

8-Bit CMOS Microcontrollers with A/D Converter

Devices included in this data sheet:

- PIC16C70
- PIC16C71
- PIC16C71A
- 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: 3.0V to 6.0V
- High Sink/Source Current 25/25 mA
- Commercial, Industrial and Automotive Temperature Range
- Low-power consumption:
 - < 2 mA @ 5V, 4 MHz
 - 15 μ A typical @ 3V, 32 kHz
 - < 1 μ 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 I²C™
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI)
- Parallel Slave Port (PSP) 8-bit wide, with external \overline{RD} , \overline{WR} and \overline{CS} controls
- Brown-out detection circuitry for Brown-out Reset (BOR)

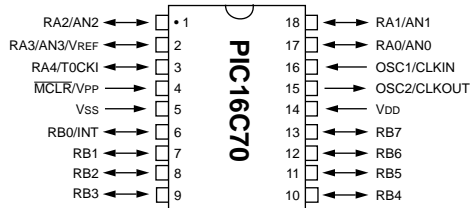
PIC16C7X Features	70	71	71A	72	73	73A	74	74A
Program Memory (EPROM)	512	1K	1K	2K	4K	4K	4K	4K
Data Memory (Bytes)	36	36	68	128	192	192	192	192
I/O Pins	13	13	13	22	22	22	33	33
Parallel Slave Port	—	—	—	—	—	—	Yes	Yes
Capture/Compare/PWM Modules	—	—	—	1	2	2	2	2
Timer Modules	1	1	1	3	3	3	3	3
A/D Channels	4	4	4	5	5	5	8	8
Serial Communication	—	—	—	SPI/I ² C	SPI/I ² C, USART	SPI/I ² C, USART	SPI/I ² C, USART	SPI/I ² 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

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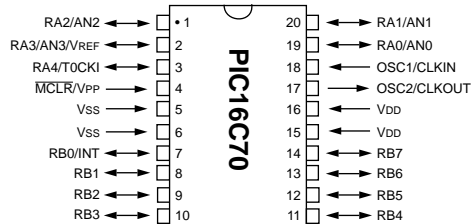
PIC16C7X

Pin Diagrams

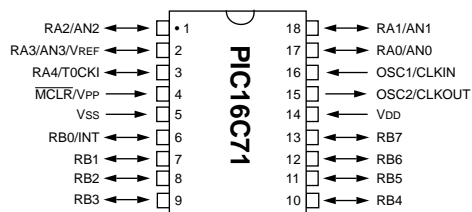
PDIP, SOIC, Windowed Cerdip



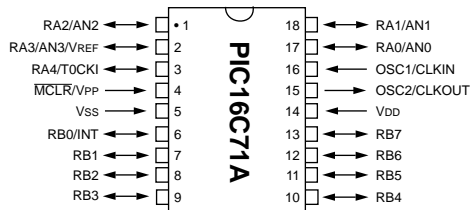
SSOP



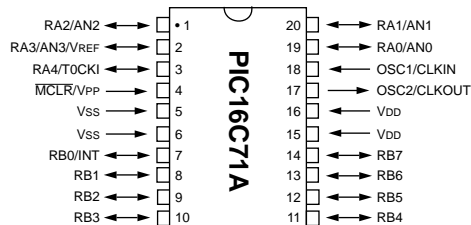
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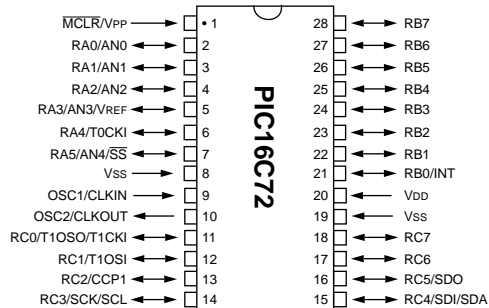
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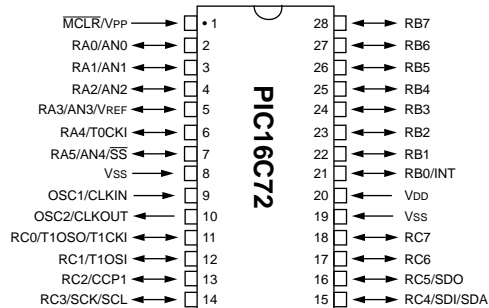
SSOP



SDIP, SOIC, Windowed Side Brazed Ceramic

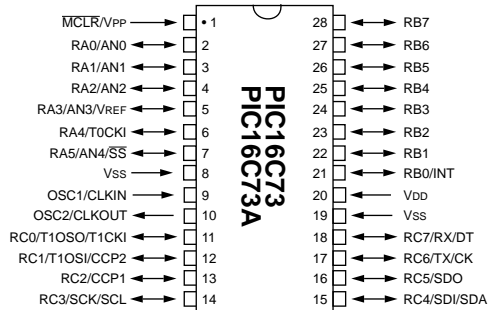


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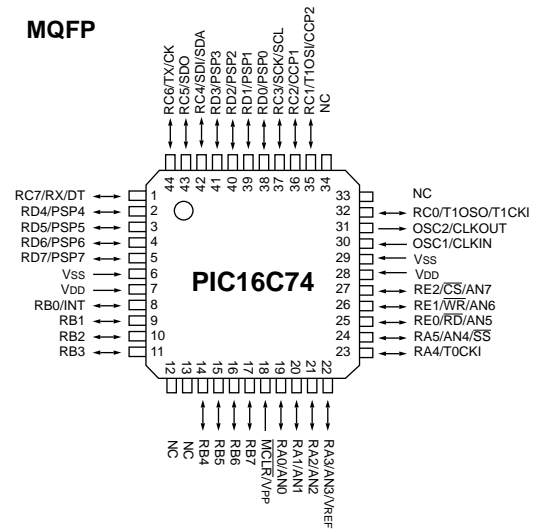


Pin Diagrams (Cont.'d)

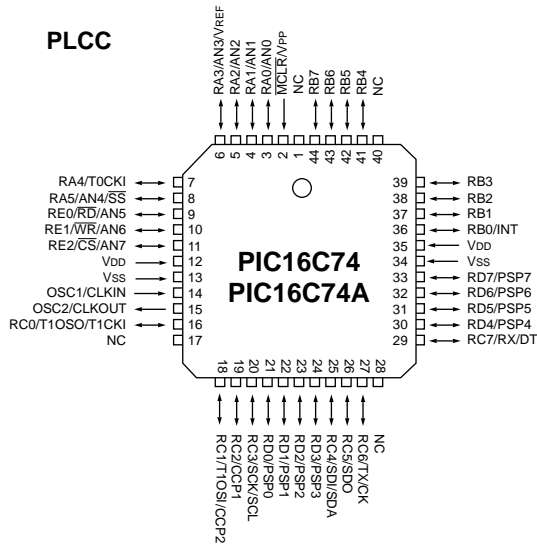
SDIP, SOIC, Windowed Side Brazed Ceramic



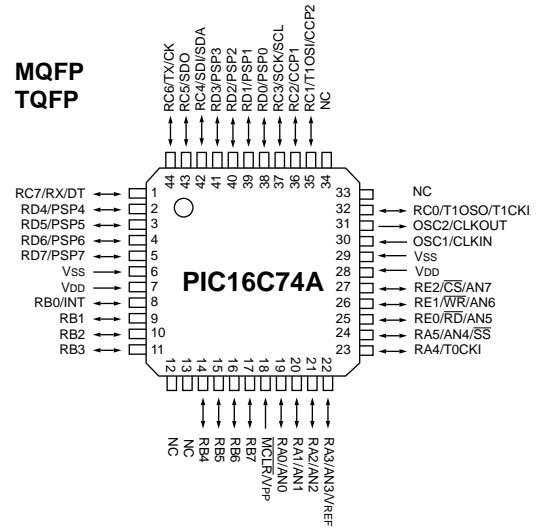
MQFP



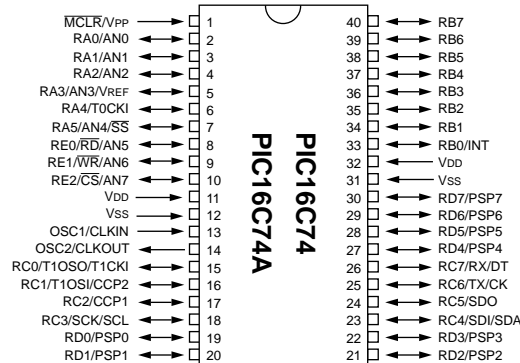
PLCC



**MQFP
TQFP**



PDIP, Windowed Cerdip



PIC16C7X

Table of Contents

1.0	General Description	5
2.0	PIC16C7X Device Varieties	7
3.0	Architectural Overview	9
4.0	Memory Organization	21
5.0	I/O Ports	43
6.0	Overview of Timer Modules	57
7.0	Timer0 Module	59
8.0	Timer1 Module	65
9.0	Timer2 Module	69
10.0	Capture/Compare/PWM Module(s)	71
11.0	Synchronous Serial Port (SSP) Module	77
12.0	Universal Synchronous Asynchronous Receiver Transmitter (USART)	93
13.0	Analog-to-Digital Converter (A/D) Module	109
14.0	Special Features of the CPU	121
15.0	Instruction Set Summary	141
16.0	Development Support	153
17.0	Electrical Characteristics for PIC16C70 and PIC16C71A	159
18.0	DC and AC Characteristics Graphs and Tables for PIC16C70 and PIC16C71A	173
19.0	Electrical Characteristics for PIC16C71	175
20.0	DC and AC Characteristics Graphs and Tables for PIC16C71	189
21.0	Electrical Characteristics for PIC16C72	197
22.0	DC and AC Characteristics Graphs and Tables for PIC16C72	217
23.0	Electrical Characteristics for PIC16C73/74	219
24.0	DC and AC Characteristics Graphs and Tables for PIC16C73/74	241
25.0	Electrical Characteristics for PIC16C73A/74A	243
26.0	DC and AC Characteristics Graphs and Tables for PIC16C73A/74A	265
27.0	Packaging Information	267
Appendix A:	283
Appendix B: Compatibility		283
Appendix C: What's New		284
Appendix D: What's Changed		284
Appendix E: PIC16/17 Microcontrollers		285
Index		293
Connecting to Microchip BBS		303
Reader Response		304
Product Information System		305

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 PIC16C71A, PIC16C72, PIC16C73A and PIC16C74A devices.

Applicable Devices							
70	71	71A	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 **PIC16C70/71** devices have 36 bytes of RAM, and the **PIC16C71A** has 68 bytes of RAM. The **PIC16C70/71/71A** 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 (I²C) 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 (I²C) 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 (I²C) 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 reset(s).

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

	Clock			Memory		Peripherals					Features		
	Maximum Frequency of Operation (MHz)	Program Memory (Kbytes)	EPROM	Data Memory (bytes)	Timer Module(s)	Serial Ports (SPI/I ² C, USART)	Parallel Slave Port	AD Converter (8-bit) Channels	Interrupt Sources	I/O Pins	Voltage Range (Volts)	In-Circuit Serial Programming	Packages
PIC16C70 ⁽¹⁾	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
PIC16C71A ⁽¹⁾	20	1K	68	TMR0	—	—	4	4	13	3.0-6.0	Yes	Yes	18-pin DIP, SOIC; 20-pin SSOP
PIC16C72 ⁽¹⁾	20	2K	128	TMR0, TMR1, TMR2	1 SPI/I ² C	—	5	8	22	3.0-6.0	Yes	Yes	28-pin SDIP, SOIC, SSOP
PIC16C73	20	4K	192	TMR0, TMR1, TMR2	2 SPI/I ² C, USART	—	5	11	22	3.0-6.0	Yes	—	28-pin SDIP, SOIC
PIC16C73A ⁽¹⁾	20	4K	192	TMR0, TMR1, TMR2	2 SPI/I ² C, USART	—	5	11	22	3.0-6.0	Yes	Yes	28-pin SDIP, SOIC
PIC16C74	20	4K	192	TMR0, TMR1, TMR2	2 SPI/I ² C, USART	Yes	8	12	33	3.0-6.0	Yes	—	40-pin DIP; 44-pin PLCC, MQFP
PIC16C74A ⁽¹⁾	20	4K	192	TMR0, TMR1, TMR2	2 SPI/I ² C, USART	Yes	8	12	33	3.0-6.0	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 PIC16CXX 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 Selection 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™ and PRO MATE™ 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 (SQTPSM) 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

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 where 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
PIC16C70	512 x 14	36 x 8
PIC16C71	1K x 14	36 x 8
PIC16C71A	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: PIC16C70/71/71A BLOCK DIAGRAM

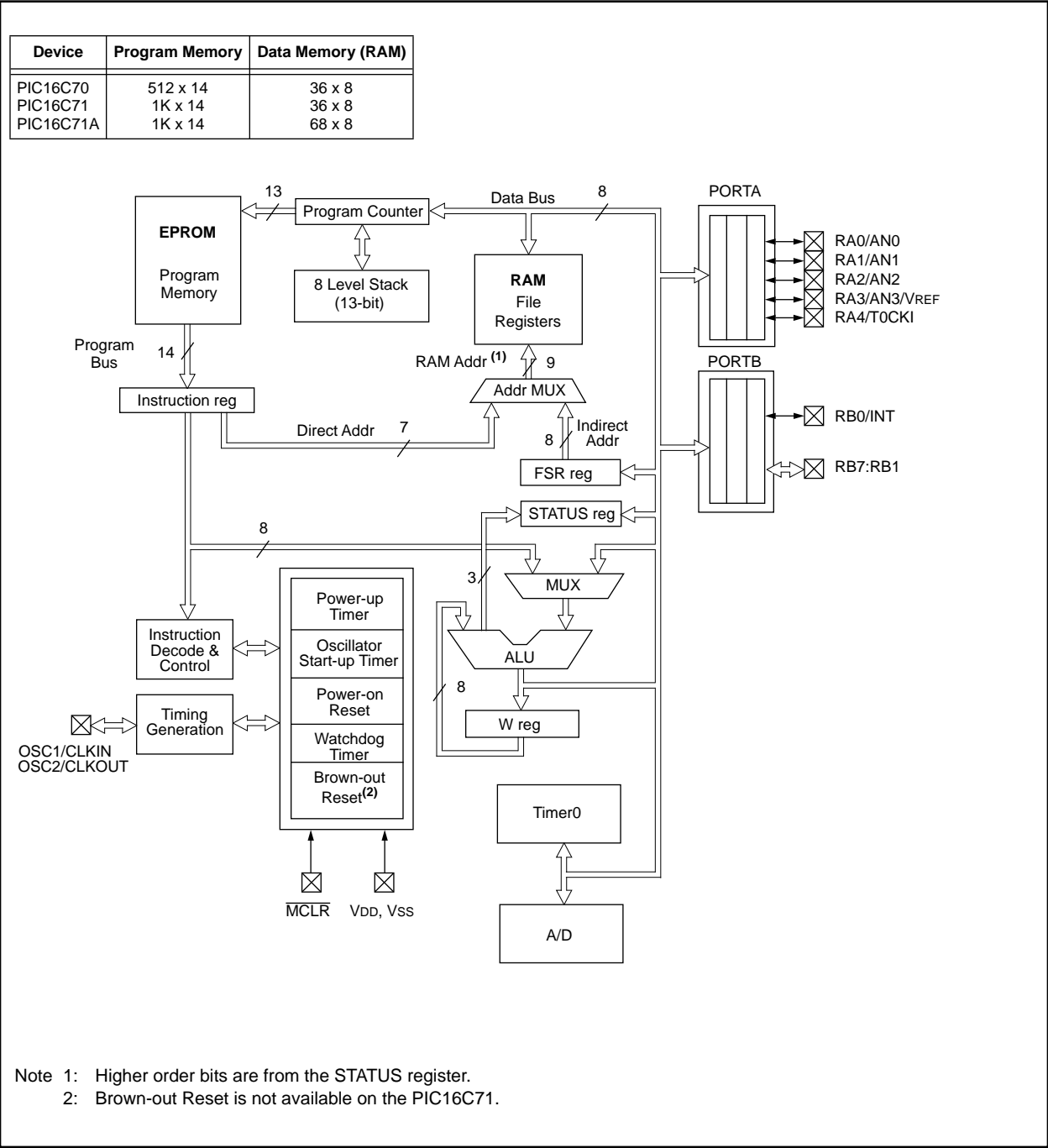
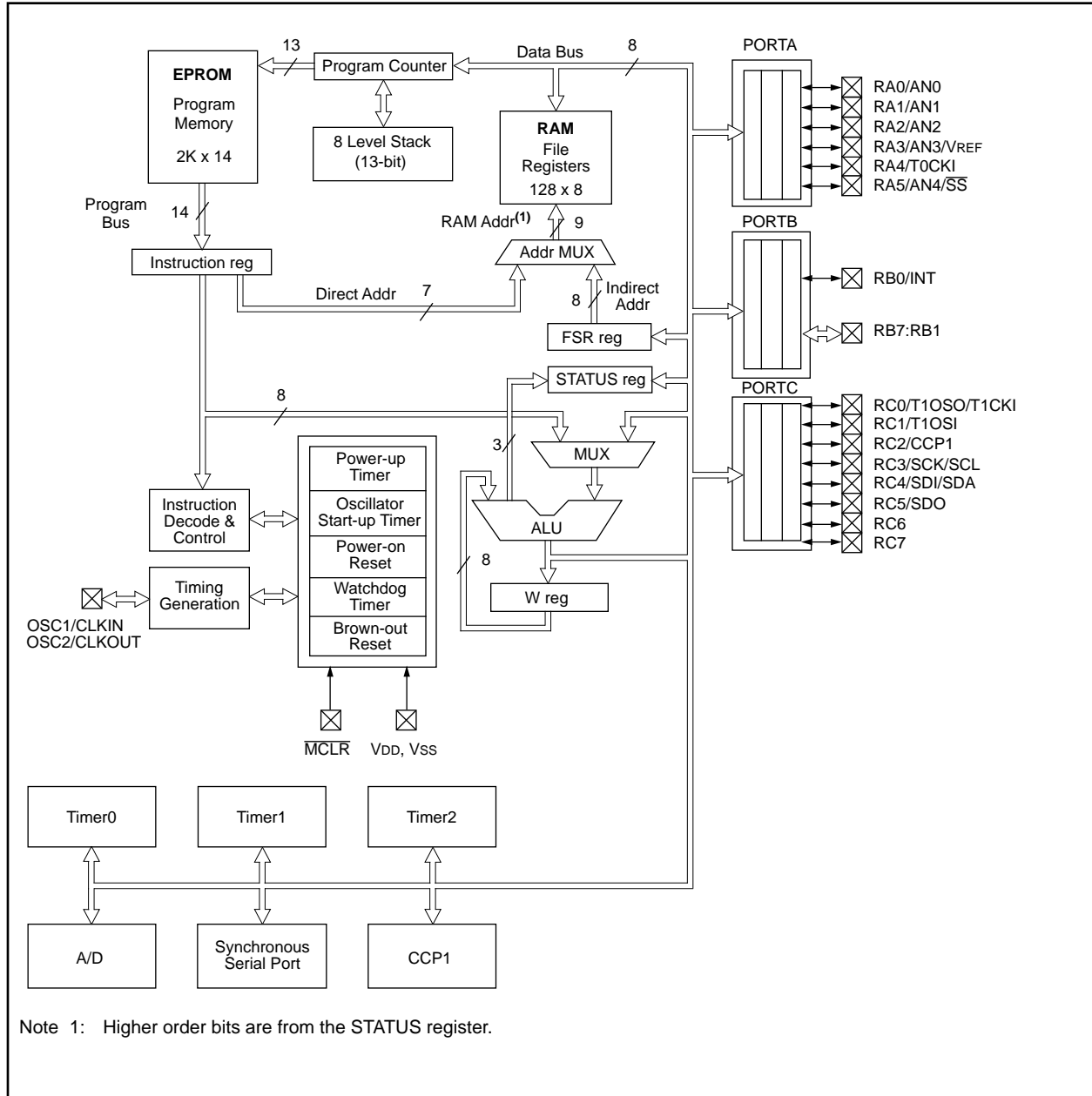


