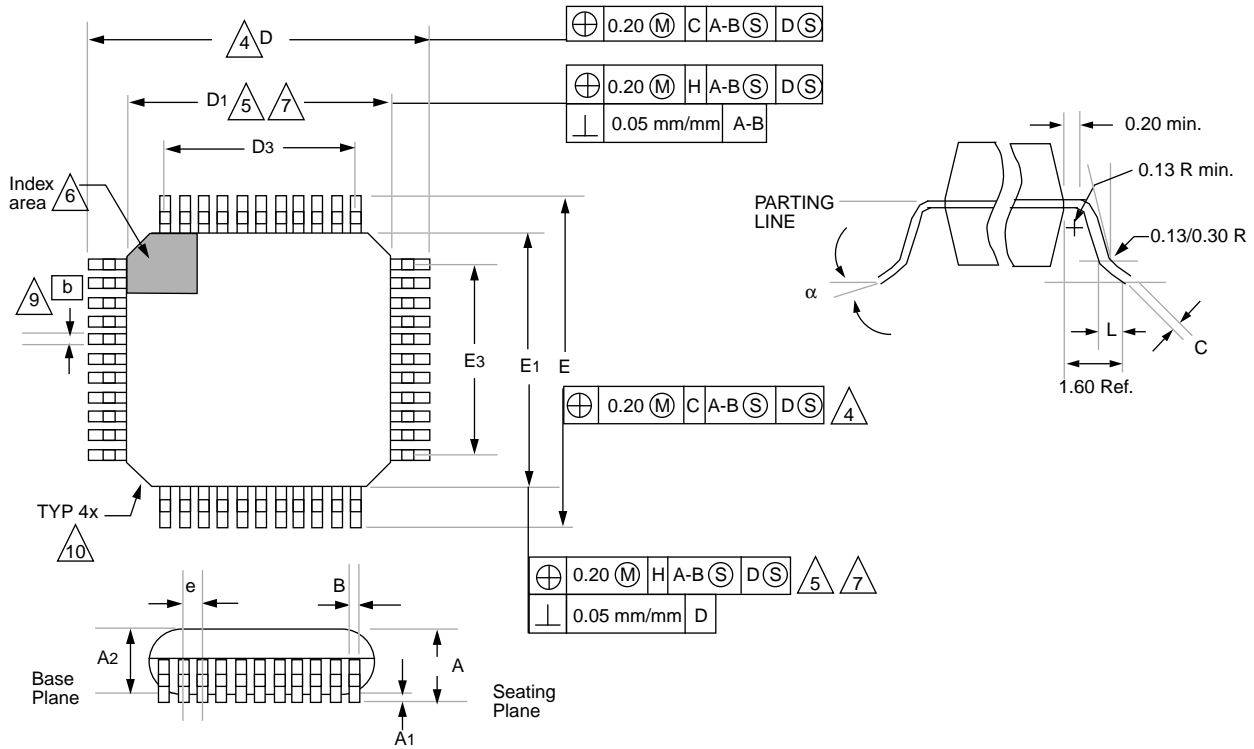
## 25.11 44-Lead Plastic Leaded Chip Carrier (Square)



Package Group: Plastic Leaded Chip Carrier (PLCC)						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
A	4.191	4.572		0.165	0.180	
A1	2.413	2.921		0.095	0.115	
D	17.399	17.653		0.685	0.695	
D1	16.510	16.663		0.650	0.656	
D2	15.494	16.002		0.610	0.630	
D3	12.700	12.700	Reference	0.500	0.500	Reference
E	17.399	17.653		0.685	0.695	
E1	16.510	16.663		0.650	0.656	
E2	15.494	16.002		0.610	0.630	
E3	12.700	12.700	Reference	0.500	0.500	Reference
N	44	44		44	44	
CP	-	0.102		-	0.004	
LT	0.203	0.381		0.008	0.015	