FIGURE 3-2: PIC16C72 BLOCK DIAGRAM



PIC16C7X

FIGURE 3-3: PIC16C73/73A BLOCK DIAGRAM

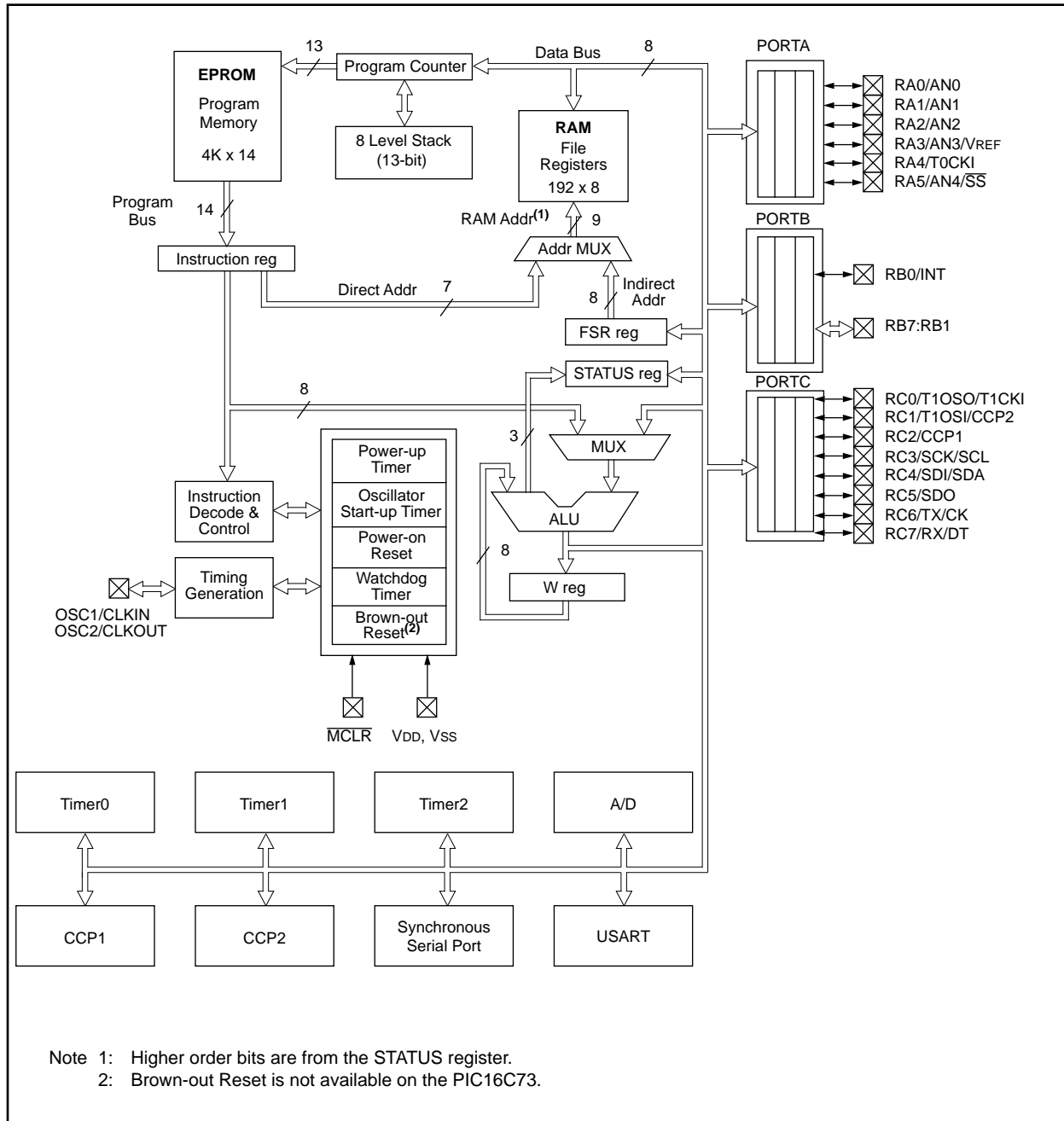
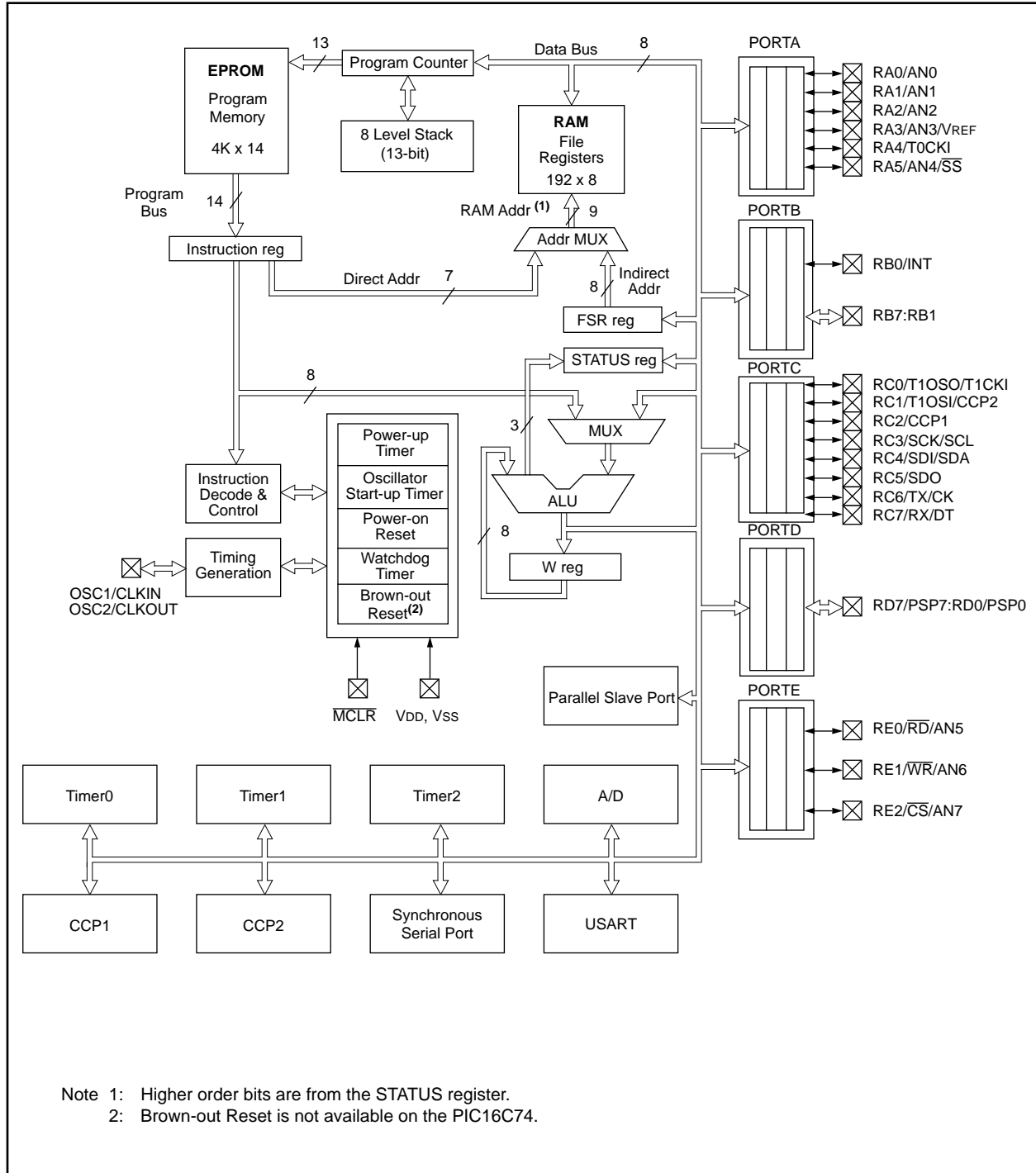


FIGURE 3-4: PIC16C74/74A BLOCK DIAGRAM



PIC16C7X

TABLE 3-1: PIC16C70/71A 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 ⁽³⁾	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 ⁽¹⁾	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 ⁽²⁾	
RB7	13	14	13	I/O	TTL/ST ⁽²⁾	
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 ⁽³⁾	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/V _{REF} 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/V _{REF}	2	2	I/O	TTL	
RA4/T0CKI	3	3	I/O	ST	
RB0/INT	6	6	I/O	TTL/ST ⁽¹⁾	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 ⁽²⁾	
RB7	13	13	I/O	TTL/ST ⁽²⁾	
V _{SS}	5	5	P	—	Ground reference for logic and I/O pins.
V _{DD}	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 ⁽³⁾	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 _{REF} 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 _{REF}	5	5	5	I/O	TTL	
RA4/T0CKI	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 ⁽¹⁾	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 ⁽²⁾	
RB7	28	28	28	I/O	TTL/ST ⁽²⁾	
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/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 ² C modes. RC4/SDI/SDA can also be selected as the SPI Data In (SPI mode) or data I/O (I ² 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	
V _{SS}	8, 19	8, 19	8, 19	P	—	Ground reference for logic and I/O pins.
V _{DD}	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 ⁽³⁾	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/SS	7	7	I/O	TTL	
RB0/INT	21	21	I/O	TTL/ST ⁽¹⁾	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 ⁽²⁾	
RB7	28	28	I/O	TTL/ST ⁽²⁾	
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 ² C modes. RC4/SDI/SDA can also be selected as the SPI Data In (SPI mode) or data I/O (I ² 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.

PIC16C7X

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 ⁽⁴⁾	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 ⁽¹⁾	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 ⁽²⁾	
RB7	40	44	17	I/O	TTL/ST ⁽²⁾	

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 I²C modes.</p> <p>RC4/SDI/SDA can also be selected as the SPI Data In (SPI mode) or data I/O (I²C 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 ⁽³⁾	<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 ⁽³⁾	
RD2/PSP2	21	23	40	I/O	ST/TTL ⁽³⁾	
RD3/PSP3	22	24	41	I/O	ST/TTL ⁽³⁾	
RD4/PSP4	27	30	2	I/O	ST/TTL ⁽³⁾	
RD5/PSP5	28	31	3	I/O	ST/TTL ⁽³⁾	
RD6/PSP6	29	32	4	I/O	ST/TTL ⁽³⁾	
RD7/PSP7	30	33	5	I/O	ST/TTL ⁽³⁾	
RE0/RD/AN5	8	9	25	I/O	ST/TTL ⁽³⁾	<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 ⁽³⁾	
RE2/CS/AN7	10	11	27	I/O	ST/TTL ⁽³⁾	
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.

PIC16C7X

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.

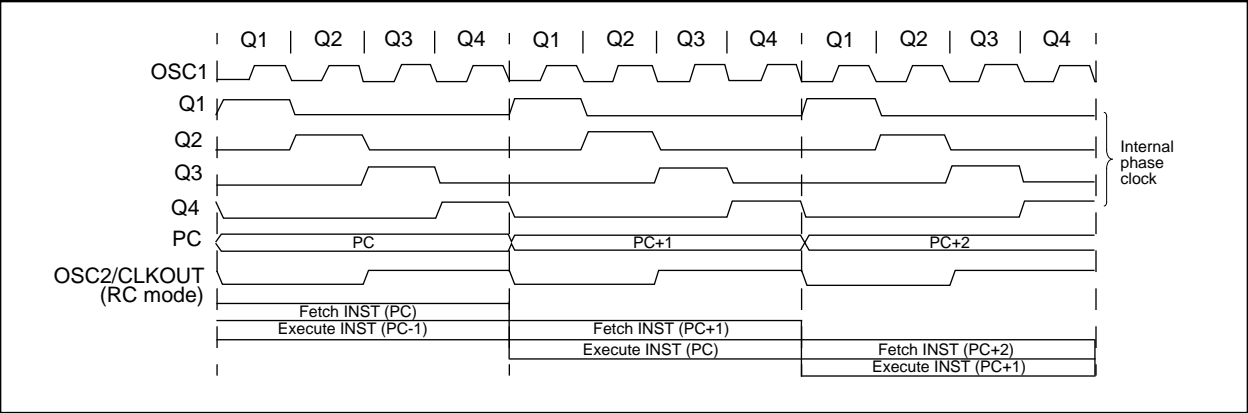
3.2 Instruction Flow/Pipelining

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).

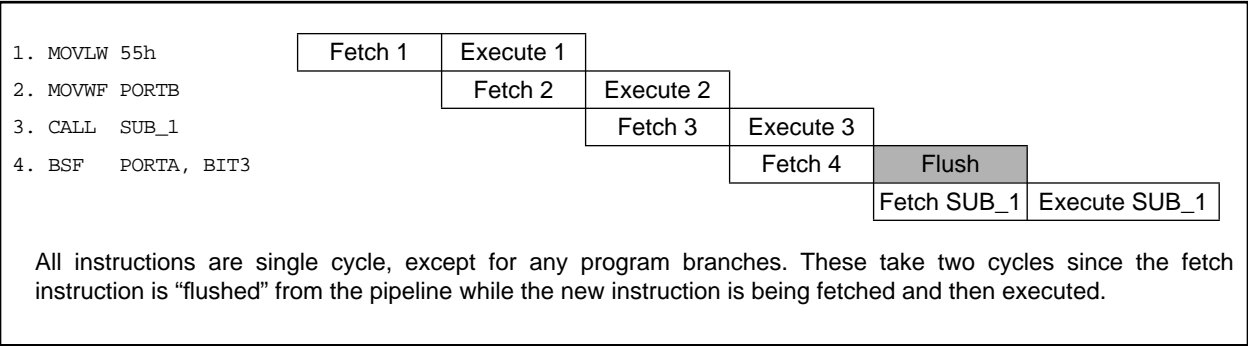
A fetch cycle begins with the program counter (PC) incrementing in Q1.

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



All instructions are single cycle, except for any program branches. These take two cycles since the fetch instruction is "flushed" from the pipeline while the new instruction is being fetched and then executed.

4.0 MEMORY ORGANIZATION

Applicable Devices

70	71	71A	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 PIC16C70, only the first 512 x 14 (0000h-01FFh) is physically implemented. For the PIC16C71/71A only the first 1K x 14 (0000h-03FFh) is implemented. For the PIC16C72, only the first 2K x 14 (0000h-07FF) 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: PIC16C70 PROGRAM MEMORY MAP AND STACK

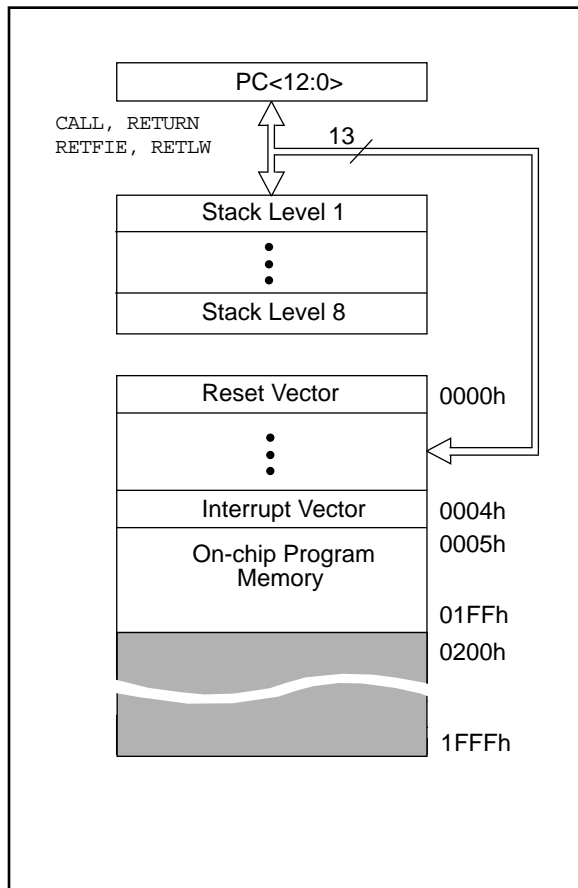
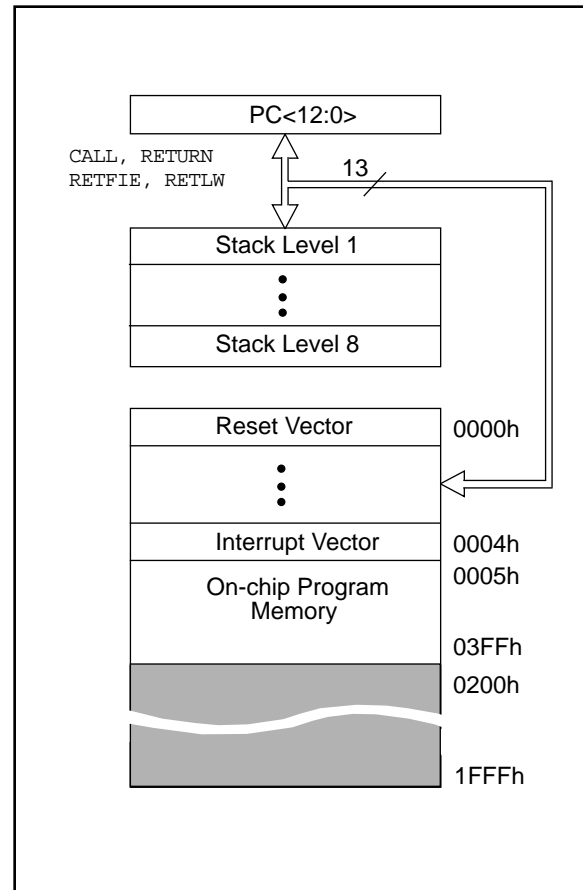


FIGURE 4-2: PIC16C71/71A PROGRAM MEMORY MAP AND STACK



PIC16C7X

FIGURE 4-3: PIC16C72 PROGRAM MEMORY MAP AND STACK

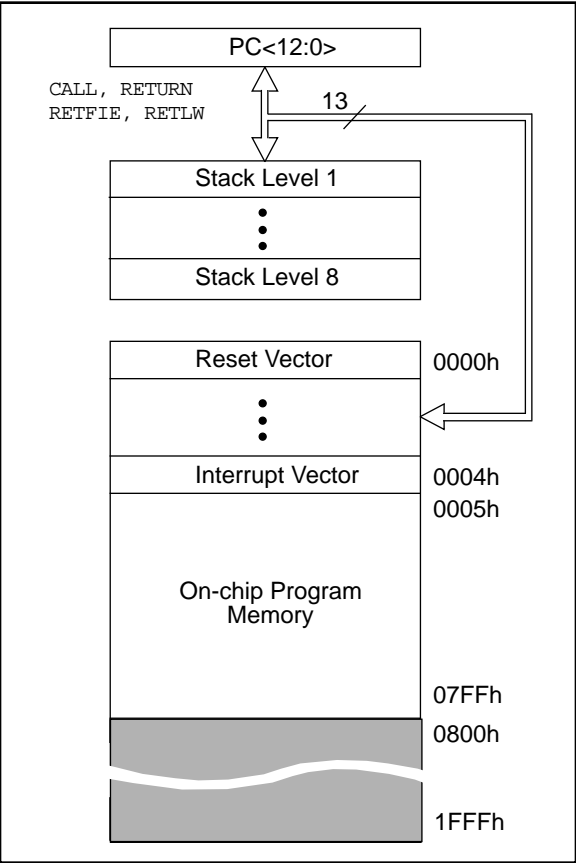
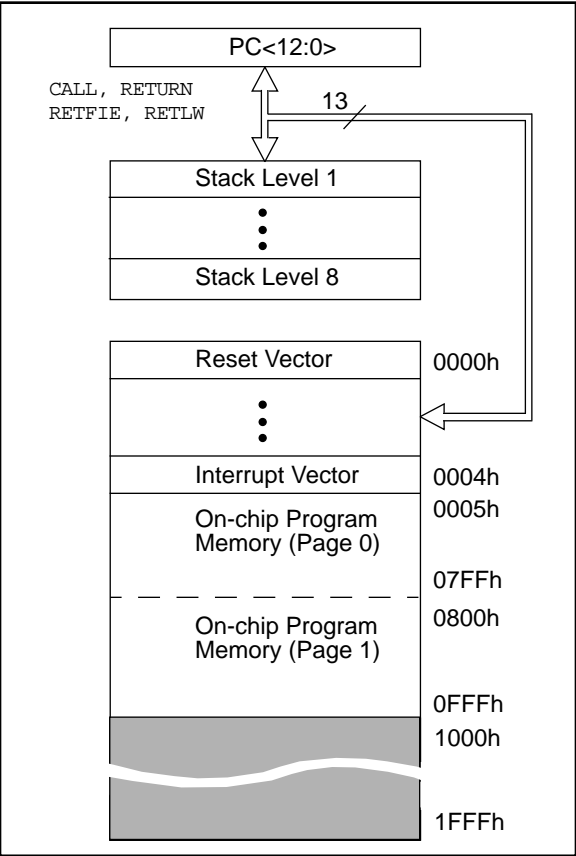


FIGURE 4-4: PIC16C73/73A/74/74A PROGRAM MEMORY MAP AND STACK



4.2 Data Memory Organization

Applicable Devices							
70	71	71A	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).

PIC16C7X

FIGURE 4-7: PIC16C72 REGISTER FILE MAP


File Address			File Address
00h	INDF ⁽¹⁾	INDF ⁽¹⁾	80h
01h	TMR0	OPTION	81h
02h	PCL	PCL	82h
03h	STATUS	STATUS	83h
04h	FSR	FSR	84h
05h	PORTA	TRISA	85h
06h	PORTB	TRISB	86h
07h	PORTC	TRISC	87h
08h			88h
09h			89h
0Ah	PCLATH	PCLATH	8Ah
0Bh	INTCON	INTCON	8Bh
0Ch	PIR1	PIE1	8Ch
0Dh			8Dh
0Eh	TMR1L	PCON	8Eh
0Fh	TMR1H		8Fh
10h	T1CON		90h
11h	TMR2		91h
12h	T2CON	PR2	92h
13h	SSPBUF	SSPADD	93h
14h	SSPCON	SSPSTAT	94h
15h	CCPR1L		95h
16h	CCPR1H		96h
17h	CCP1CON		97h
18h			98h
19h			99h
1Ah			9Ah
1Bh			9Bh
1Ch			9Ch
1Dh			9Dh
1Eh	ADRES		9Eh
1Fh	ADCON0	ADCON1	9Fh
20h	General Purpose Register	General Purpose Register	A0h
			BFh
			C0h
7Fh	Bank 0	Bank 1	FFh

 Unimplemented data memory locations, read as '0'.