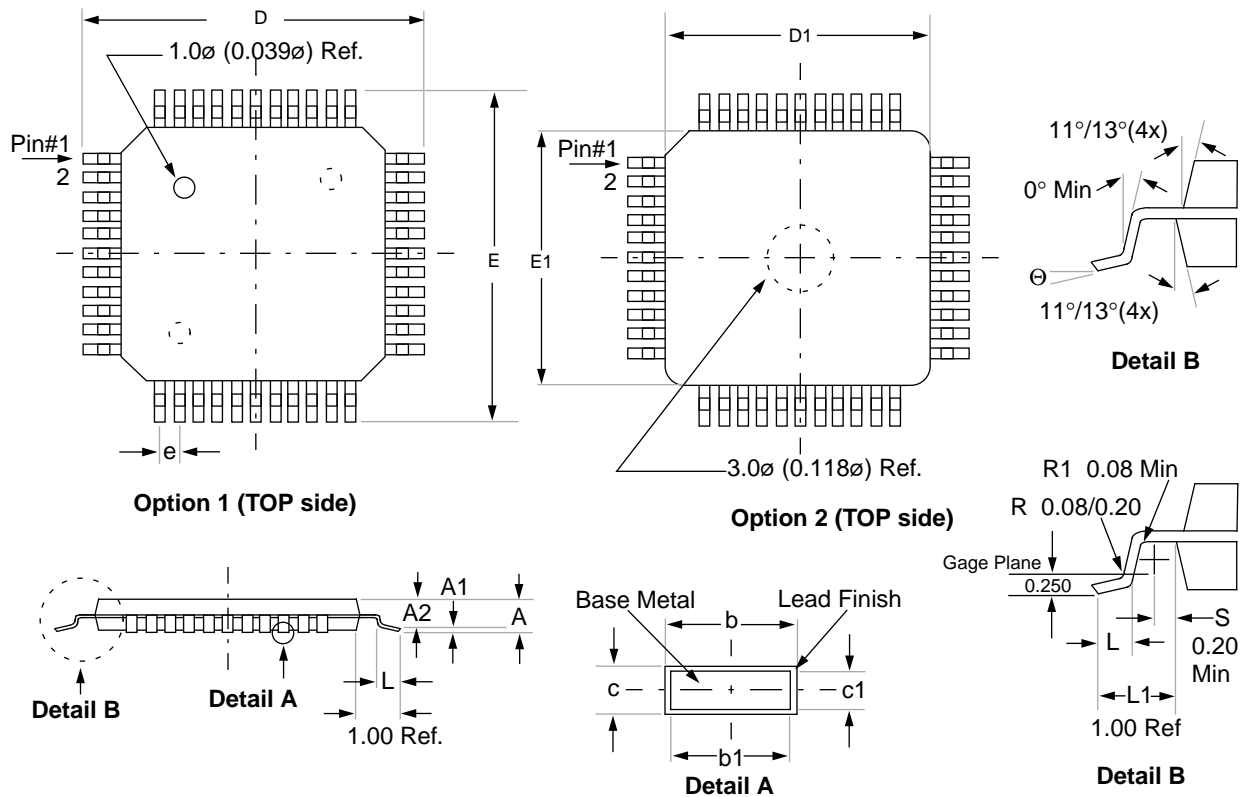
# PIC16C7X

## 25.12 44-Lead Plastic Surface Mount (MQFP 10x10 mm Body 1.6/0.15 mm Lead Form)



Package Group: Plastic MQFP						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
$\alpha$	0°	7°		0°	7°	
A	2.000	2.350		0.078	0.093	
A1	0.050	0.250		0.002	0.010	
A2	1.950	2.100		0.768	0.083	
b	0.300	0.450	Typical	0.011	0.018	Typical
C	0.150	0.180		0.006	0.007	
D	12.950	13.450		0.510	0.530	
D1	9.900	10.100		0.390	0.398	
D3	8.000	8.000	Reference	0.315	0.315	Reference
E	12.950	13.450		0.510	0.530	
E1	9.900	10.100		0.390	0.398	
E3	8.000	8.000	Reference	0.315	0.315	Reference
e	0.800	0.800		0.031	0.032	
L	0.730	1.030		0.028	0.041	
N	44	44		44	44	
CP	0.102	—		0.004	—	

## 25.13 44-Lead Plastic Surface Mount (TQFP 10x10 mm Body 1.0/0.10 mm Lead Form)



Package Group: Plastic TQFP						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
A	1.00	1.20		0.039	0.047	
A1	0.05	0.15		0.002	0.006	
A2	0.95	1.05		0.037	0.041	
D	11.75	12.25		0.463	0.482	
D1	9.90	10.10		0.390	0.398	
E	11.75	12.25		0.463	0.482	
E1	9.90	10.10		0.390	0.398	
L	0.45	0.75		0.018	0.030	
e	0.80 BSC			0.031 BSC		
b	0.30	0.45		0.012	0.018	
b1	0.30	0.40		0.012	0.016	
c	0.09	0.20		0.004	0.008	
c1	0.09	0.16		0.004	0.006	
N	44	44		44	44	
θ	0°	7°		0°	7°	

Note 1: Dimensions D1 and E1 do not include mold protrusion. Allowable mold protrusion is 0.25mm (0.010") per side. D1 and E1 dimensions including mold mismatch.

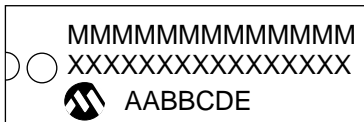
2: Dimension "b" does not include Dambar protrusion, allowable Dambar protrusion shall be 0.08mm (0.003") max.

3: This outline conforms to JEDEC MS-026.

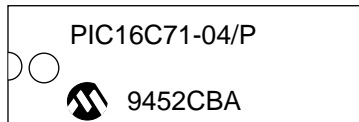
# PIC16C7X

## 25.14 Package Marking Information

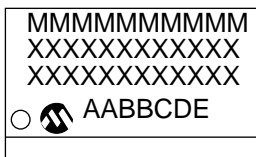
### 18-Lead PDIP



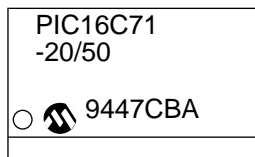
### Example



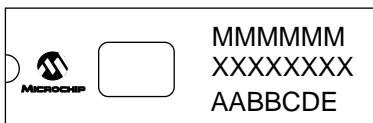
### 18-Lead SOIC



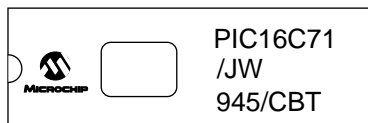
### Example



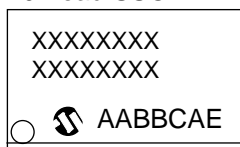
### 18-Lead CERDIP Windowed



### Example



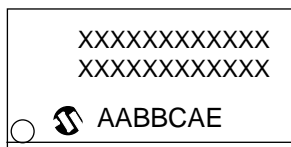
### 20-Lead SSOP



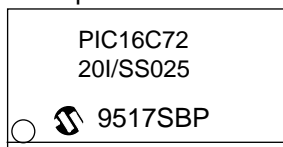
### Example



### 28-Lead SSOP



### Example



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. C = Chandler, Arizona, U.S.A. S = Tempe, Arizona, U.S.A.
	D <sub>1</sub>	Mask revision number for microcontroller
	E	Assembly code of the plant or country of origin in which part was assembled.
<b>Note:</b>	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 revision number, 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.

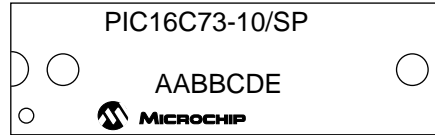


## Package Marking Information (Cont'd)

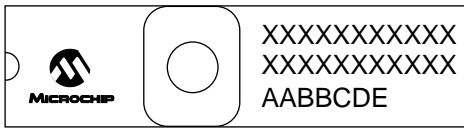
### 28-Lead PDIP (Skinny DIP)



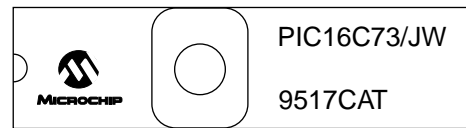
### Example



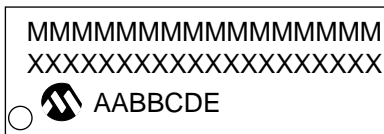
### 28-Lead Side Brazed Skinny Windowed



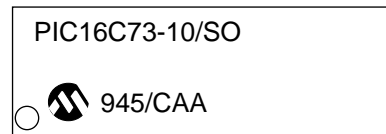
### Example



### 28-Lead SOIC



### Example



### 40-Lead PDIP



### Example



<b>Legend:</b>	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. C = Chandler, Arizona, U.S.A. S = Tempe, Arizona, U.S.A.
	D <sub>1</sub>	Mask revision number for microcontroller
	E	Assembly code of the plant or country of origin in which part was assembled.

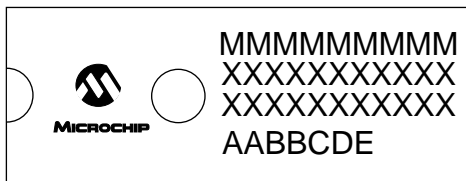
**Note:** In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line thus limiting the number of available characters for customer specific information.

\* Standard OTP marking consists of Microchip part number, year code, week code, facility code, mask revision number, 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.