Note 1: Not a physical register.

FIGURE 4-8: PIC16C73/73A/74/74A REGISTER FILE MAP

File Address	REGISTER FILE		File Address
00h	INDF ⁽¹⁾	INDF ⁽¹⁾	80h
01h	TMR0	OPTION	81h
02h	PCL	PCL	82h
03h	STATUS	STATUS	83h
04h	FSR	FSR	84h
05h	PORTA	TRISA	85h
06h	PORTB	TRISB	86h
07h	PORTC	TRISC	87h
08h	PORTD ⁽²⁾	TRISD ⁽²⁾	88h
09h	PORTE ⁽²⁾	TRISE ⁽²⁾	89h
0Ah	PCLATH	PCLATH	8Ah
0Bh	INTCON	INTCON	8Bh
0Ch	PIR1	PIE1	8Ch
0Dh	PIR2	PIE2	8Dh
0Eh	TMR1L	PCON	8Eh
0Fh	TMR1H		8Fh
10h	T1CON		90h
11h	TMR2		91h
12h	T2CON	PR2	92h
13h	SSPBUF	SSPADDD	93h
14h	SSPCON	SSPSTAT	94h
15h	CCPR1L		95h
16h	CCPR1H		96h
17h	CCP1CON		97h
18h	RCSTA	TXSTA	98h
19h	TXREG	SPBRG	99h
1Ah	RCREG		9Ah
1Bh	CCPR2L		9Bh
1Ch	CCPR2H		9Ch
1Dh	CCP2CON		9Dh
1Eh	ADRES		9Eh
1Fh	ADCON0	ADCON1	9Fh
20h			A0h
	General Purpose Register	General Purpose Register	
7Fh			FFh
	Bank 0	Bank 1	

 Unimplemented data memory locations, read as '0'.

Note 1: Not a physical register.
 2: These registers are not physically implemented on the PIC16C73/73A, read as '0'.

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: PIC16C70/71/71A 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)
Bank 0											
00h ⁽³⁾	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 ⁽³⁾	PCL	Program Counter's (PC) Least Significant Byte								0000 0000	0000 0000
03h ⁽³⁾	STATUS	IRP ⁽⁵⁾	RP1 ⁽⁵⁾	RP0	\overline{TO}	\overline{PD}	Z	DC	C	0001 1xxx	000q quuu
04h ⁽³⁾	FSR	Indirect data memory address pointer								xxxx xxxx	uuuu uuuu
05h	PORTA	—	—	—	PORTA Data Latch when written: PORTA pins when read					--x xxxx	---u uuuu
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/DONE	ADIF	ADON	00-0 0000	00-0 0000
09h ⁽³⁾	ADRES	A/D Result Register								xxxx xxxx	uuuu uuuu
0Ah ^(2,3)	PCLATH	—	—	—	Write Buffer for the upper 5 bits of the Program Counter					---0 0000	---0 0000
0Bh ⁽³⁾	INTCON	GIE	ADIE	TOIE	INTE	RBIE	TOIF	INTF	RBIF	0000 000x	0000 000u
Bank 1											
80h ⁽³⁾	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 ⁽³⁾	PCL	Program Counter's (PC) Least Significant Byte								0000 0000	0000 0000
83h ⁽³⁾	STATUS	IRP ⁽⁵⁾	RP1 ⁽⁵⁾	RP0	\overline{TO}	\overline{PD}	Z	DC	C	0001 1xxx	000q quuu
84h ⁽³⁾	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 ⁽⁴⁾	PCON	—	—	—	—	—	—	POR	BOR	---- --qq	---- --uu
88h	ADCON1	—	—	—	—	—	—	PCFG1	PCFG0	---- --00	---- --00
89h ⁽³⁾	ADRES	A/D Result Register								xxxx xxxx	uuuu uuuu
8Ah ^(2,3)	PCLATH	—	—	—	Write Buffer for the upper 5 bits of the Program Counter					---0 0000	---0 0000
8Bh ⁽³⁾	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 PIC16C70/71A, this bit is unimplemented, read as '0'.

PIC16C7X

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)
Bank 0											
00h ⁽¹⁾	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 ⁽¹⁾	PCL	Program Counter's (PC) Least Significant Byte								0000 0000	0000 0000
03h ⁽¹⁾	STATUS	IRP ⁽⁴⁾	RP1 ⁽⁴⁾	RP0	T \overline{O}	P \overline{D}	Z	DC	C	0001 1xxx	000q quuu
04h ⁽¹⁾	FSR	Indirect data memory address pointer								xxxx xxxx	uuuu uuuu
05h	PORTA	—	—	PORTA Data Latch when written: PORTA pins when read						--xx xxxx	--uu uuuu
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 ^(1,2)	PCLATH	—	—	—	Write Buffer for the upper 5 bits of the Program Counter					---0 0000	---0 0000
0Bh ⁽¹⁾	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	T1SYN \overline{C}	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)
Bank 1											
80h ⁽¹⁾	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 ⁽¹⁾	PCL	Program Counter's (PC) Least Significant Byte								0000 0000	0000 0000
83h ⁽¹⁾	STATUS	IRP ⁽⁴⁾	RP1 ⁽⁴⁾	RP0	$\bar{T}O$	$\bar{P}D$	Z	DC	C	0001 1xxx	000q quuu
84h ⁽¹⁾	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 ^(1,2)	PCLATH	—	—	—	Write Buffer for the upper 5 bits of the PC					---0 0000	---0 0000
8Bh ⁽¹⁾	INTCON	GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	0000 000x	0000 000u
8Ch	PIE1	—	ADIE	—	—	SSPIE	CCP1IE	TMR2IE	TMR1IE	-0-- 0000	-0-- 0000
8Dh	—	Unimplemented								—	—
8Eh	PCON	—	—	—	—	—	—	POR	BOR	---- --qq	---- --uu
8Fh	—	Unimplemented								—	—
90h	—	Unimplemented								—	—
91h	—	Unimplemented								—	—
92h	PR2	Timer2 Period Register								1111 1111	1111 1111
93h	SSPADD	Synchronous Serial Port (I ² 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 MCLR 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)
Bank 0											
00h ⁽⁴⁾	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 ⁽⁴⁾	PCL	Program Counter's (PC) Least Significant Byte								0000 0000	0000 0000
03h ⁽⁴⁾	STATUS	IRP ⁽⁷⁾	RP1 ⁽⁷⁾	RP0	T \overline{O}	P \overline{D}	Z	DC	C	0001 1xxx	000q quuu
04h ⁽⁴⁾	FSR	Indirect data memory address pointer								xxxx xxxx	uuuu uuuu
05h	PORTA	—	—	PORTA Data Latch when written: PORTA pins when read						--xx xxxx	--uu uuuu
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 ⁽⁵⁾	PORTD	PORTD Data Latch when written: PORTD pins when read								xxxx xxxx	uuuu uuuu
09h ⁽⁵⁾	PORTE	—	—	—	—	—	RE2	RE1	RE0	---- -xxx	---- -uuu
0Ah ^(1,4)	PCLATH	—	—	—	Write Buffer for the upper 5 bits of the Program Counter					---0 0000	---0 0000
0Bh ⁽⁴⁾	INTCON	GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	0000 000x	0000 000u
0Ch	PIR1	PSPIF ⁽³⁾	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	T1SYN \overline{C}	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)
Bank 1											
80h ⁽⁴⁾	INDF	Addressing this location uses contents of FSR to address data memory (not a physical register)								0000 0000	0000 0000
81h	OPTION	RBPU	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0	1111 1111	1111 1111
82h ⁽⁴⁾	PCL	Program Counter's (PC) Least Significant Byte								0000 0000	0000 0000
83h ⁽⁴⁾	STATUS	IRP ⁽⁷⁾	RP1 ⁽⁷⁾	RP0	T0	PD	Z	DC	C	0001 1xxx	000q quuu
84h ⁽⁴⁾	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 ⁽⁵⁾	TRISD	PORTD Data Direction Register								1111 1111	1111 1111
89h ⁽⁵⁾	TRISE	IBF	OBF	IBOV	PSPMODE	—	TRISE2	TRISE1	TRISE0	0000 -111	0000 -111
8Ah ^(1,4)	PCLATH	—	—	—	Write Buffer for the upper 5 bits of the Program Counter					---0 0000	---0 0000
8Bh ⁽⁴⁾	INTCON	GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	0000 000x	0000 000u
8Ch	PIE1	PSPIE ⁽³⁾	ADIE	RCIE	TXIE	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
8Dh	PIE2	—	—	—	—	—	—	—	CCP2IE	---- -0	---- -0
8Eh	PCON	—	—	—	—	—	—	POR	BOR ⁽⁶⁾	---- -qq	---- -uu
8Fh	—	Unimplemented								—	—
90h	—	Unimplemented								—	—
91h	—	Unimplemented								—	—
92h	PR2	Timer2 Period Register								1111 1111	1111 1111
93h	SSPADD	Synchronous Serial Port (I ² C mode) Address Register								0000 0000	0000 0000
94h	SSPSTAT	—	—	D/Ā	P	S	R/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 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.

PIC16C7X

4.2.2.1 STATUS REGISTER

Applicable Devices							
70	71	71A	72	73	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>bit 7: IRP: 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: RP1:RP0: 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: TO: Time-out bit 1 = After power-up, <code>CLRWDT</code> instruction, or <code>SLEEP</code> instruction 0 = A WDT time-out occurred</p> <p>bit 3: PD: Power-down bit 1 = After power-up or by the <code>CLRWDT</code> instruction 0 = By execution of the <code>SLEEP</code> instruction</p> <p>bit 2: Z: 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: DC: Digit carry/borrow bit (<code>ADDWF</code>, <code>ADDLW</code>, <code>SUBLW</code>, <code>SUBWF</code> 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: C: Carry/borrow bit (<code>ADDWF</code>, <code>ADDLW</code>, <code>SUBLW</code>, <code>SUBWF</code> 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 (<code>RRF</code>, <code>RLF</code>) instructions, this bit is loaded with either the high or low order bit of the source register.</p>							

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

4.2.2.2 OPTION REGISTER

Applicable Devices							
70	71	71A	72	73	73A	74	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
RBP\overline{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: **RBP \overline{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							
70	71	71A	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 PIC16C70/71/71A (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	ADIE	TOIE	INTE	RBIE	TOIF	INTF	RBIF
bit7							bit0
<p>bit 7: GIE: Global Interrupt Enable bit⁽¹⁾ 1 = Enables all un-masked interrupts 0 = Disables all interrupts</p> <p>bit 6: ADIE: A/D Converter Interrupt Enable bit 1 = Enables A/D interrupt 0 = Disables A/D interrupt</p> <p>bit 5: TOIE: TMR0 Overflow Interrupt Enable bit 1 = Enables the TMR0 interrupt 0 = Disables the TMR0 interrupt</p> <p>bit 4: INTE: RB0/INT External Interrupt Enable bit 1 = Enables the RB0/INT external interrupt 0 = Disables the RB0/INT external interrupt</p> <p>bit 3: RBIE: RB Port Change Interrupt Enable bit 1 = Enables the RB port change interrupt 0 = Disables the RB port change interrupt</p> <p>bit 2: TOIF: TMR0 Overflow Interrupt Flag bit 1 = TMR0 register has overflowed (must be cleared in software) 0 = TMR0 register did not overflow</p> <p>bit 1: INTF: 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> <p>bit 0: RBIF: RB Port Change Interrupt Flag bit 1 = When 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 PIC16C71 only, if an interrupt occurs while the GIE bit is being cleared, the GIE bit may be unintentionally re-enabled by the RETFIE instruction in the user's Interrupt Service Routine. Refer to Section 14.5 for a detailed description.</p>							
<p>R = Readable bit W = Writable bit U = Unimplemented bit, read as '0' - n = Value at POR reset</p>							

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
<p>bit 7: GIE: Global Interrupt Enable bit⁽¹⁾ 1 = Enables all un-masked interrupts 0 = Disables all interrupts</p> <p>bit 6: PEIE: Peripheral Interrupt Enable bit 1 = Enables all un-masked peripheral interrupts 0 = Disables all peripheral interrupts</p> <p>bit 5: TOIE: TMR0 Overflow Interrupt Enable bit 1 = Enables the TMR0 interrupt 0 = Disables the TMR0 interrupt</p> <p>bit 4: INTE: RB0/INT External Interrupt Enable bit 1 = Enables the RB0/INT external interrupt 0 = Disables the RB0/INT external interrupt</p> <p>bit 3: RBIE: RB Port Change Interrupt Enable bit 1 = Enables the RB port change interrupt 0 = Disables the RB port change interrupt</p> <p>bit 2: TOIF: TMR0 Overflow Interrupt Flag bit 1 = TMR0 register has overflowed (must be cleared in software) 0 = TMR0 register did not overflow</p> <p>bit 1: INTF: 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> <p>bit 0: RBIF: RB Port Change Interrupt Flag bit 1 = When 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 only, 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>							

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

PIC16C7X

4.2.2.4 PIE1 REGISTER

Applicable Devices							
70	71	71A	72	73	73A	74	74A

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

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

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

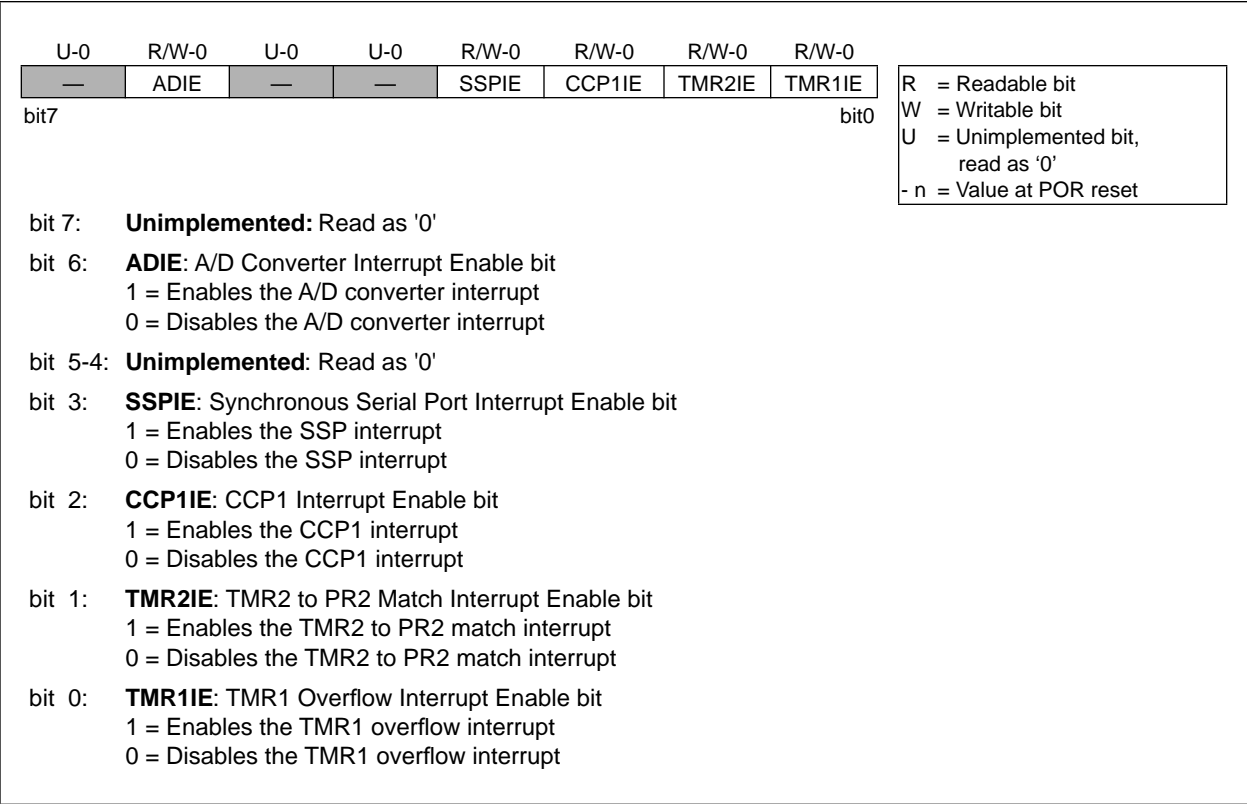


FIGURE 4-14: PIE1 REGISTER PIC16C73/73A/74/74A (ADDRESS 8Ch)

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 ⁽¹⁾	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⁽¹⁾**: 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 converter interrupt
0 = Disables the A/D converter 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							
70	71	71A	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)

U-0	R/W-0	U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0
—	ADIF	—	—	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: **Unimplemented:** Read as '0'

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

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

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

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 ⁽¹⁾	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⁽¹⁾**: 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.

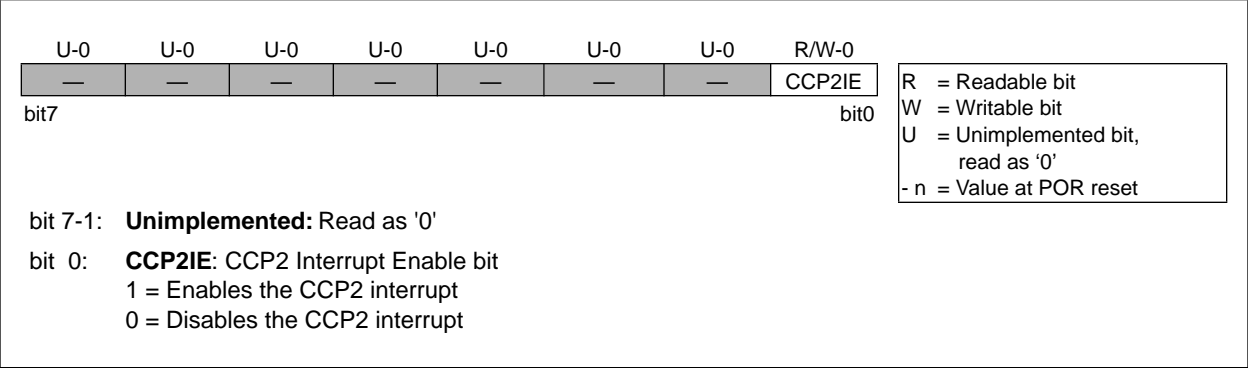
PIC16C7X

4.2.2.6 PIE2 REGISTER

Applicable Devices							
70	71	71A	72	73	73A	74	74A

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

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



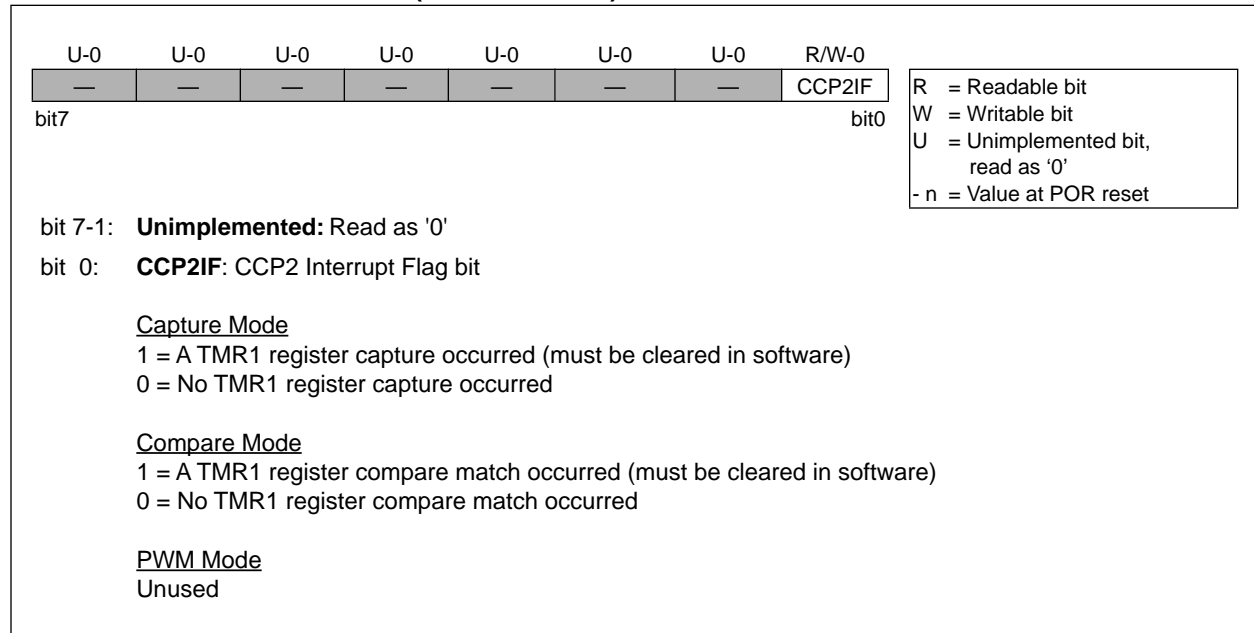
4.2.2.7 PIR2 REGISTER

Applicable Devices							
70	71	71A	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