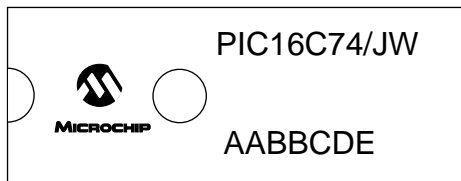
# PIC16C7X

## Package Marking Information (Cont'd)

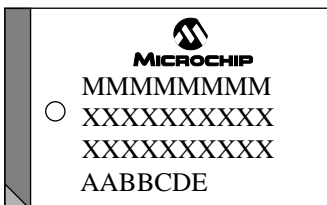
40-Lead CERDIP Windowed



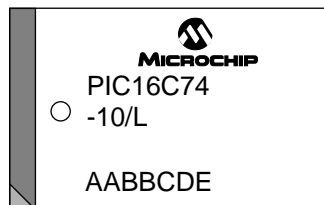
Example



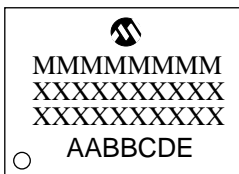
44-Lead PLCC



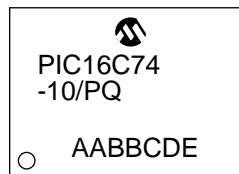
Example



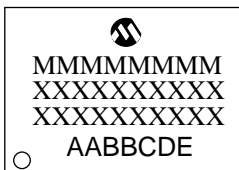
44-Lead MQFP



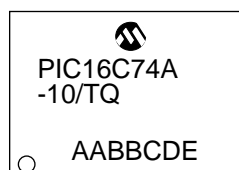
Example



44-Lead TQFP



Example



<b>Legend:</b>	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. C = Chandler, Arizona, U.S.A. S = Tempe, Arizona, U.S.A.
	D <sub>1</sub>	Mask revision number for microcontroller
	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 revision number, 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.

## APPENDIX A:

The following are the list of modifications over the PIC16C5X microcontroller family:

1. Instruction word length is increased to 14-bits. This allows larger page sizes both in program memory (4K now as opposed to 512 before) and register file (192 bytes now versus 32 bytes before).
2. A PC high latch register (PCLATH) is added to handle program memory paging. Bits PA2, PA1, PA0 are removed from STATUS register.
3. Data memory paging is redefined slightly. STATUS register is modified.
4. Four new instructions have been added: RETURN, RETFIE, ADDLW, and SUBLW. Two instructions TRIS and OPTION are being phased out although they are kept for compatibility with PIC16C5X.
5. OPTION and TRIS registers are made addressable.
6. Interrupt capability is added. Interrupt vector is at 0004h.
7. Stack size is increased to 8 deep.
8. Reset vector is changed to 0000h.
9. Reset of all registers is revisited. Five different reset (and wake-up) types are recognized. Registers are reset differently.
10. Wake up from SLEEP through interrupt is added.
11. Two separate timers, Oscillator Start-up Timer (OST) and Power-up Timer (PWRT) are included for more reliable power-up. These timers are invoked selectively to avoid unnecessary delays on power-up and wake-up.
12. PORTB has weak pull-ups and interrupt on change feature.
13. T0CKI pin is also a port pin (RA4) now.
14. FSR is made a full eight bit register.
15. "In-circuit serial programming" is made possible. The user can program PIC16CXX devices using only five pins: VDD, VSS,  $\overline{\text{MCLR}}$ /VPP, RB6 (clock) and RB7 (data in/out).
16. PCON status register is added with a Power-on Reset status bit (POR).
17. Code protection scheme is enhanced such that portions of the program memory can be protected, while the remainder is unprotected.
18. Brown-out protection circuitry has been added. Controlled by configuration word bit BODEN. Brown-out reset ensures the device is placed in a reset condition if VDD dips below a fixed set-point.

## APPENDIX B: COMPATIBILITY

To convert code written for PIC16C5X to PIC16CXX, the user should take the following steps:

1. Remove any program memory page select operations (PA2, PA1, PA0 bits) for CALL, GOTO.
2. Revisit any computed jump operations (write to PC or add to PC, etc.) to make sure page bits are set properly under the new scheme.
3. Eliminate any data memory page switching. Redefine data variables to reallocate them.
4. Verify all writes to STATUS, OPTION, and FSR registers since these have changed.
5. Change reset vector to 0000h.

# PIC16C7X

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## APPENDIX C: WHAT'S NEW

Characterization data charts and graphs have been added for the following devices:

- PIC16C72
- PIC16C73
- PIC16C73A
- PIC16C74
- PIC16C74A

## APPENDIX D: WHAT'S CHANGED

Minor changes, spelling and grammatical changes.

## APPENDIX E: PIC16/17 MICROCONTROLLERS

### E.1 PIC14000 Devices

	Clock	Memory	Peripherals	Features
PIC14000	20	4K	192	20
	Maximum Frequency of Operation (MHz)	EPRM Program Memory (K14 words)	Data Memory (bytes)	Timer Module(s)
				Serial Ports (SPI/I <sup>2</sup> C, USART)
				Slope A/D Converter (high-res) Channels
				Interrupt Sources
				I/O Pins
				Voltage Range (Volts)
				In-Circuit Serial Programming
				Additional Features
				Packages
				Internal Oscillator, Bandgap Reference, Temperature Sensor, Calibration Factors, Low Voltage Detector, SLEEP, HIBERNATE, Comparators with Programmable References (2)
				Yes
				2.7-6.0
				22
				11
				14
				I <sup>2</sup> C/ SMBus
				TMR0 ADTMR
				192
				4K
				20

# PIC16C7X

## E.2 PIC16C5X Family of Devices

Device	Clock		Memory		Peripherals		Features		
	Maximum Frequency of Operation (MHz)	Program Memory (x12 words)	RAM Data Memory (bytes)	Timer Module(s)	I/O Pins	Voltage Range (Volts)	Number of Instructions	Packages	
PIC16C52	4	384	—	25	TMR0	12	2.5-6.25	33	18-pin DIP, SOIC
PIC16C54	20	512	—	25	TMR0	12	2.5-6.25	33	18-pin DIP, SOIC; 20-pin SSOP
PIC16C54A	20	512	—	25	TMR0	12	2.0-6.25	33	18-pin DIP, SOIC; 20-pin SSOP
PIC16CR54A	20	—	512	25	TMR0	12	2.0-6.25	33	18-pin DIP, SOIC; 20-pin SSOP
PIC16C55	20	512	—	24	TMR0	20	2.5-6.25	33	28-pin DIP, SOIC, SSOP
PIC16C56	20	1K	—	25	TMR0	12	2.5-6.25	33	18-pin DIP, SOIC; 20-pin SSOP
PIC16C57	20	2K	—	72	TMR0	20	2.5-6.25	33	28-pin DIP, SOIC, SSOP
PIC16CR57B	20	—	2K	72	TMR0	20	2.5-6.25	33	28-pin DIP, SOIC, SSOP
PIC16C58A	20	2K	—	73	TMR0	12	2.0-6.25	33	18-pin DIP, SOIC; 20-pin SSOP
PIC16CR58A	20	—	2K	73	TMR0	12	2.5-6.25	33	18-pin DIP, SOIC; 20-pin SSOP

All PIC16/17 Family devices have Power-On Reset, selectable Watchdog Timer, selectable code protect and high I/O current capability.

## E.3 PIC16CXXX Family of Devices

Device	Clock		Memory			Peripherals			Features		
	Maximum Frequency of Operation (MHz)	Program Memory (K14 words)	Data Memory (bytes)	Timer Module(s)	Comparators	Internal Reference Voltage	Interrupt Sources	I/O Pins	Voltage Range (Volts)	Brown-out Reset	Packages
PIC16C554	20	512	80	TMR0	—	3	13	2.5-6.0	—	—	18-pin DIP; SOIC; 20-pin SSOP
PIC16C556	20	1K	80	TMR0	—	3	13	2.5-6.0	—	—	18-pin DIP; SOIC; 20-pin SSOP
PIC16C558	20	2K	128	TMR0	—	3	13	2.5-6.0	—	—	18-pin DIP; SOIC; 20-pin SSOP
PIC16C620	20	512	80	TMR0	2	Yes	4	2.5-6.0	Yes	Yes	18-pin DIP; SOIC; 20-pin SSOP
PIC16C621	20	1K	80	TMR0	2	Yes	4	2.5-6.0	Yes	Yes	18-pin DIP; SOIC; 20-pin SSOP
PIC16C622	20	2K	128	TMR0	2	Yes	4	2.5-6.0	Yes	Yes	18-pin DIP; SOIC; 20-pin SSOP

All PIC16/17 Family devices have Power-on Reset, selectable Watchdog Timer, selectable code protect and high I/O current capability.

All PIC16C6XXX Family devices use serial programming with clock pin RB6 and data pin RB7.