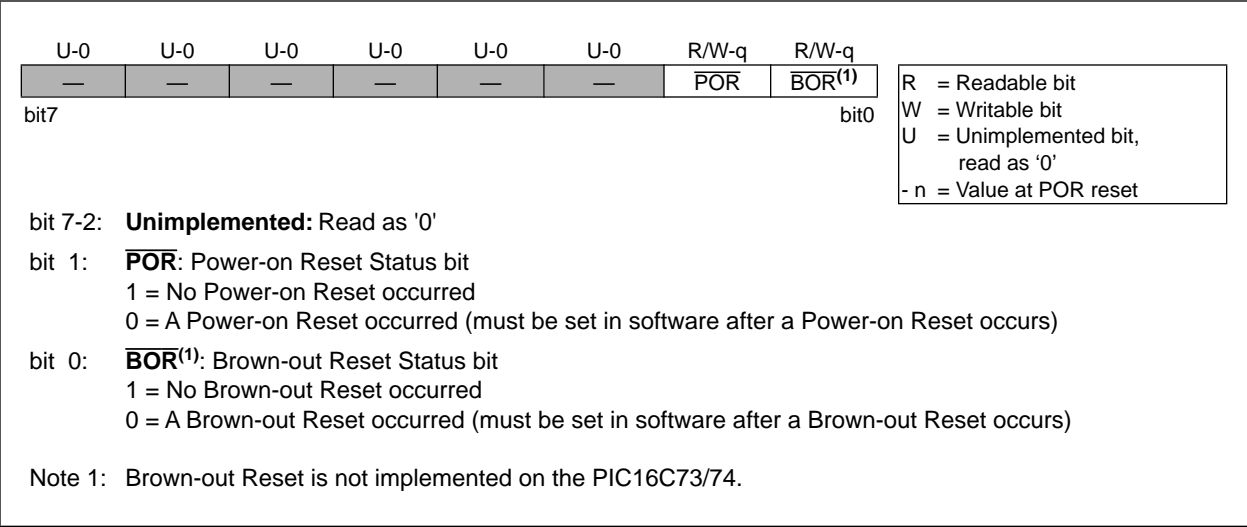
4.2.2.8 PCON REGISTER

Applicable Devices							
70	71	71A	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 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)



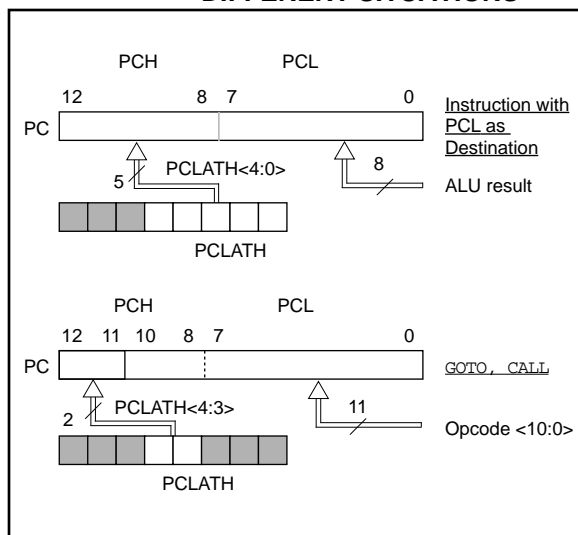
4.3 PCL and PCLATH

Applicable Devices

70	71	71A	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

70	71	71A	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 PIC16C70/71/71A/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.

PIC16C7X

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

70	71	71A	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.

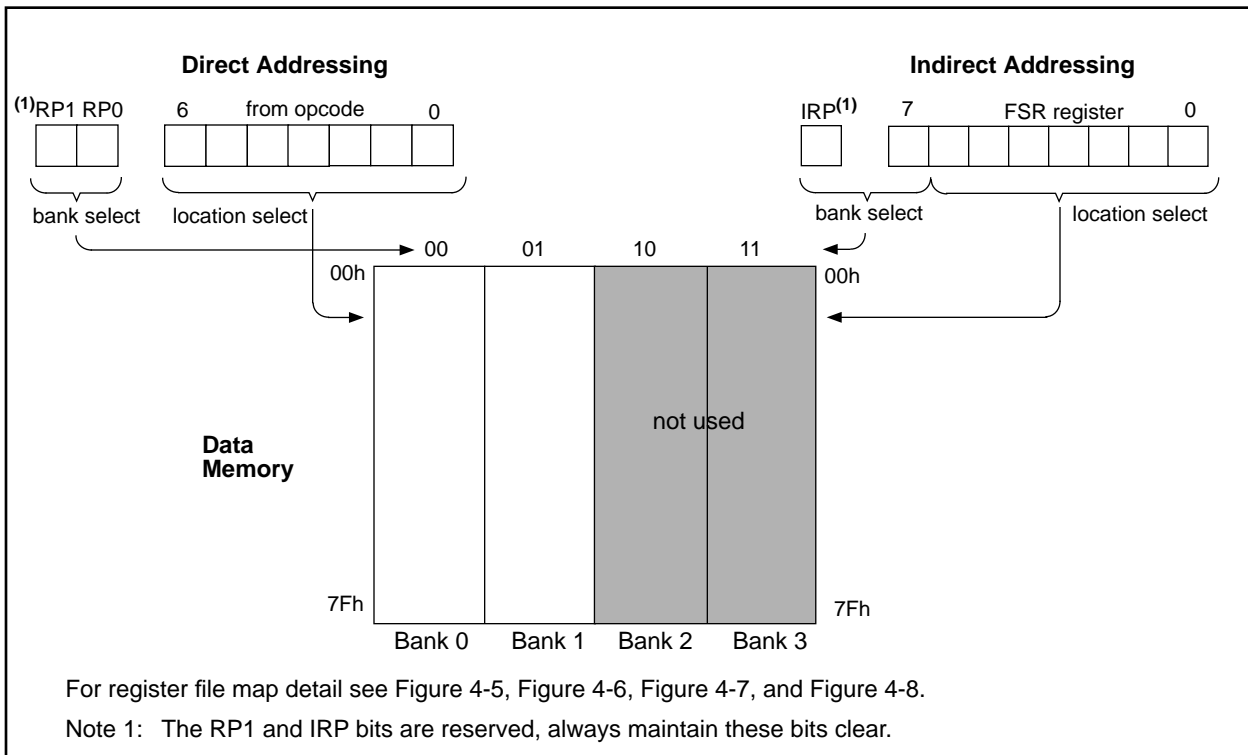
EXAMPLE 4-2: INDIRECT ADDRESSING

```

        movlw 0x20    ;initialize pointer
        movwf FSR     ;to RAM
NEXT     clrf  INDF    ;clear INDF register
        incf  FSR,F    ;inc pointer
        btfs  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							
70	71	71A	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							
70	71	71A	72	73	73A	74	74A

PORTA is a 5-bit latch for PIC16C70/71/71A.

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).

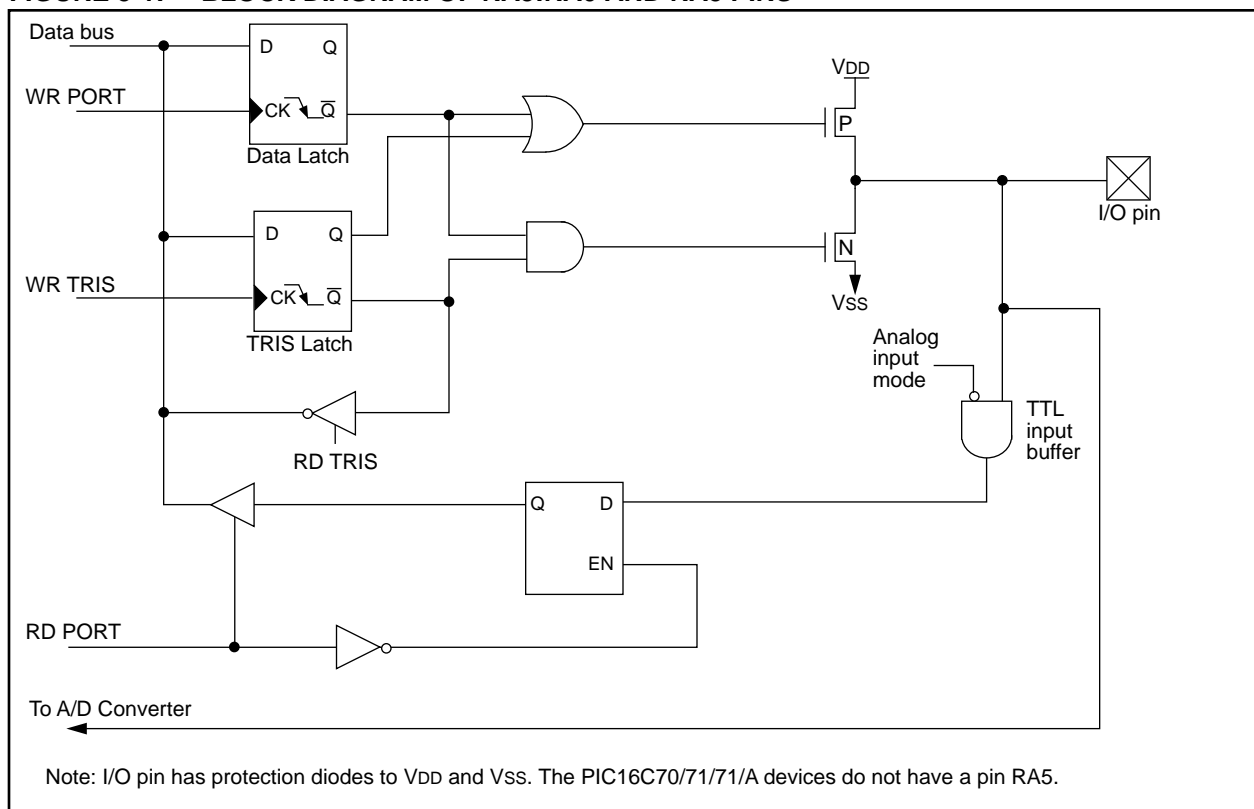
Note: On a Power-on Reset, these pins are configured as analog inputs and read as '0'.

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
                        ; setting 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



PIC16C7X

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

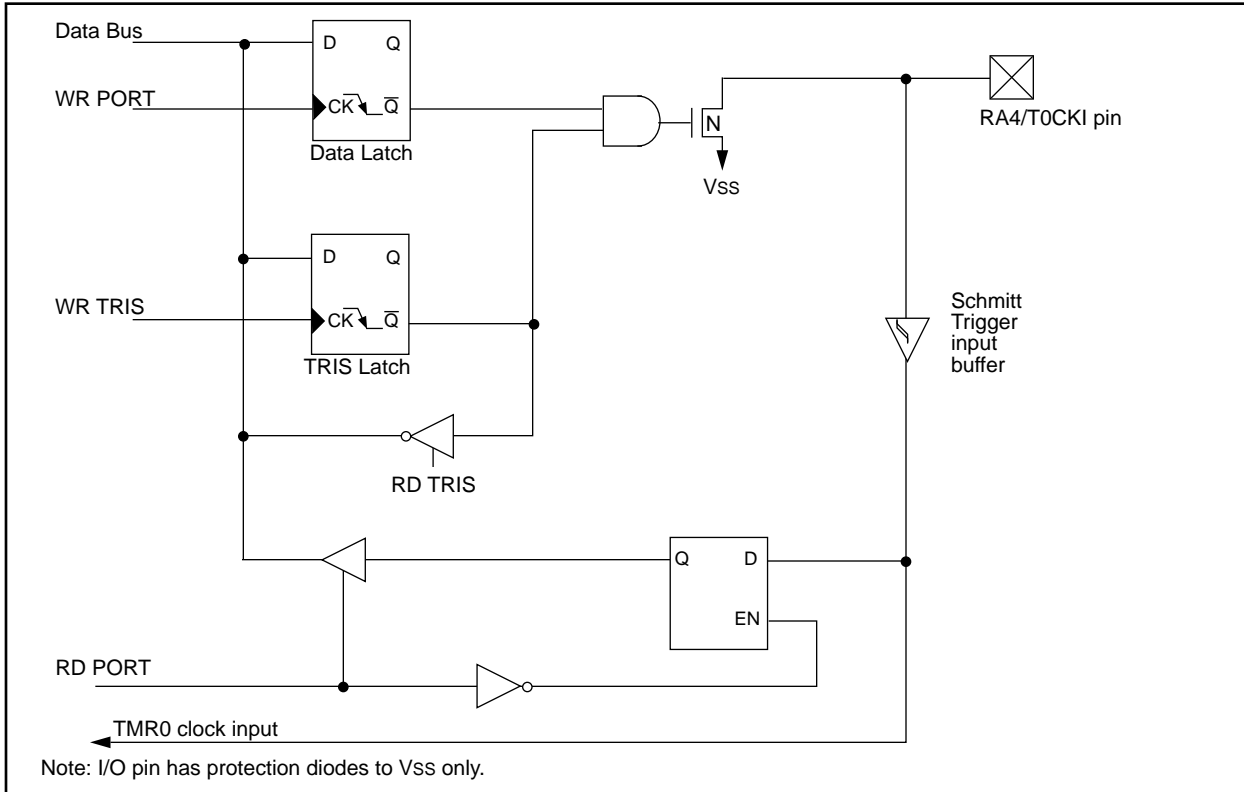


TABLE 5-1: PORTA FUNCTIONS

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/SS ⁽¹⁾	bit5	TTL	Input/output, slave select input for synchronous serial port, or analog input

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

Note 1: The PIC16C70/71/71A 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 ⁽¹⁾	RA4	RA3	RA2	RA1	RA0	--xx xxxx	--uu uuuu
85h	TRISA	—	—	TRISA5 ⁽¹⁾	TRISA4	TRISA3	TRISA2	TRISA1	TRISA0	--11 1111	--11 1111
9Fh	ADCON1	—	—	—	—	—	PCFG2 ⁽²⁾	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 PIC16C70/71/71A.

2: Bit PCFG2 is not implemented on the PIC16C70/71/71A.

5.2 PORTB and TRISB Registers

Applicable Devices

70	71	71A	72	73	73A	74	74A
----	----	-----	----	----	-----	----	-----

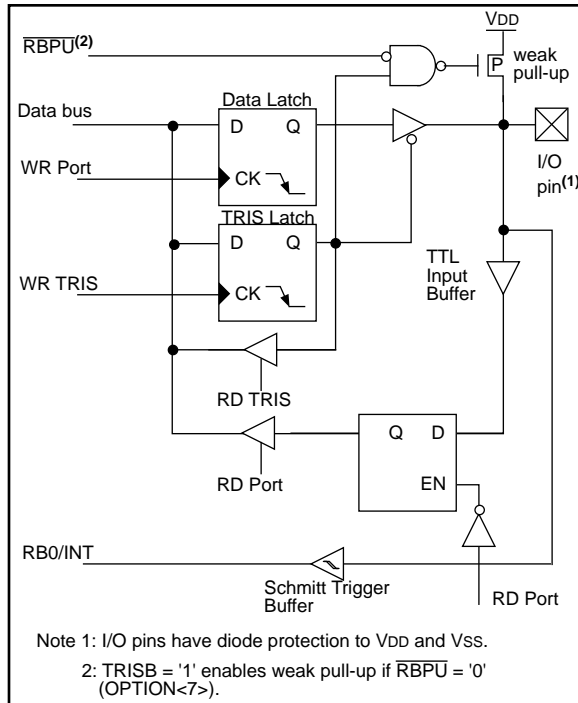
PORTB is an 8-bit wide bi-directional port. The corresponding data direction register is TRISB. Setting a bit in the TRISB register puts the corresponding output driver in a hi-impedance input mode. Clearing a bit in the TRISB register puts the contents of the output latch on the selected pin(s).

EXAMPLE 5-2: INITIALIZING PORTB

```
CLRF    PORTB      ; Initialize PORTB by
                   ; setting 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 done by clearing bit $\overline{\text{RBP}}\text{U}$ (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.

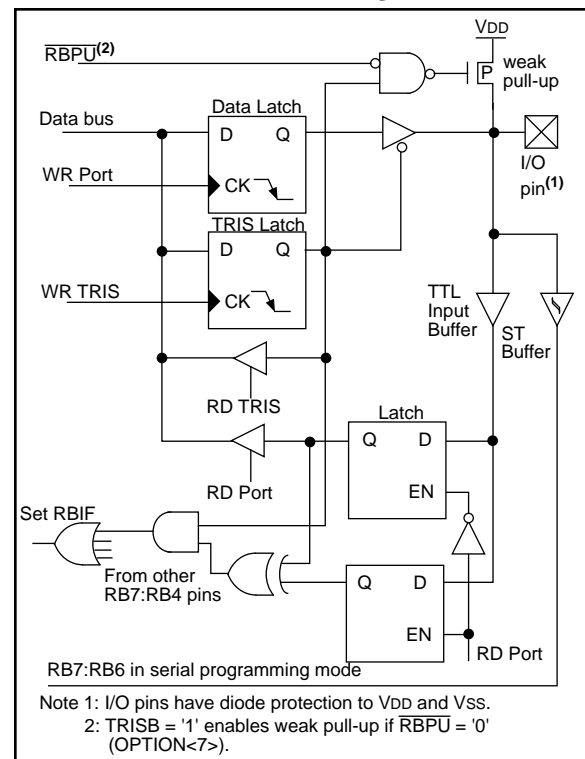
A mismatch condition will continue to set flag bit RBIF. Reading PORTB will end the mismatch condition, and allow flag bit RBIF to be cleared.

This interrupt on mismatch feature, together with software configurable pull-ups on these four pins allow easy interface to a key pad 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 only, 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.

FIGURE 5-4: BLOCK DIAGRAM OF RB7:RB4 PINS



PIC16C7X

TABLE 5-3: PORTB FUNCTIONS

Name	Bit#	Buffer	Function
RB0/INT	bit0	TTL/ST ⁽¹⁾	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 ⁽²⁾	Input/output pin (with interrupt on change). Internal software programmable weak pull-up. Serial programming clock.
RB7	bit7	TTL/ST ⁽²⁾	Input/output pin (with interrupt on change). Internal software programmable weak pull-up. Serial programming data.

Legend: TTL = TTL input, ST = Schmitt Trigger

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	RBPU	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0	1111 1111	1111 1111

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

5.3 PORTC and TRISC Registers

Applicable Devices

70	71	71A	72	73	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.

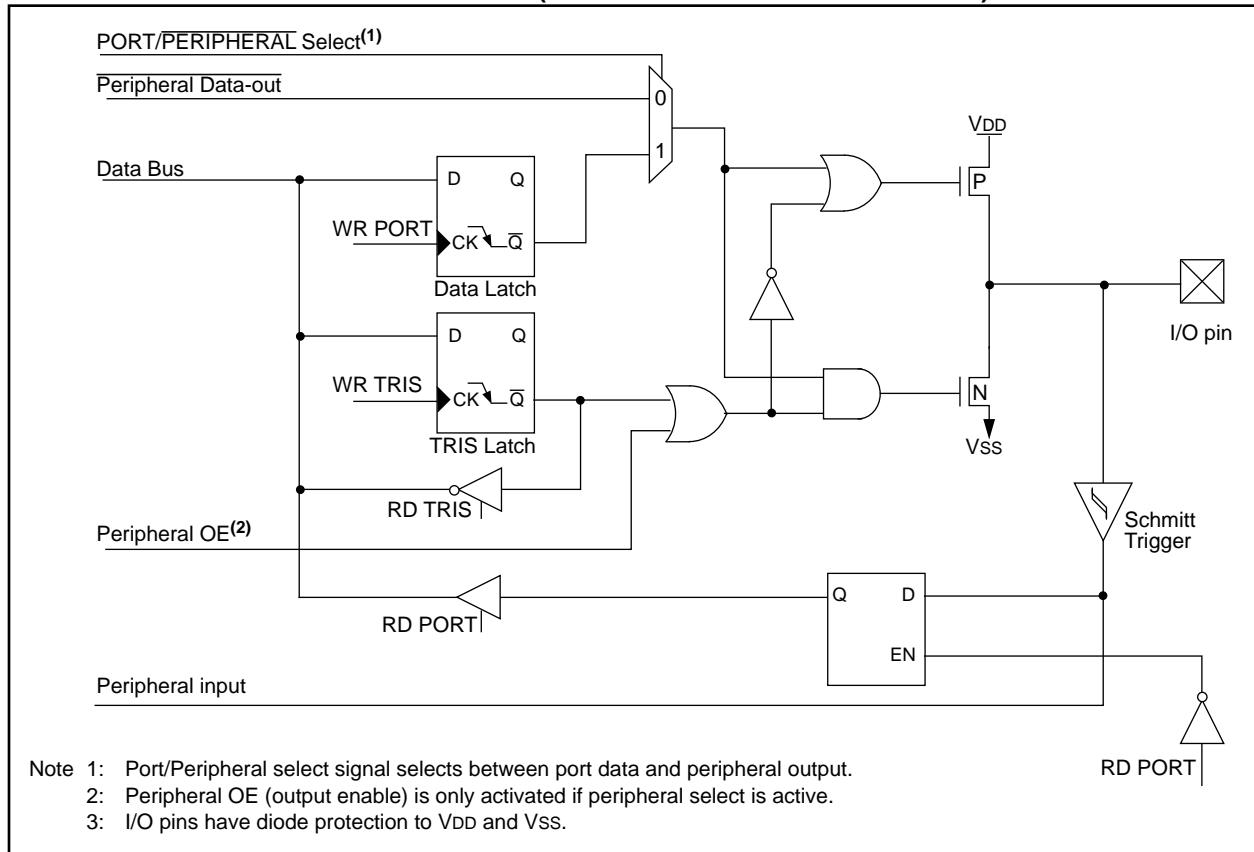
When enabling peripheral functions, care should be taken in defining TRIS bits for each PORTC pin. Some peripherals override the TRIS bit to make a pin an output, while other peripherals override the TRIS bit to make a pin an input. The TRIS bit override is in effect only while the peripheral is enabled. 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
                   ; setting 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 5-5: PORTC BLOCK DIAGRAM (PERIPHERAL OUTPUT OVERRIDE)



PIC16C7X

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 ⁽¹⁾	bit1	ST	Input/output port pin, Timer1 oscillator input, 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 ² 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 ² C mode).
RC5/SDO	bit5	ST	Input/output port pin or Synchronous Serial Port data output
RC6/TX/CK ⁽²⁾	bit6	ST	Input/output port pin, USART Asynchronous Transmit, or USART Synchronous Clock
RC7/RX/DT ⁽²⁾	bit7	ST	Input/output port pin 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.