# PIC16C7X

## E.4 PIC16C6X Family of Devices

Device	Clock			Memory			Peripherals				Features		
	Maximum Frequency of Operation (MHz)	Program Memory (K x 14 words)	Data Memory (bytes)	Timer Module(s)	Capture/Compare/PWM Module(s)	Serial Ports (SPI/I <sup>2</sup> C, USART)	Parallel Slave Port	I/O Pins	Voltage Range (Volts)	In-Circuit Serial Programming	Brown-out Reset	Packages	
PIC16C62	20	2K	—	128	TMR0, TMR1, TMR2	1 SPI/I <sup>2</sup> C	—	7	22	3.0-6.0	Yes	—	28-pin SDIP, SOIC, SSOP
PIC16C62A <sup>(1)</sup>	20	2K	—	128	TMR0, TMR1, TMR2	1 SPI/I <sup>2</sup> C	—	7	22	2.5-6.0	Yes	Yes	28-pin SDIP, SOIC, SSOP
PIC16CR62 <sup>(1)</sup>	20	—	2K	128	TMR0, TMR1, TMR2	1 SPI/I <sup>2</sup> C	—	7	22	2.5-6.0	Yes	Yes	28-pin SDIP, SOIC, SSOP
PIC16C63	20	4K	—	192	TMR0, TMR1, TMR2	2 SPI/I <sup>2</sup> C, USART	—	10	22	2.5-6.0	Yes	Yes	28-pin SDIP, SOIC
PIC16CR63 <sup>(1)</sup>	20	—	4K	192	TMR0, TMR1, TMR2	2 SPI/I <sup>2</sup> C, USART	—	10	22	2.5-6.0	Yes	Yes	28-pin SDIP, SOIC
PIC16C64	20	2K	—	128	TMR0, TMR1, TMR2	1 SPI/I <sup>2</sup> C	Yes	8	33	3.0-6.0	Yes	—	40-pin DIP; 44-pin PLCC, MQFP
PIC16C64A <sup>(1)</sup>	20	2K	—	128	TMR0, TMR1, TMR2	1 SPI/I <sup>2</sup> C	Yes	8	33	2.5-6.0	Yes	Yes	40-pin DIP; 44-pin PLCC, MQFP, TQFP
PIC16CR64 <sup>(1)</sup>	20	—	2K	128	TMR0, TMR1, TMR2	1 SPI/I <sup>2</sup> C	Yes	8	33	2.5-6.0	Yes	Yes	40-pin DIP; 44-pin PLCC, MQFP, TQFP
PIC16C65	20	4K	—	192	TMR0, TMR1, TMR2	2 SPI/I <sup>2</sup> C, USART	Yes	11	33	3.0-6.0	Yes	—	40-pin DIP; 44-pin PLCC, MQFP
PIC16C65A <sup>(1)</sup>	20	4K	—	192	TMR0, TMR1, TMR2	2 SPI/I <sup>2</sup> C, USART	Yes	11	33	2.5-6.0	Yes	Yes	40-pin DIP; 44-pin PLCC, MQFP, TQFP
PIC16CR65 <sup>(1)</sup>	20	—	4K	192	TMR0, TMR1, TMR2	2 SPI/I <sup>2</sup> C, USART	Yes	11	33	2.5-6.0	Yes	Yes	40-pin DIP; 44-pin PLCC, MQFP, TQFP

All PIC16/17 family devices have Power-on Reset, selectable Watchdog Timer, selectable code protect, and high I/O current capability.

All PIC16C6X family devices use serial programming with clock pin RB6 and data pin RB7.

Note 1: Please contact your local sales office for availability of these devices.