5.4 PORTD and TRISD Registers

Applicable Devices							
70	71	71A	72	73	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 (or parallel slave port) by setting control bit PSPMODE (TRISE<4>). In this mode, the input buffers are TTL.

FIGURE 5-6: PORTD BLOCK DIAGRAM (IN I/O PORT MODE)

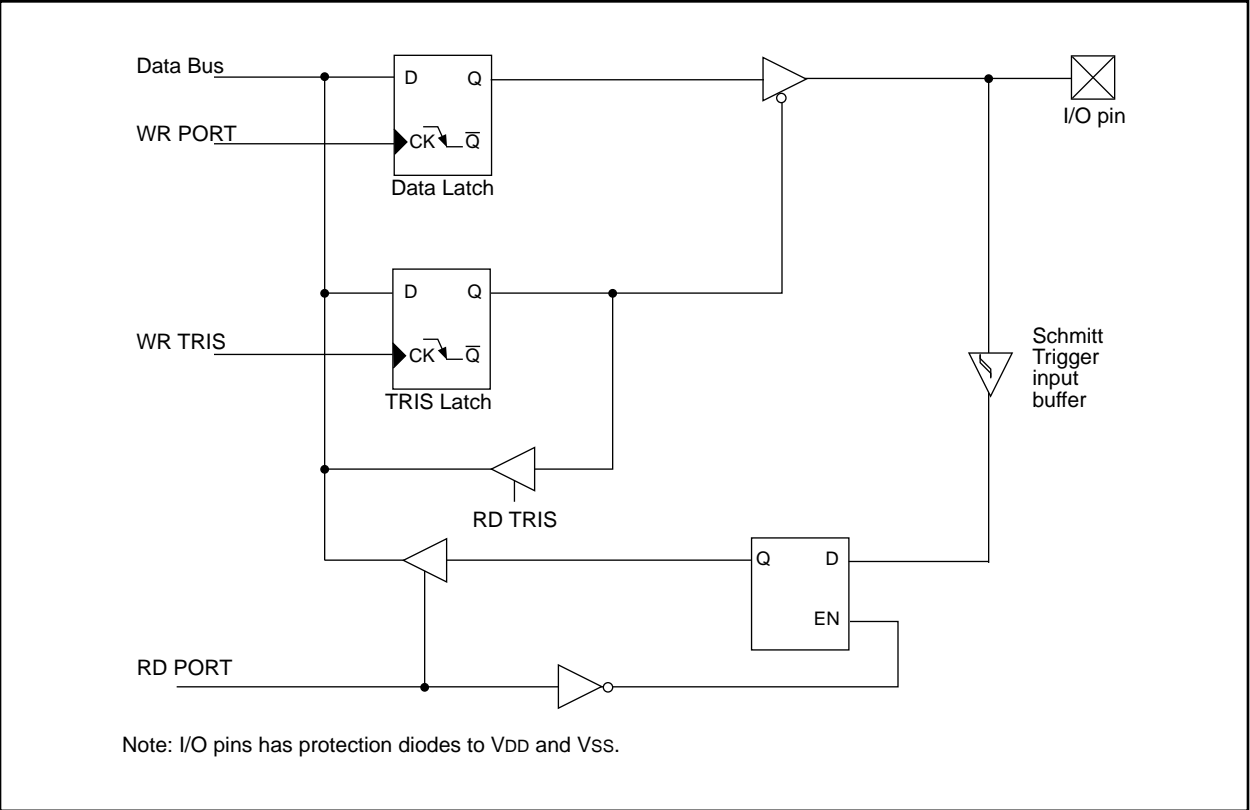


TABLE 5-7: PORTD FUNCTIONS

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

PIC16C7X

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.

5.5 PORTE and TRISE Register

Applicable Devices							
70	71	71A	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 5-7 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 5-7: 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: **IBF:** 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: **OBF:** Output Buffer Full Status bit
1 = The output buffer still holds a previously written word
0 = The output buffer has been read

bit 5: **IBOV:** 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: **PSPMODE:** Parallel Slave Port Mode Select bit
1 = Parallel slave port mode
0 = General purpose I/O mode

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

bit 2: **TRISE2:** Direction control bit for pin RE2/ \overline{CS} /AN7
1 = Input
0 = Output

bit 1: **TRISE1:** Direction control bit for pin RE1/ \overline{WR} /AN6
1 = Input
0 = Output

bit 0: **TRISE0:** Direction control bit for pin RE0/ \overline{RD} /AN5
1 = Input
0 = Output

PIC16C7X

FIGURE 5-8: PORTE BLOCK DIAGRAM (IN I/O PORT MODE)

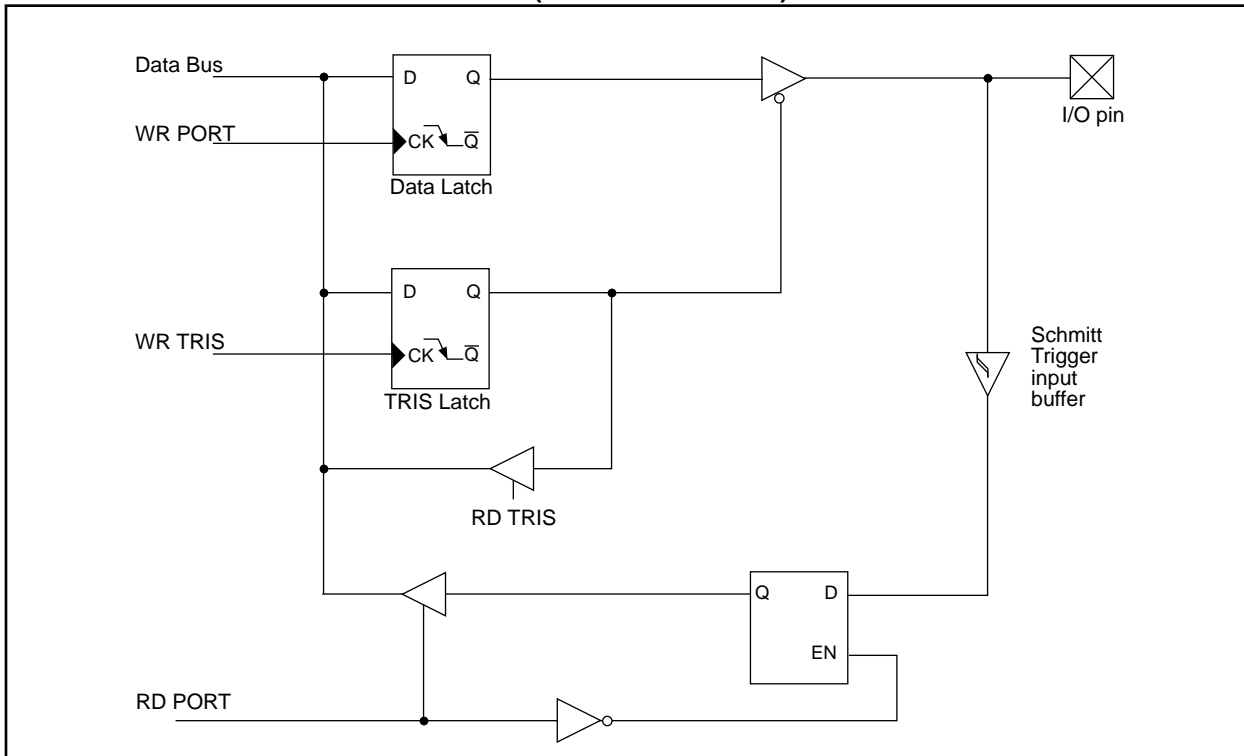


TABLE 5-9: PORTE FUNCTIONS

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

5.6 I/O Programming Considerations

Applicable Devices							
70	71	71A	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

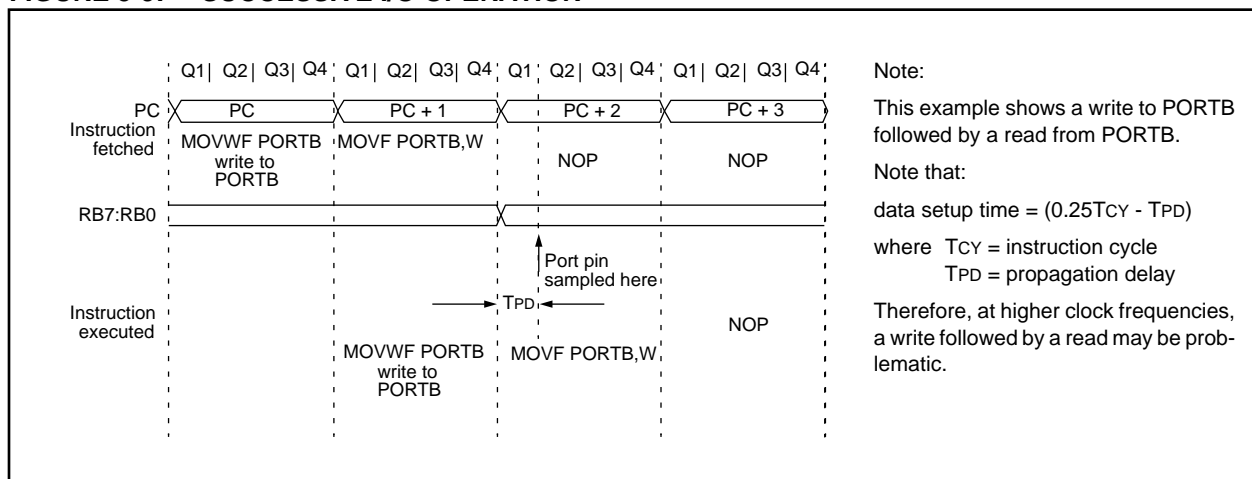
```
;Initial PORT settings: PORTB<7:4> Inputs
;                          PORTB<3:0> Outputs
;PORTB<7:6> have external pull-ups and are
;not connected to other circuitry
;
;                          PORT latch  PORT pins
;                          -----
BCF PORTB, 7      ; 01pp ppp   11pp ppp
BCF PORTB, 6      ; 10pp ppp   11pp ppp
BSF STATUS, RP0   ;
BCF TRISB, 7      ; 10pp ppp   11pp ppp
BCF TRISB, 6      ; 10pp ppp   10pp ppp
;
;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 5-9). 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 5-9: SUCCESSIVE I/O OPERATION



PIC16C7X

5.7 Parallel Slave Port

Applicable Devices							
70	71	71A	72	73	73A	74	74A

PORTD operates as an 8-bit wide Parallel Slave Port, or microprocessor port when control bit PSPMODE (TRISE<4>) is set. In slave mode it is asynchronously readable and writable by the external world through \overline{RD} control input pin RE0/ \overline{RD} /AN5 and \overline{WR} control input pin RE1/ \overline{WR} /AN6.

It can directly interface to an 8-bit microprocessor data bus. The external microprocessor can read or write the PORTD latch as an 8-bit latch. Setting bit PSPMODE enables port pin RE0/RD/AN5 to be the \overline{RD} input, RE1/ \overline{WR} /AN6 to be the \overline{WR} input and RE2/ \overline{CS} /AN7 to be the \overline{CS} (chip select) input. For this functionality, the corresponding data direction bits of the TRISE register (TRISE<2:0>) must be configured as inputs (set) and the A/D port configuration bits PCFG2:PCFG0 (ADCON1<2:0>) must be set, which will configure pins RE2:RE0 as digital I/O.

There are actually two 8-bit latches, one for data-out (from the PIC16/17) and one for data input. The user writes 8-bit data to PORTD data latch and reads data from the port pin latch (note that they have the same

address). In this mode, the TRISD register is ignored, since the microprocessor is controlling the direction of data flow.

Input Buffer Full Status Flag bit IBF (TRISE<7>), is set if a received word is waiting to be read by the CPU. Once the PORTD input latch is read, IBF is cleared. IBF is a read only status bit. Output Buffer Full Status Flag bit OBF (TRISE<6>), is set if a word written to PORTD latch is waiting to be read by the external bus. Once the PORTD output latch is read by the microprocessor, OBF is cleared. Input Buffer Overflow Status Flag bit IBOV (TRISE<5>) is set if a second write to the microprocessor port is attempted when the previous word has not been read by the CPU (the first word is retained in the buffer).

When not in Parallel Slave Port mode, the IBF and OBF bits are held clear. However, if flag bit IBOV was previously set, it must be cleared in the software.

An interrupt is generated and latched into flag bit PSPIF (PIR1<7>) when a read or a write operation is completed. Interrupt flag bit PSPIF must be cleared by user software and the interrupt can be disabled by clearing interrupt enable bit PSPIE (PIE1<7>).

FIGURE 5-10: PORTD AND PORTE BLOCK DIAGRAM (PARALLEL SLAVE PORT)

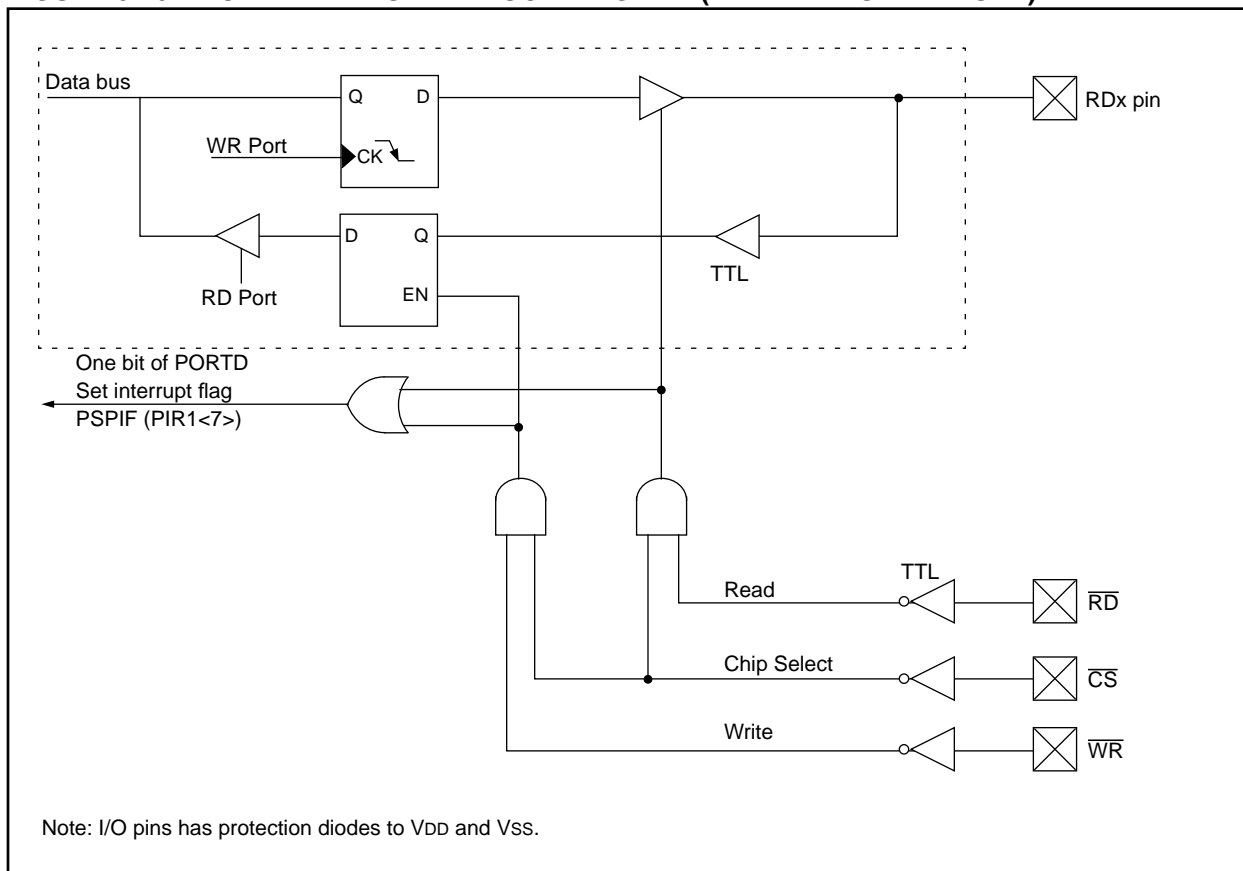


TABLE 5-11: REGISTERS ASSOCIATED WITH PARALLEL SLAVE PORT

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	RD7	RD6	RD5	RD4	RD3	RD2	RD1	RD0	xxxx xxxx	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.

PIC16C7X

NOTES:

6.0 OVERVIEW OF TIMER MODULES

Applicable Devices							
70	71	71A	72	73	73A	74	74A

The PIC16C70 and PIC16C71/71A have one timer module.

The PIC16C72, PIC16C73/73A and PIC16C74/74A 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							
70	71	71A	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							
70	71	71A	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

Capture/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							
70	71	71A	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							
70	71	71A	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 Timer1 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.

PIC16C7X

NOTES:

7.0 TIMER0 MODULE

Applicable Devices							
70	71	71A	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 the 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							
70	71	71A	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

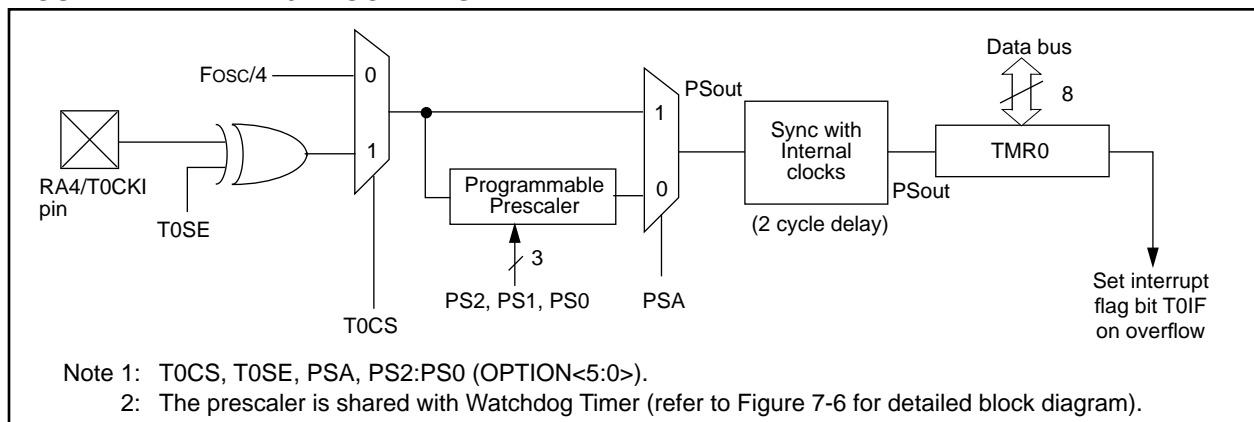


FIGURE 7-2: TIMER0 TIMING: INTERNAL CLOCK/NO PRESCALE

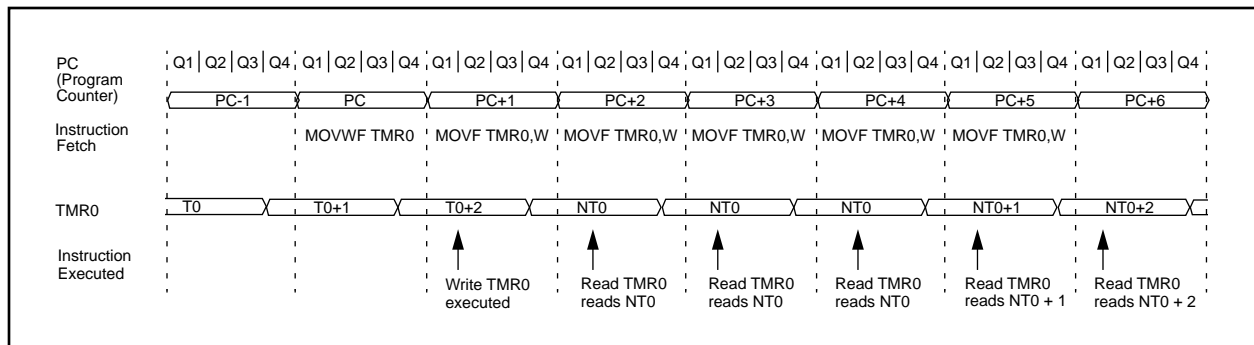


FIGURE 7-3: TIMER0 TIMING: INTERNAL CLOCK/PRESCALE 1:2

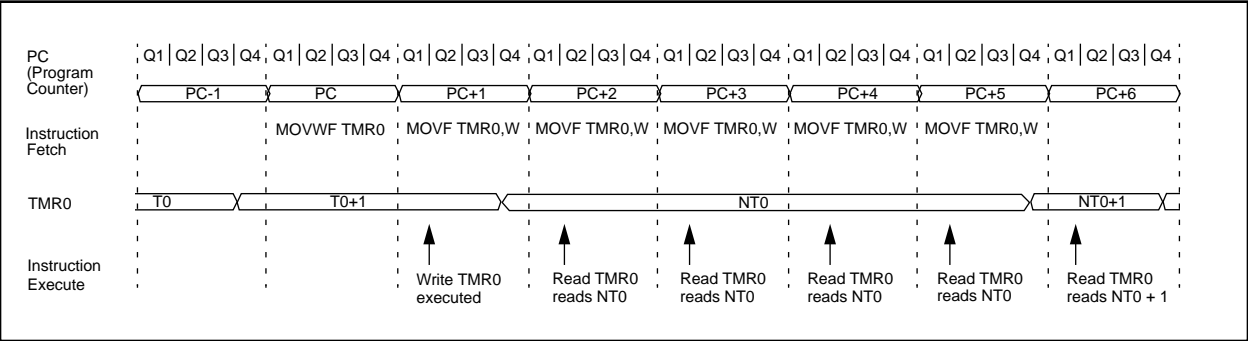
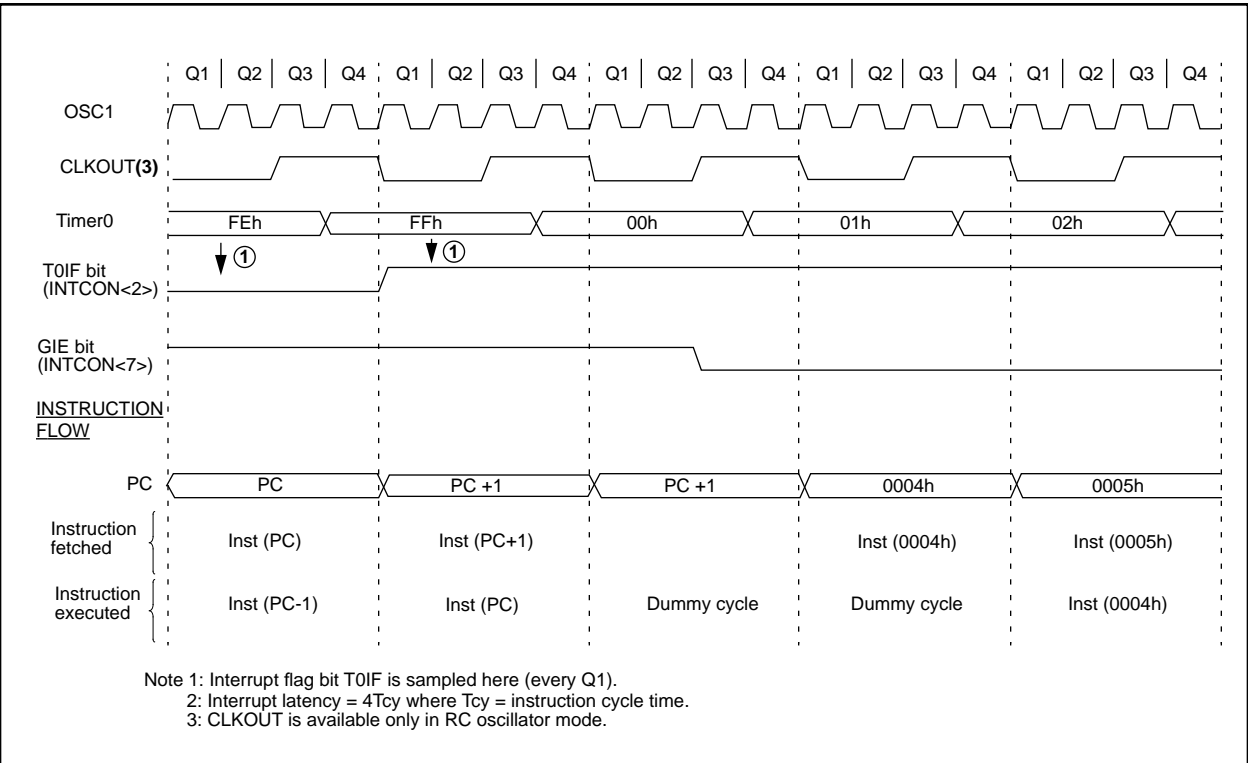


FIGURE 7-4: TIMER0 INTERRUPT TIMING



7.2 Using Timer0 with an External Clock

Applicable Devices

70	71	71A	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

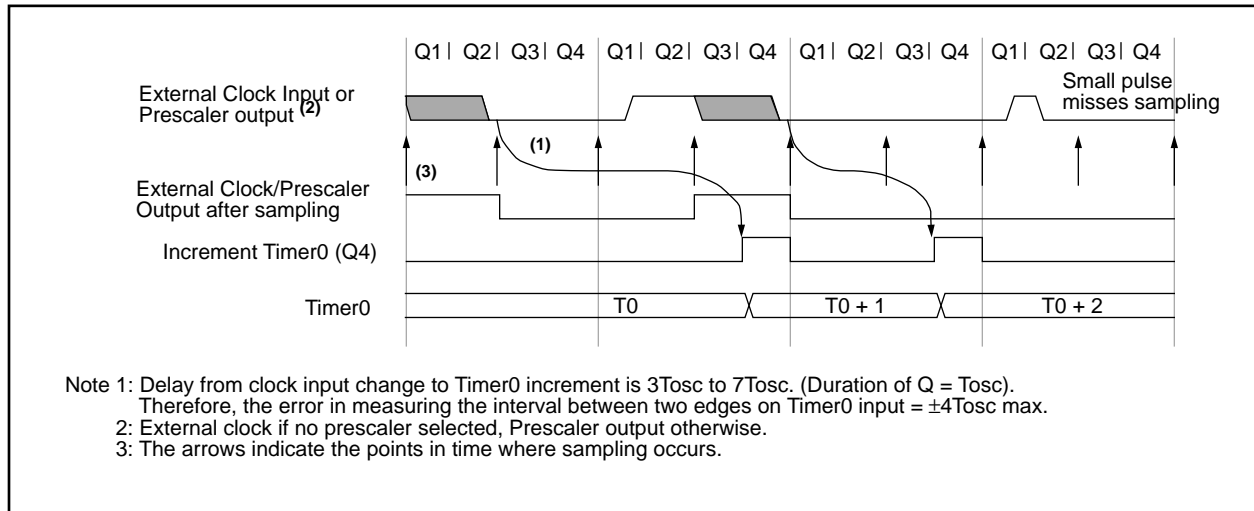
When no prescaler is used, the external clock input is the same as the prescaler output. The synchronization of T0CKI with the internal phase clocks is accomplished by sampling the prescaler output on the Q2 and Q4 cycles of the internal phase clocks (Figure 7-5). Therefore, it is necessary for T0CKI 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



PIC16C7X

7.3 Prescaler

Applicable Devices							
70	71	71A	72	73	73A	74	74A

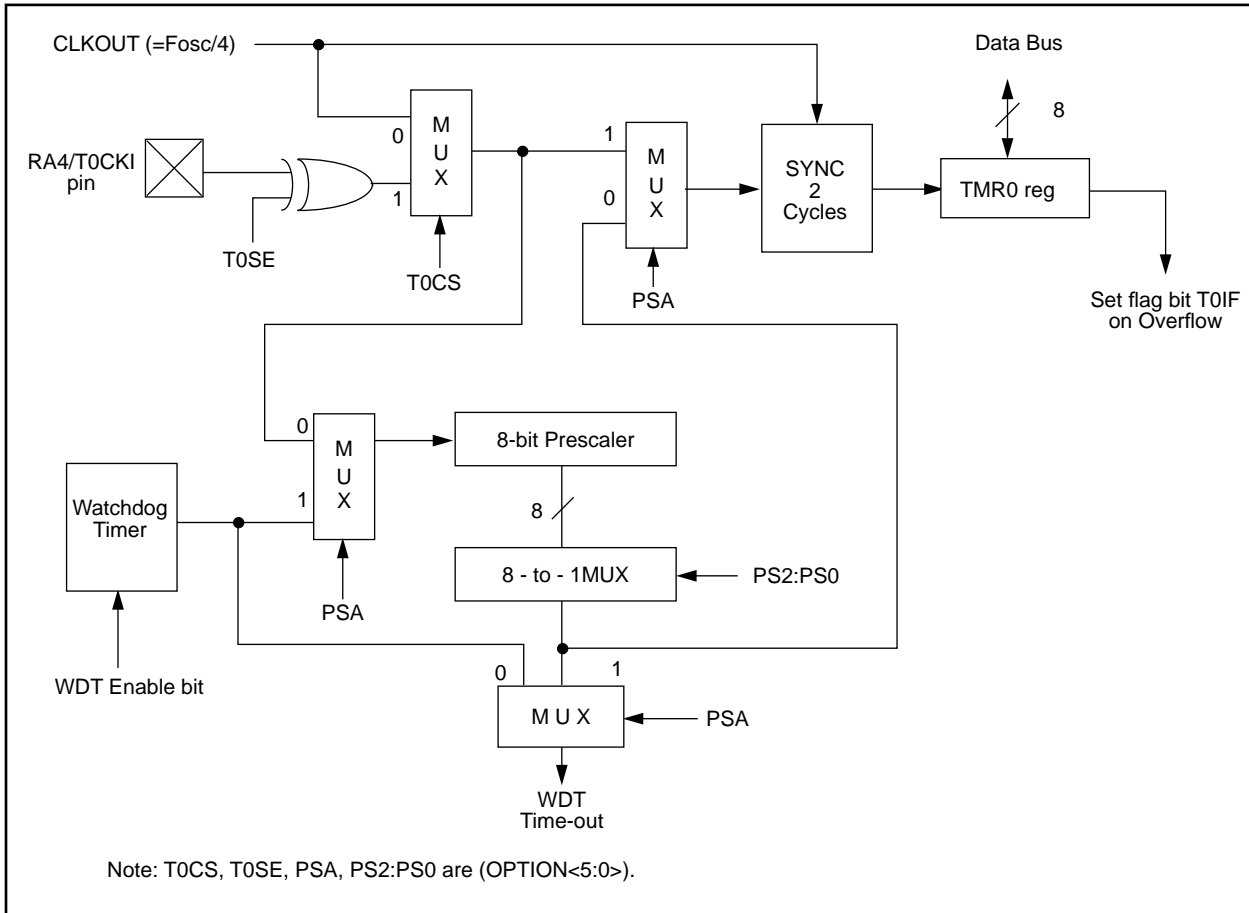
An 8-bit counter is available as a prescaler for the Timer0 module, or as a postscaler for the Watchdog Timer, respectively (Figure 7-6). For simplicity, this counter is being referred to as “prescaler” throughout this data sheet. Note that there is only one prescaler available which is mutually exclusive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

caler 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        ;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'xxxx0xxx' ;Select TMR0, new
                ;prescale value and
MOVWF   OPTION    ;clock source
BCF     STATUS, RP0 ;Bank 0
```

TABLE 7-1: REGISTERS ASSOCIATED WITH TIMER0, PIC16C70/71/71A

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	RBPU	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	RBPU	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.

PIC16C7X

NOTES:

8.0 TIMER1 MODULE

Applicable Devices							
70	71	71A	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 or disabled using 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 (T1OSCEN 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 (T1OSCEN 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)

U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	—	T1CKPS1	T1CKPS0	T1OSCEN	T1SYNCR	TMR1CS	TMR1ON
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: **T1CKPS1:T1CKPS0:** Timer1 Input Clock Prescale Select bits

11 = 1:8 Prescale value
10 = 1:4 Prescale value
01 = 1:2 Prescale value
00 = 1:1 Prescale value

bit 3: **T1OSCEN:** Timer1 Oscillator Enable Control bit

1 = Oscillator is enabled
0 = Oscillator is shut off

Note: The oscillator inverter and feedback resistor are turned off to eliminate power drain

bit 2: **T1SYNCR:** Timer1 External Clock Input Synchronization Control bit

TMR1CS = 1

1 = Do not synchronize external clock input
0 = Synchronize external clock input

TMR1CS = 0

This bit is ignored. Timer1 uses the external clock when TMR1CS = 0.

bit 1: **TMR1CS:** Timer1 Clock Source Select bit

1 = External clock from pin RC0/T1OSO/T1CKI (on the rising edge)
0 = Internal clock (OSC/4)

bit 0: **TMR1ON:** Timer1 On bit

1 = Enables Timer1
0 = Stops Timer1

8.1 Timer1 Operation in Timer Mode

Applicable Devices

70	71	71A	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 OSC/4. The synchronize control bit T1SYNC (T1CON<2>) has no effect since the internal clock is always in sync.

8.2 Timer1 Operation in Synchronized Counter Mode

Applicable Devices

70	71	71A	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 T1OSCEN is set or pin RC0/T1OSO/T1CKI when bit T1OSCEN is cleared.

If 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.

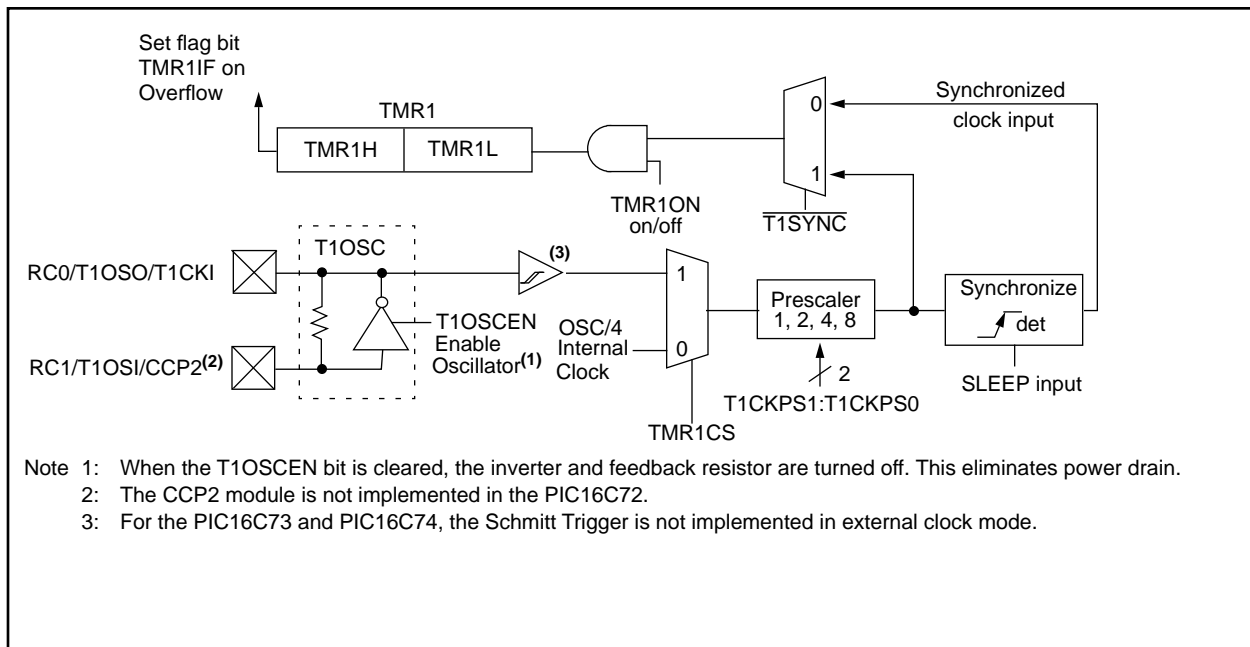
8.2.1 EXTERNAL CLOCK INPUT TIMING FOR SYNCHRONIZED COUNTER MODE

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 (Tosc) 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 2Tosc (and a small RC delay of 20 ns) and low for at least 2Tosc (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 4Tosc (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							
70	71	71A	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 a 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							
70	71	71A	72	73	73A	74	74A

A crystal oscillator circuit is built in between T1OSI pin (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 ⁽¹⁾	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.			
Crystals Tested:			
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	

PIC16C7X

8.5 Resetting Timer1 using a CCP Trigger Output

Applicable Devices							
70	71	71A	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							
70	71	71A	72	73	73A	74	74A

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

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							
70	71	71A	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 ^(1,2)	ADIF	RCIF ⁽²⁾	TXIF ⁽²⁾	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
8Ch	PIE1	PSPIE ^(1,2)	ADIE	RCIE ⁽²⁾	TXIE ⁽²⁾	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

70	71	71A	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

70	71	71A	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, or Watchdog Timer reset)

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

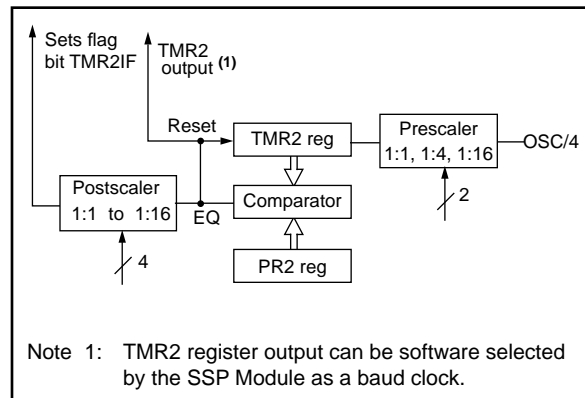
9.2 Output of TMR2

Applicable Devices

70	71	71A	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



PIC16C7X

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	
—	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 ^(1,2)	ADIF	RCIF ⁽²⁾	TXIF ⁽²⁾	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
8Ch	PIE1	PSPIE ^(1,2)	ADIE	RCIE ⁽²⁾	TXIE ⁽²⁾	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.

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							
70	71	71A	72	73	73A	74	74A
70	71	71A	72	73	73A	74	74A

CCP1
CCP2

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 output. 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). Both are readable and writable.

CCP2 module:

Capture/Compare/PWM Register2 (CCPR2) is made up of two 8-bit registers: CCPR2L (low byte) and CCPR2H (high byte). Both 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 timebase.
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

PIC16C7X

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 High Resolution, Low Order Select bits
Capture Mode: Unused
Compare Mode: Unused
PWM Mode: Write the two low order bits in high resolution (10-bit) mode. May be kept constant (at '0') if only 8-bit resolution (in standard resolution mode) is desired.

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							
70	71	71A	72	73	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:

- A falling edge
- A 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 reset in software. If another capture occurs before the value in register CCPR1 is read, the old captured value will be lost. 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.

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.

10.1.1 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.

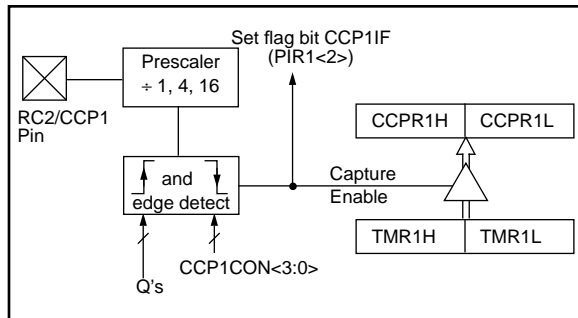
EXAMPLE 10-1: CHANGING BETWEEN CAPTURE PRESCALERS

```
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
```

10.1.2 CAPTURE 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.

FIGURE 10-2: CAPTURE MODE OPERATION BLOCK DIAGRAM



10.2 Compare Mode

Applicable Devices

70	71	71A	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. 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.

10.2.1 COMPARE 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.

10.2.2 SOFTWARE INTERRUPT MODE

Another compare mode is software interrupt mode in which the CCP1 pin is not affected. Only a CCP interrupt is generated (if enabled).

10.2.3 SPECIAL EVENT TRIGGER

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

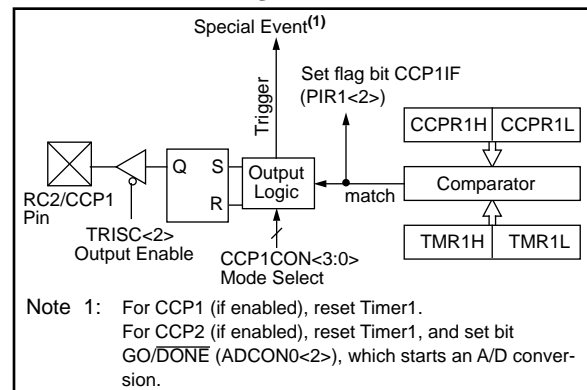
The special event trigger output of CCP1 resets the TMR1 register pair. This allows the CCPR1 register to effectively be a 16-bit programmable period register for Timer1.