## E.5 PIC16C7X Family of Devices

Device	Clock		Memory		Peripherals				Features			
	Maximum Frequency of Operation (MHz)	EPROM Program Memory (K x 4 words)	Data Memory (bytes)	Timer Modules(s)	Serial Ports (SPI/I <sup>2</sup> C, USART)	A/D Converter (8-bit) Channels	Interrupt Sources	I/O Pins	Voltage Range (Volts)	In-Circuit Serial Programming	Brown-out Reset	Packages
PIC16C710	20	512	36	TMR0	—	—	4	4	13	3.0-6.0	Yes	18-pin DIP, SOIC; 20-pin SSOP
PIC16C71	20	1K	36	TMR0	—	—	4	4	13	3.0-6.0	Yes	18-pin DIP, SOIC
PIC16C711	20	1K	68	TMR0	—	—	4	4	13	3.0-6.0	Yes	18-pin DIP, SOIC; 20-pin SSOP
PIC16C72	20	2K	128	TMR0, TMR1, TMR2	1	SPI/I <sup>2</sup> C	—	5	8	2.5-6.0	Yes	28-pin SDIP, SOIC, SSOP
PIC16C73	20	4K	192	TMR0, TMR1, TMR2	2	SPI/I <sup>2</sup> C, USART	—	5	11	3.0-6.0	Yes	28-pin SDIP, SOIC
PIC16C73A <sup>(1)</sup>	20	4K	192	TMR0, TMR1, TMR2	2	SPI/I <sup>2</sup> C, USART	—	5	11	2.5-6.0	Yes	28-pin SDIP, SOIC
PIC16C74	20	4K	192	TMR0, TMR1, TMR2	2	SPI/I <sup>2</sup> C, USART	Yes	8	12	3.0-6.0	Yes	40-pin DIP; 44-pin PLCC, MQFP
PIC16C74A <sup>(1)</sup>	20	4K	192	TMR0, TMR1, TMR2	2	SPI/I <sup>2</sup> C, USART	Yes	8	12	2.5-6.0	Yes	40-pin DIP; 44-pin PLCC, MQFP, TQFP

All PIC16/17 Family devices have Power-on Reset, selectable Watchdog Timer, selectable code protect and high I/O current capability.

All PIC16C7X Family devices use serial programming with clock pin RB6 and data pin RB7.

Note 1: Please contact your local sales office for availability of these devices.

# PIC16C7X

## E.6 PIC16C8X Family of Devices

Device	Clock		Memory			Peripherals		Features			
	Maximum Frequency of Operation (MHz)	Program Memory	Data Memory (bytes)	Data EEPROM (bytes)	Timer Modules	Interrupt Sources	I/O Pins				
PIC16C84	10	—	1K	—	36	64	TMR0	4	13	2.0-6.0	18-pin DIP, SOIC
PIC16F84 <sup>(1)</sup>	10	1K	—	—	68	64	TMR0	4	13	2.0-6.0	18-pin DIP, SOIC
PIC16CR84 <sup>(1)</sup>	10	—	—	1K	68	64	TMR0	4	13	2.0-6.0	18-pin DIP, SOIC
PIC16F83 <sup>(1)</sup>	10	512	—	—	36	64	TMR0	4	13	2.0-6.0	18-pin DIP, SOIC
PIC16CR83 <sup>(1)</sup>	10	—	—	512	36	64	TMR0	4	13	2.0-6.0	18-pin DIP, SOIC

All PIC16/17 family devices have Power-on Reset, selectable Watchdog Timer, selectable code protect, and high I/O current capability.

All PIC16C8X family devices use serial programming with clock pin RB6 and data pin RB7.

Note 1: Please contact your local sales office for availability of these devices.

## E.7 PIC16C9XX Family Of Devices

Device	Clock		Memory		Peripherals					Features					
	Maximum Frequency of Operation (MHz)	Program Memory (Kbytes)	Data Memory (bytes)	Timer Module(s)	EPRAM	Serial Port(s) (SPI/I <sup>2</sup> C, USART)	Parallel Slave Port	A/D Converter (8-bit) Channels	Interrupt Sources	I/O Pins	Input Pins	Voltage Range (Volts)	In-Circuit Serial Programming	Brown-out Reset	Packages
PIC16C923	8	4K	176	TMR0, TMR1, TMR2	1	SPI/I <sup>2</sup> C	—	4 Com 32 Seg	8	25	27	3.0-6.0	Yes	—	64-pin SDIP(1), TQFP, 68-pin PLCC, DIE
PIC16C924	8	4K	176	TMR0, TMR1, TMR2	1	SPI/I <sup>2</sup> C	—	5	4 Com 32 Seg	9	25	3.0-6.0	Yes	—	64-pin SDIP(1), TQFP, 68-pin PLCC, DIE

All PIC16/17 Family devices have Power-on Reset, selectable Watchdog Timer, selectable code protect and high I/O current capability.

All PIC16CXX Family devices use serial programming with clock pin RB6 and data pin RB7.

Note 1: Please contact your local Microchip representative for availability of this package.