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>).

FIGURE 10-3: COMPARE MODE OPERATION BLOCK DIAGRAM



PIC16C7X

10.3 PWM Mode

Applicable Devices							
70	71	71A	72	73	73A	74	74A

In Pulse Width Modulation mode (PWM), pin RC2/CCP1 produces up to a 10-bit resolution PWM output. This pin must be configured as an output by clearing the TRISC<2> bit. The pin is multiplexed with the data latch. In PWM mode, the user writes the 8-bit duty cycle value to the low byte of the CCPR1 register, namely CCPR1L. The high-byte, CCPR1H is used as the slave buffer to the low byte. The 8-bit data is transferred from the master to the slave when the PWM1 output is set (i.e. at the beginning of the duty cycle). This double buffering is essential for glitchless PWM output. In PWM mode, CCPR1H is readable but not writable. The period of the PWM is determined by the Timer2 period register (PR2).

PWM period is =

$$[(PR2) + 1] \cdot 4 T_{osc} \cdot (TMR2 \text{ prescale value})$$

PWM duty cycle =

$$(DC1) \cdot T_{osc} \cdot (TMR2 \text{ prescale value})$$

where DC1 = 10-bit value from CCPRxL and CCPx-CON<5:4> concatenated.

The PWM output resolution is therefore programmable up to a maximum of 10-bits.

Note: Clearing the CCP1CON register will force the RC2/CCP1 PWM output latch to the default low level. This is not the I/O data latch. The Timer2 postscaler 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.

FIGURE 10-4: SIMPLIFIED PWM BLOCK DIAGRAM

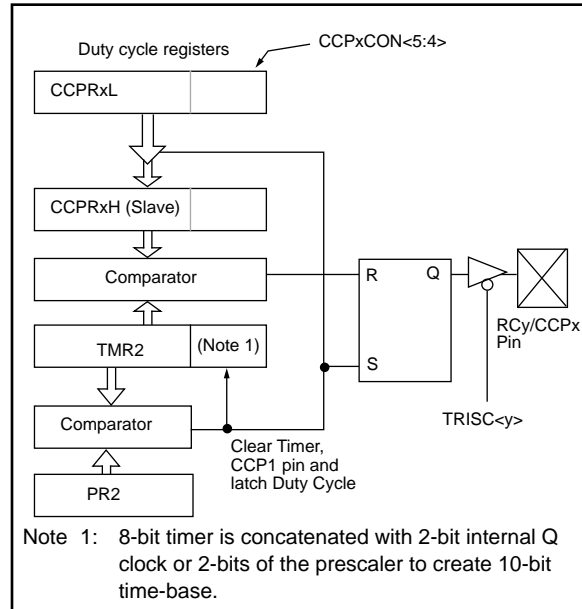


TABLE 10-3: PWM FREQUENCY vs. RESOLUTION AT 20 MHz

Max. Resolution (High Resolution Mode)	Frequency		
	TMR2 Prescale=1	TMR2 Prescale=4	TMR2 Prescale=16
10-bit	19.53 kHz	4.88 kHz	1.22 kHz
9-bit	39.06 kHz	9.77 kHz	2.44 kHz
8-bit	78.13 kHz	19.53 kHz	4.88 kHz

TABLE 10-4: 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 (16, 4, 1)	16	4	1	1	1	1
PR2 Value	0xFF	0xFF	0xFF	0x3F	0x1F	0x17
Resolution (High-resolution mode)	10-bit	10-bit	10-bit	8-bit	7-bit	5.5-bit
Resolution (Standard-resolution mode) ⁽¹⁾	8-bit	8-bit	8-bit	6-bit	5-bit	3.5-bit

Note 1: Standard resolution mode has the CCPx:CCPxY bits constant (or '0'), and only compares the TMR2 register value against the PR2 register value. The Q-cycles are not used.

TABLE 10-5: REGISTERS ASSOCIATED WITH CAPTURE 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 ^(1,2)	ADIF	RCIF ⁽²⁾	TXIF ⁽²⁾	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
0Dh ⁽²⁾	PIR2	—	—	—	—	—	—	—	CCP2IF	---- --0	---- --0
8Ch	PIE1	PSPIE ^(1,2)	ADIE	RCIE ⁽²⁾	TXIE ⁽²⁾	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
8Dh ⁽²⁾	PIE2	—	—	—	—	—	—	—	CCP2IE	---- --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	T1SYN \overline{C}	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 ⁽²⁾	CCPR2L	Capture/Compare/PWM register2 (LSB)								xxxx xxxx	uuuu uuuu
1Ch ⁽²⁾	CCPR2H	Capture/Compare/PWM register2 (MSB)								xxxx xxxx	uuuu uuuu
1Dh ⁽²⁾	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.

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

TABLE 10-6: REGISTERS ASSOCIATED WITH 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 ^(1,2)	ADIF	RCIF ⁽²⁾	TXIF ⁽²⁾	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
0Dh ⁽²⁾	PIR2	—	—	—	—	—	—	—	CCP2IF	---- --0	---- --0
8Ch	PIE1	PSPIE ^(1,2)	ADIE	RCIE ⁽²⁾	TXIE ⁽²⁾	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
8Dh ⁽²⁾	PIE2	—	—	—	—	—	—	—	CCP2IE	---- --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	T1SYN \overline{C}	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 ⁽²⁾	CCPR2L	Capture/Compare/PWM register2 (LSB)								xxxx xxxx	uuuu uuuu
1Ch ⁽²⁾	CCPR2H	Capture/Compare/PWM register2 (MSB)								xxxx xxxx	uuuu uuuu
1Dh ⁽²⁾	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 Compare and Timer1.

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, USART or CCP2 module, these bits are unimplemented, read as '0'.

PIC16C7X

TABLE 10-7: 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	TOIE	INTE	RBIE	TOIF	INTF	RBIF	0000 000x	0000 000u
0Ch	PIR1	PSPIF ^(1,2)	ADIF	RCIF ⁽²⁾	TXIF ⁽²⁾	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
0Dh ⁽²⁾	PIR2	—	—	—	—	—	—	—	CCP2IF	---- --0	---- --0
8Ch	PIE1	PSPIE ^(1,2)	ADIE	RCIE ⁽²⁾	TXIE ⁽²⁾	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
8Dh ⁽²⁾	PIE2	—	—	—	—	—	—	—	CCP2IE	---- --0	---- --0
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 ⁽²⁾	CCPR2L	Capture/Compare/PWM register2 (LSB)								xxxx xxxx	uuuu uuuu
1Ch ⁽²⁾	CCPR2H	Capture/Compare/PWM register2 (MSB)								xxxx xxxx	uuuu uuuu
1Dh ⁽²⁾	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.

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 I²C Multi-Master Environment."

Applicable Devices							
70	71	71A	72	73	73A	74	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 (I²C)

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/ \overline{A}	P	S	R/ \overline{W}	UA	BF
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: **D/ \overline{A} :** Data/Address bit (I²C mode only)
1 = Indicates that the last byte received or transmitted was data
0 = Indicates that the last byte received or transmitted was address

bit 4: **P:** Stop bit (I²C 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

bit 3: **S:** Start bit (I²C 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

bit 2: **R/ \overline{W} :** Read/Write bit information (I²C 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

bit 1: **UA:** Update Address (10-bit I²C mode only)
1 = Indicates that the user needs to update the address in the SSPADD register
0 = Address does not need to be updated

bit 0: **BF:** Buffer Full Status bit
Receive (SPI and I²C modes)
1 = Receive complete, SSPBUF is full
0 = Receive not complete, SSPBUF is empty
Transmit (I²C mode only)
1 = Transmit in progress, SSPBUF is full
0 = Transmit complete, SSPBUF is empty

PIC16C7X

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 I²C 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 SDK, SDO, and SDI as serial port pins
0 = Disables serial port and configures these pins as I/O port pins
In I²C 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 I²C 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 = I²C slave mode, 7-bit address
0111 = I²C slave mode, 10-bit address
1011 = I²C start and stop bit interrupts enabled (slave idle)
1110 = I²C slave mode, 7-bit address with start and stop bit interrupts enabled
1111 = I²C slave mode, 10-bit address with start and stop bit interrupts enabled

11.1 SPI Mode

Applicable Devices							
70	71	71A	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/ $\overline{AN4}/\overline{SS}$