# PIC16C7X

## E.8 PIC17CXX Family of Devices

Device	Clock			Memory			Peripherals					Features		
	Maximum Frequency of Operation (MHz)	Program Memory (Words)	RAM Data Memory (bytes)	Timer Module(s)	Captures/PWMs	Serial Port(s) (USART)	Hardware Multiply	External Interrupts	Interrupt Sources	I/O Pins	Voltage Range (Volts)	Number of Instructions	Packages	
PIC17C42	25	2K	—	232	2	2	Yes	—	Yes	11	33	4.5-5.5	55	40-pin DIP; 44-pin PLCC, MQFP
PIC17C42A	25	2K	—	232	2	2	Yes	Yes	Yes	11	33	2.5-6.0	58	40-pin DIP; 44-pin PLCC, TQFP, MQFP
PIC17CR42	25	—	2K	232	2	2	Yes	Yes	Yes	11	33	2.5-6.0	58	40-pin DIP; 44-pin PLCC, TQFP, MQFP
PIC17C43	25	4K	—	454	2	2	Yes	Yes	Yes	11	33	2.5-6.0	58	40-pin DIP; 44-pin PLCC, TQFP, MQFP
PIC17CR43	25	—	4K	454	2	2	Yes	Yes	Yes	11	33	2.5-6.0	58	40-pin DIP; 44-pin PLCC, TQFP, MQFP
PIC17C44	25	8K	—	454	2	2	Yes	Yes	Yes	11	33	2.5-6.0	58	40-pin DIP; 44-pin PLCC, TQFP, MQFP

All PIC16/17 Family devices have Power-on Reset, selectable Watchdog Timer, selectable code protect and high I/O current capability.

## PIN COMPATIBILITY

Devices that have the same package type and VDD, VSS and MCLR pin locations are said to be pin compatible. This allows these different devices to operate in the same socket. Compatible devices may only require minor software modification to allow proper operation in the application socket (ex., PIC16C56 and PIC16C61 devices). Not all devices in the same package size are pin compatible; for example, the PIC16C62 is compatible with the PIC16C63, but not the PIC16C55.

Pin compatibility does not mean that the devices offer the same features. As an example, the PIC16C54 is pin compatible with the PIC16C71, but does not have an A/D converter, weak pull-ups on PORTB, or interrupts.

**TABLE E-1: PIN COMPATIBLE DEVICES**

Pin Compatible Devices	Package
PIC12C508, PIC12C509	8-pin
PIC16C54, PIC16C54A, PIC16CR54A, PIC16C56, PIC16C58A, PIC16CR58A, PIC16C61, PIC16C554, PIC16C556, PIC16C558 PIC16C620, PIC16C621, PIC16C622, PIC16C710, PIC16C71, PIC16C711, PIC16F83, PIC16CR83, PIC16C84, PIC16F84A, PIC16CR84	18-pin 20-pin
PIC16C55, PIC16C57, PIC16CR57B	28-pin
PIC16C62, PIC16CR62, PIC16C62A, PIC16C63, PIC16C72, PIC16C73, PIC16C73A	28-pin
PIC16C64, PIC16CR64, PIC16C64A, PIC16C65, PIC16C65A, PIC16C74, PIC16C74A	40-pin
PIC17C42, PIC17CR42, PIC17C42A, PIC17C43, PIC17CR43, PIC17C44	40-pin
PIC16C923, PIC16C924	64/68-pin

# PIC16C7X

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PART NO.	-XX	X	/XX	XXX		Examples
					<b>Pattern:</b>	QTP, SQTP, Code or Special Requirements
					<b>Package:</b>	JW = Windowed CERDIP PQ = MQFP (Metric PQFP) TQ = TQFP (Thin Quad Flatpack) SO = SOIC SP = Skinny plastic dip P = PDIP L = PLCC SS = SSOP
					<b>Temperature Range:</b>	- = 0°C to +70°C I = -40°C to +85°C E = -40°C to +125°C
					<b>Frequency Range:</b>	04 = 200 kHz (PIC16C7X-04) 04 = 4 MHz 10 = 10 MHz 20 = 20 MHz
					<b>Device</b>	PIC16C7X :V <sub>DD</sub> range 4.0V to 6.0V PIC16C7XT :V <sub>DD</sub> range 4.0V to 6.0V (Tape/Reel) PIC16LC7X :V <sub>DD</sub> range 2.5V to 6.0V PIC16LC7XT :V <sub>DD</sub> range 2.5V to 6.0V (Tape/Reel)
						a) PIC16C71 - 04/P 301 Commercial Temp., PDIP Package, 4 MHz, normal V <sub>DD</sub> limits, QTP pattern #301  b) PIC16LC73 - 041/SO Industrial Temp., SOIC package, 4 MHz, extended V <sub>DD</sub> limits  c) PIC16C74A - 10E/P Automotive Temp., PDIP package, 10 MHz, normal V <sub>DD</sub> limits

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