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

```

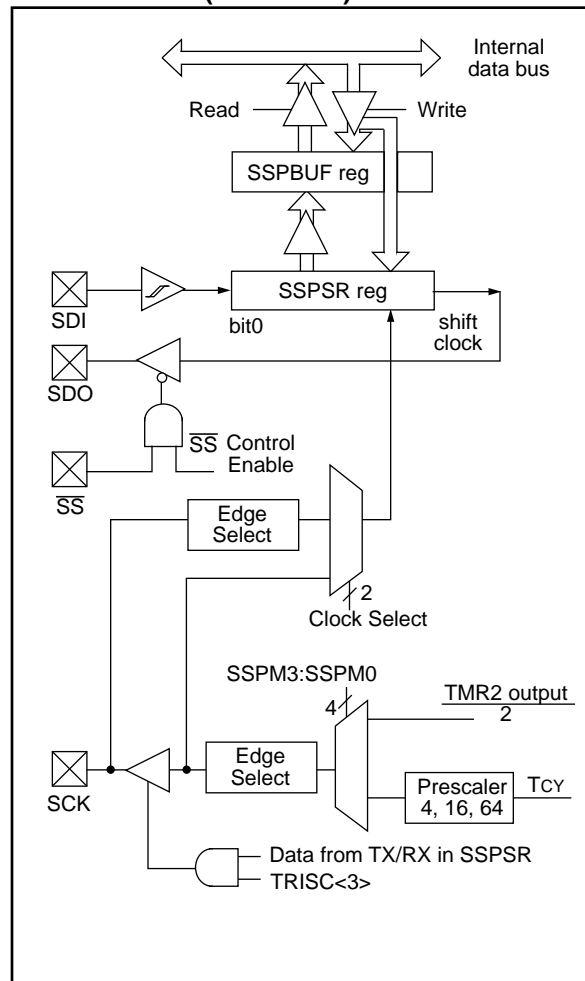
BSF    STATUS, RP0    ;Specify Bank 1
LOOP  BTFSS SSPSTAT, BF ;Has data been
                        ;received
                        ;(transmit
                        ;complete)?

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)



PIC16C7X

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.

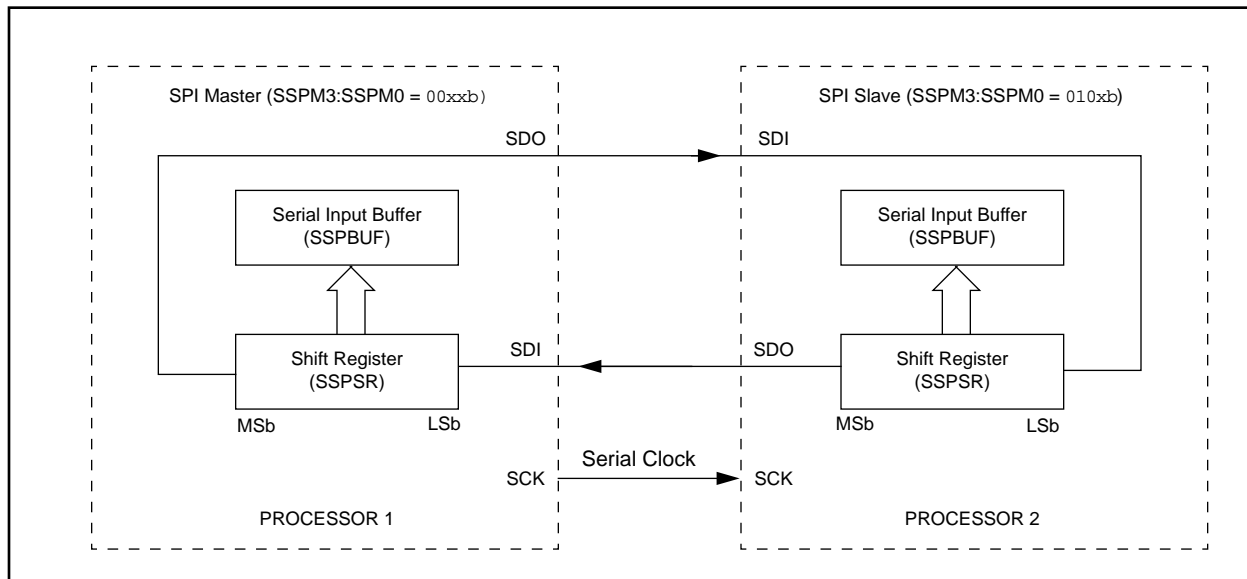
The clock polarity is selected by appropriately programming bit CKP (SSPCON<4>). This then would give waveforms for SPI communication as shown in Figure 11-5 and Figure 11-6 where the MSB is transmitted first. In master mode, the SPI clock rate (bit rate) is user programmable to be one of the following:

- $F_{OSC}/4$ (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 ($SSPCON<3:0> = 04h$) and the $TRISA<5>$ 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. 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)

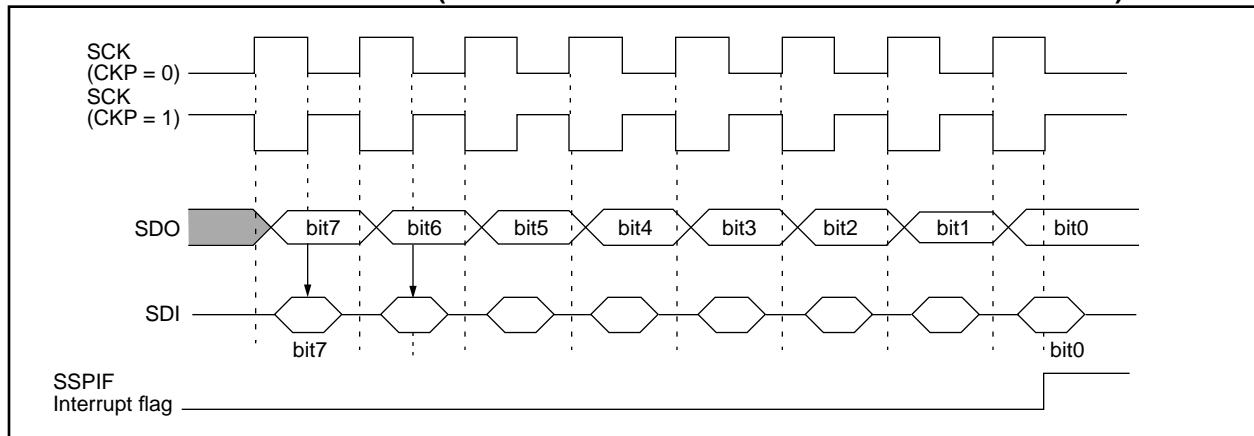
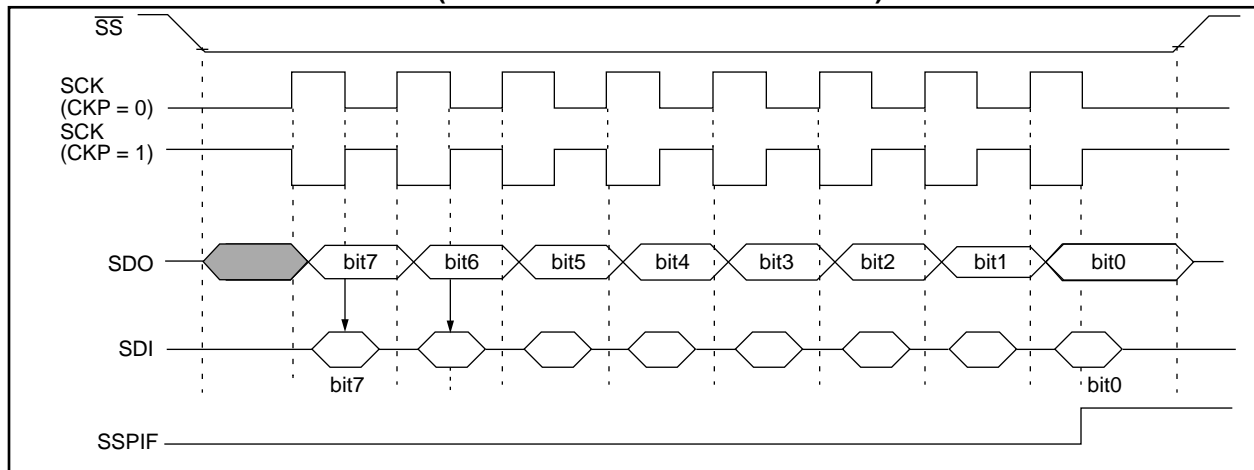


FIGURE 11-6: SPI MODE TIMING (SLAVE MODE WITH \overline{SS} CONTROL)



PIC16C7X

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 ^(1,2)	ADIF	RCIF ⁽²⁾	TXIF ⁽²⁾	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
8Ch	PIE1	PSPIE ^(1,2)	ADIE	RCIE ⁽²⁾	TXIE ⁽²⁾	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 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
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 I²C™ Overview

Applicable Devices

70	71	71A	72	73	73A	74	74A
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This section provides an overview of the Inter-Integrated Circuit (I²C) bus, with Section 11.3 discussing the operation of the SSP module in I²C mode.

The I²C 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 I²C 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 I²C bus terminology. For additional information on the I²C interface specification, refer to the Philips document “*The I²C bus and how to use it.*”, which can be obtained from the Philips Corporation.

In the I²C 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 I²C 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

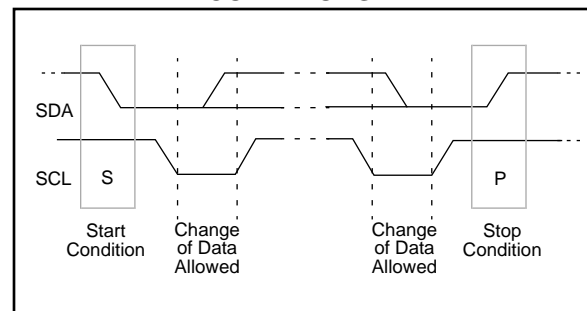


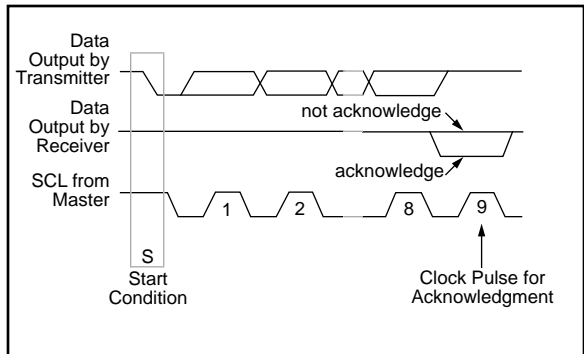
TABLE 11-2: I²C BUS TERMINOLOGY

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.

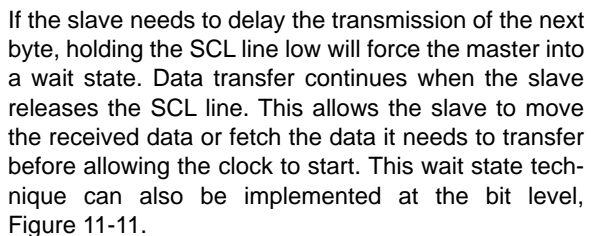
11.2.3 TRANSFER ACKNOWLEDGE

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 ($\overline{\text{ACK}}$) (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.



The diagram shows the timing relationship between the Serial Data (SDA) and Serial Clock (SCL) lines. The SCL signal is a periodic clock, while the SDA signal carries the data. The sequence of events is as follows:

- Start Condition (S):** The SDA line transitions from high to low while SCL is high.
- Address:** The first seven bits of the address (1-7) are transmitted. The first bit is labeled as the Most Significant Bit (MSB).
- R/W:** The eighth bit (8) indicates the direction of communication (Read/Write).
- ACK:** The ninth bit (9) is the acknowledgment from the receiver.
- Wait State:** The SCL line is held low while interrupts are serviced. This occurs after the first ACK and before the data transmission.
- Data:** The data is transmitted in a byte (bits 1-8).
- ACK:** The ninth bit (9) is the acknowledgment from the receiver.
- Stop Condition (P):** The SDA line transitions from low to high while SCL is high.

Annotations on the diagram include:

- MSB:** Most Significant Bit, pointing to the first address bit.
- acknowledgment signal from receiver:** Points to the ACK bits (9) after the address and data.
- byte complete interrupt with receiver:** Points to the end of the data byte (bit 8).
- clock line held low while interrupts are serviced:** Points to the 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

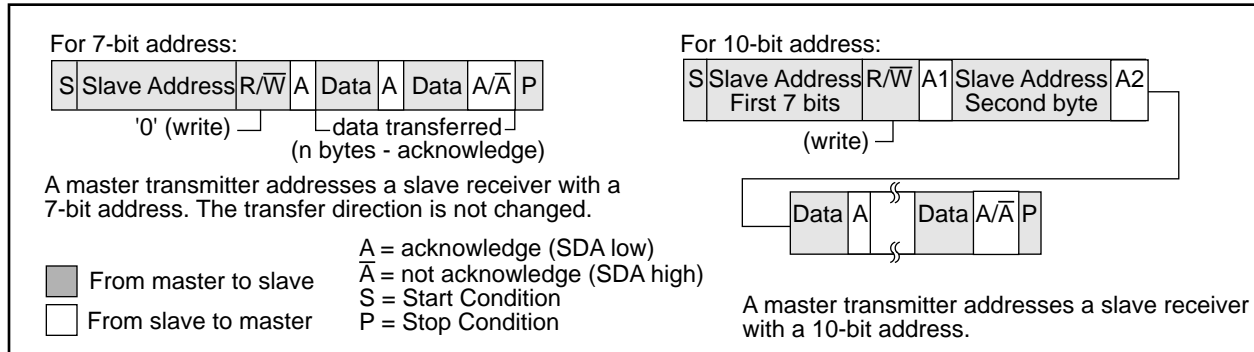


FIGURE 11-13: MASTER-RECEIVER SEQUENCE

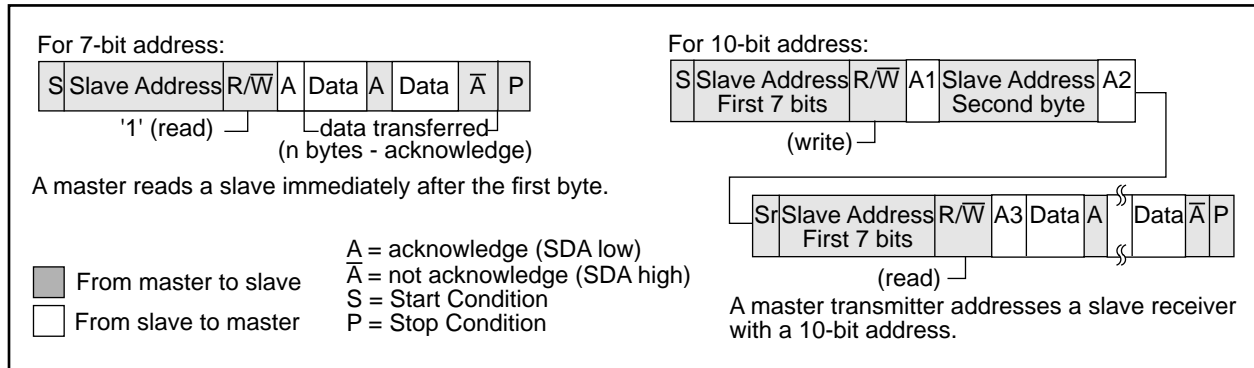
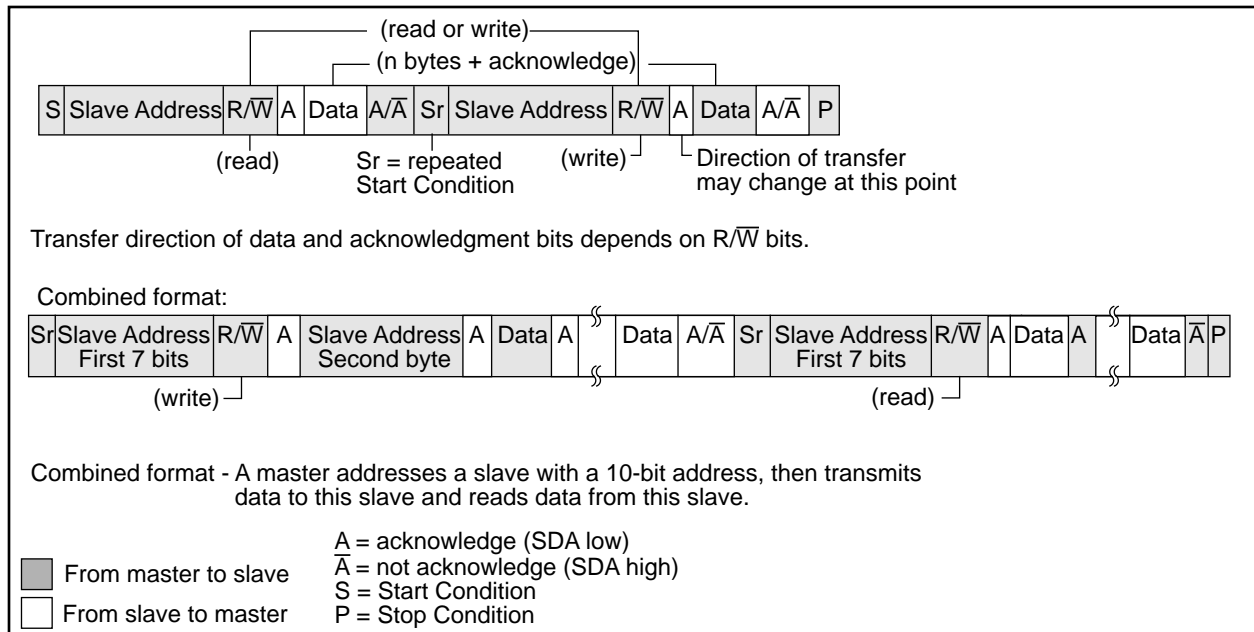


FIGURE 11-14: COMBINED FORMAT



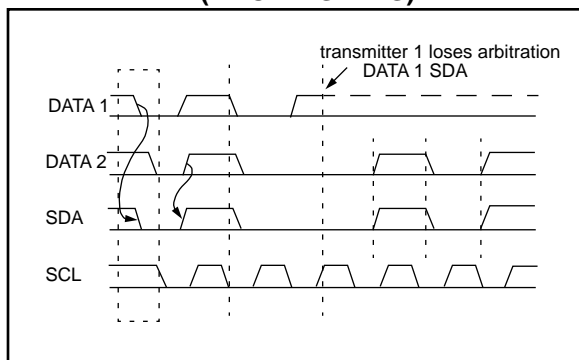
11.2.4 MULTI-MASTER

The I²C 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:

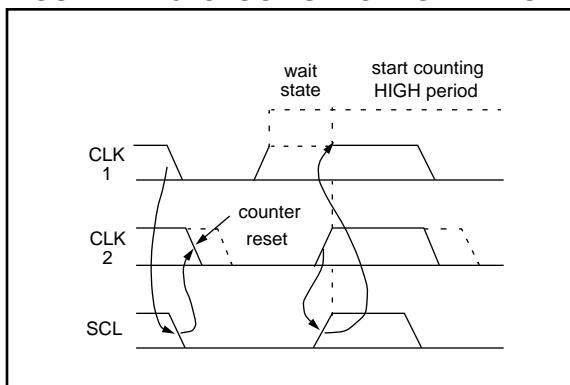
- A repeated START condition
- A STOP condition and a data bit
- A repeated START condition and a STOP condition

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

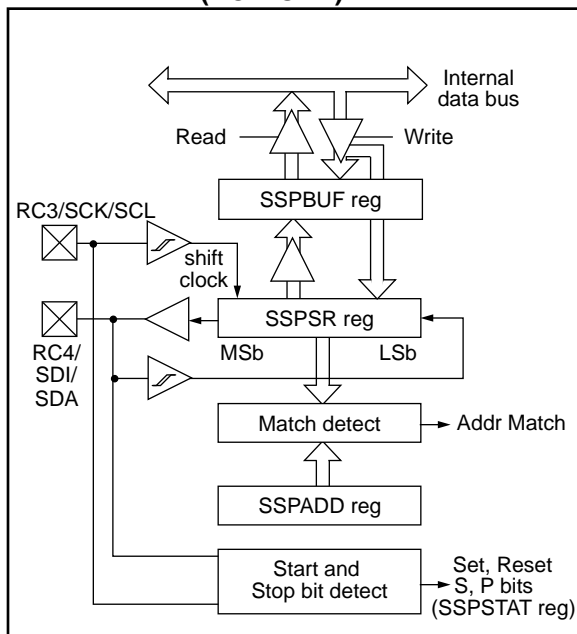


11.3 SSP I²C Operation

Applicable Devices							
70	71	71A	72	73	73A	74	74A

The SSP module in I²C 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 (I²C MODE)



The SSP module has five registers for I²C 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 I²C operation. Four mode selection bits (SSPCON<3:0>) allow one of the following I²C modes to be selected:

- I²C Slave mode (7-bit address)
- I²C Slave mode (10-bit address)
- I²C Slave mode (7-bit address), with start and stop bit interrupts enabled
- I²C Slave mode (10-bit address), with start and stop bit interrupts enabled
- I²C start and stop bit interrupts enabled, slave is idle

Selection of any I²C 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).

PIC16C7X

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 for proper operation. The high and low times of the I²C specification as well as the requirement of the SSP module is shown in timing parameter #100 and parameter #101.

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 10-bit address are 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

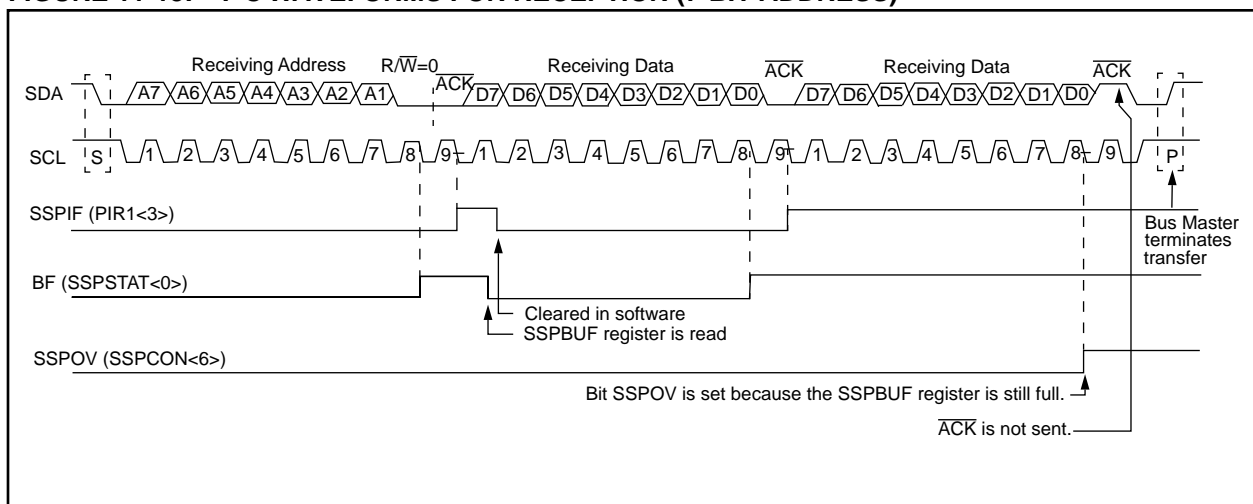
11.3.1.2 RECEPTION

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: I²C WAVEFORMS FOR RECEPTION (7-BIT ADDRESS)



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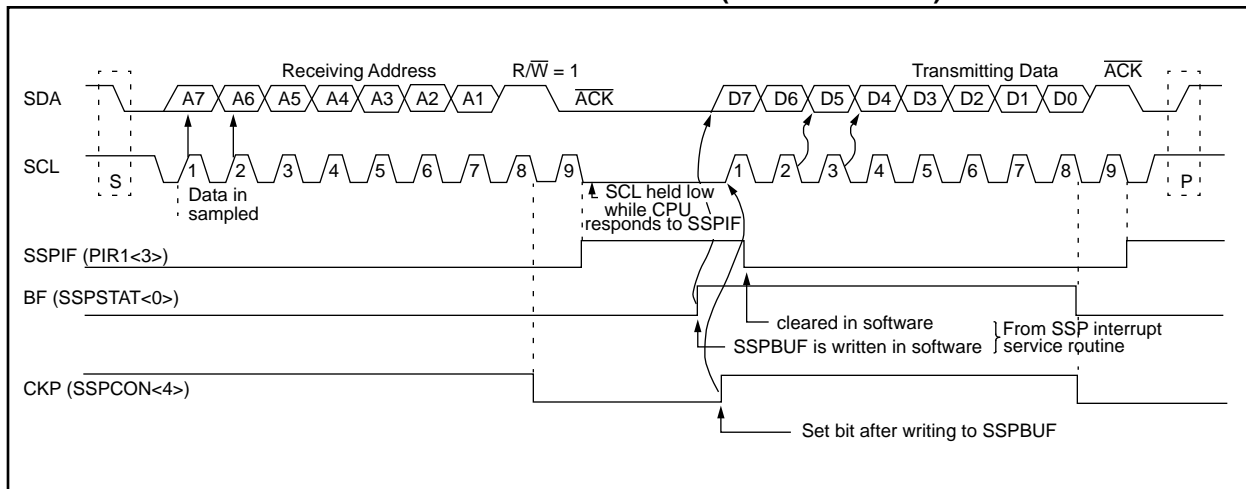
11.3.1.3 TRANSMISSION

When the R/\overline{W} bit of the incoming address byte is set and an address match occurs, the R/\overline{W} bit of the SSPSTAT register is set. The received address is loaded into the SSPBUF register. The \overline{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 \overline{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 \overline{ACK}), then the data transfer is complete. The slave then monitors for another occurrence of the START bit. If the SDA line was low (\overline{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: I²C 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 I²C bus may be taken when the P bit is set, or the bus is idle and both the S and P bits are 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 PORTB<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 SSPIF 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 I²C bus may be taken when bit P (SSPSTAT<4>) is set, or the bus is idle and both the S and P bits are cleared. 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, these 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{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 I²C 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	TOIE	INTE	RBIE	TOIF	INTF	RBIF	0000 000x	0000 000u
0Ch	PIR1	PSPIF ^(1,2)	ADIF	RCIF ⁽²⁾	TXIF ⁽²⁾	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
8Ch	PIE1	PSPIE ^(1,2)	ADIE	RCIE ⁽²⁾	TXIE ⁽²⁾	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
13h	SSPBUF	Synchronous Serial Port Receive Buffer/Transmit Register								xxxx xxxx	uuuu uuuu
93h	SSPAD	Synchronous Serial Port (I ² 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/A	P	S	R/W	UA	BF	--00 0000	--00 0000
89h	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 I²C 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'.

PIC16C7X

FIGURE 11-20: OPERATION OF THE I²C MODULE IN IDLE_MODE, RCV_MODE OR XMIT_MODE

IDLE_MODE (7-bit):

```

if (Addr_match)      {      Set interrupt;
                        if (R/W = 1)  {      Send  $\overline{ACK}$  = 0;
                                                set XMIT_MODE;
                                                }
                        else if (R/W = 0) set RCV_MODE;
                    }

```

RCV_MODE:

```

if ((SSPBUF=Full) OR (SSPOV = 1))
    {      Set SSPOV;
            Do not acknowledge;
    }

else      {      transfer SSPSR → SSPBUF;
                send  $\overline{ACK}$  = 0;
            }

Receive 8-bits in SSPSR;
Set interrupt;

```

XMIT_MODE:

```

While ((SSPBUF = Empty) AND (CKP=0)) Hold SCL Low;
Send byte;
Set interrupt;
if (  $\overline{ACK}$  Received = 1)      {      End of transmission;
                                Go back to IDLE_MODE;
                            }

else if (  $\overline{ACK}$  Received = 0) Go back to XMIT_MODE;

```

IDLE_MODE (10-Bit):

```

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  $\overline{ACK}$  = 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  $\overline{ACK}$  = 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  $\overline{ACK}$  = 0;
                    set XMIT_MODE;
            }

            else PRIOR_ADDR_MATCH = FALSE;
    }

```

12.0 UNIVERSAL SYNCHRONOUS ASYNCHRONOUS RECEIVER TRANSMITTER (USART)

Applicable Devices							
70	71	71A	72	73	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
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.

PIC16C7X

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
bit7							bit0

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

bit 7: **SPEN:** 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: **RX9:** 9-bit Receive Enable bit
1 = Selects 9-bit reception
0 = Selects 8-bit reception

bit 5: **SREN:** Single Receive Enable bit
Asynchronous mode
Don't care
Synchronous mode - master
1 = Enables single receive
0 = Disables single receive
This bit is cleared after reception is complete.
Synchronous mode - slave
Unused in this mode

bit 4: **CREN:** Continuous Receive Enable bit
Asynchronous mode
1 = Enables continuous receive
0 = Disables continuous receive
Synchronous mode
1 = Enables continuous receive until enable bit CREN is cleared (CREN overrides SREN)
0 = Disables continuous receive

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

bit 2: **FERR:** Framing Error bit
1 = Framing error (Can be updated by reading RCREG register)
0 = No framing error

bit 1: **OERR:** Overrun Error bit
1 = Overrun error (Can be cleared by clearing bit CREN)
0 = No overrun error

bit 0: **RX9D:** 9th bit of received data (Can be parity bit)

12.1 USART Baud Rate Generator (BRG)

Applicable Devices							
70	71	71A	72	73	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

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

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

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 = $\text{FOSC}/(64(X+1))$	Baud Rate = $\text{FOSC}/(16(X+1))$
1	(Synchronous) Baud Rate = $\text{FOSC}/(4(X+1))$	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.

PIC16C7X

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			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)
0.3	NA	-	-	NA	-	-	NA	-	-	0.303	+1.14	26
1.2	NA	-	-	NA	-	-	1.202	+0.16	207	1.170	-2.48	6
2.4	NA	-	-	NA	-	-	2.404	+0.16	103	NA	-	-
9.6	9.6	0	131	9.622	+0.23	92	9.615	+0.16	25	NA	-	-
19.2	19.2	0	65	19.04	-0.83	46	19.24	+0.16	12	NA	-	-
76.8	79.2	+3.13	15	74.57	-2.90	11	83.34	+8.51	2	NA	-	-
96	97.48	+1.54	12	99.43	+3.57	8	NA	-	-	NA	-	-
300	316.8	+5.60	3	298.3	-0.57	2	NA	-	-	NA	-	-
500	NA	-	-	NA	-	-	NA	-	-	NA	-	-
HIGH	1267	-	0	894.9	-	0	250	-	0	8.192	-	0
LOW	4.950	-	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			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)
0.3	0.31	+3.13	255	0.301	+0.23	185	0.300	+0.16	51	0.256	-14.67	1
1.2	1.2	0	65	1.190	-0.83	46	1.202	+0.16	12	NA	-	-
2.4	2.4	0	32	2.432	+1.32	22	2.232	-6.99	6	NA	-	-
9.6	9.9	+3.13	7	9.322	-2.90	5	NA	-	-	NA	-	-
19.2	19.8	+3.13	3	18.64	-2.90	2	NA	-	-	NA	-	-
76.8	79.2	+3.13	0	NA	-	-	NA	-	-	NA	-	-
96	NA	-	-	NA	-	-	NA	-	-	NA	-	-
300	NA	-	-	NA	-	-	NA	-	-	NA	-	-
500	NA	-	-	NA	-	-	NA	-	-	NA	-	-
HIGH	79.2	-	0	55.93	-	0	15.63	-	0	0.512	-	0
LOW	0.3094	-	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			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)
9.6	9.6	0	32	9.727	+1.32	22	8.928	-6.99	6	NA	-	-
19.2	18.645	-2.94	16	18.643	-2.90	11	20.833	+8.51	2	NA	-	-
38.4	39.6	+3.12	7	37.286	-2.90	5	31.25	-18.61	1	NA	-	-
57.6	52.8	-8.33	5	55.930	-2.90	3	62.5	+8.51	0	NA	-	-
115.2	105.6	-8.33	2	111.860	-2.90	1	NA	-	-	NA	-	-
250	NA	-	-	223.721	-10.51	0	NA	-	-	NA	-	-
625	NA	-	-	NA	-	-	NA	-	-	NA	-	-
1250	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)

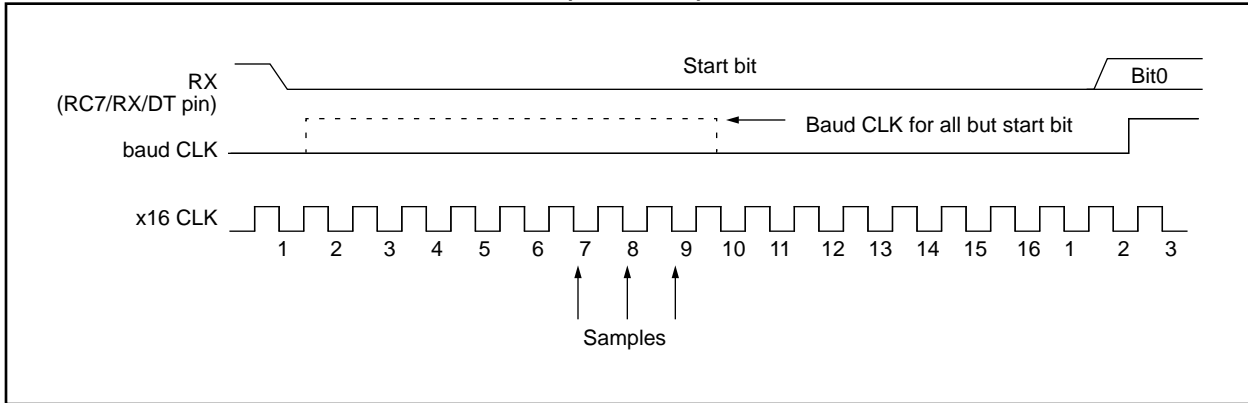


FIGURE 12-4: RX PIN SAMPLING SCHEME (BRGH = 1)

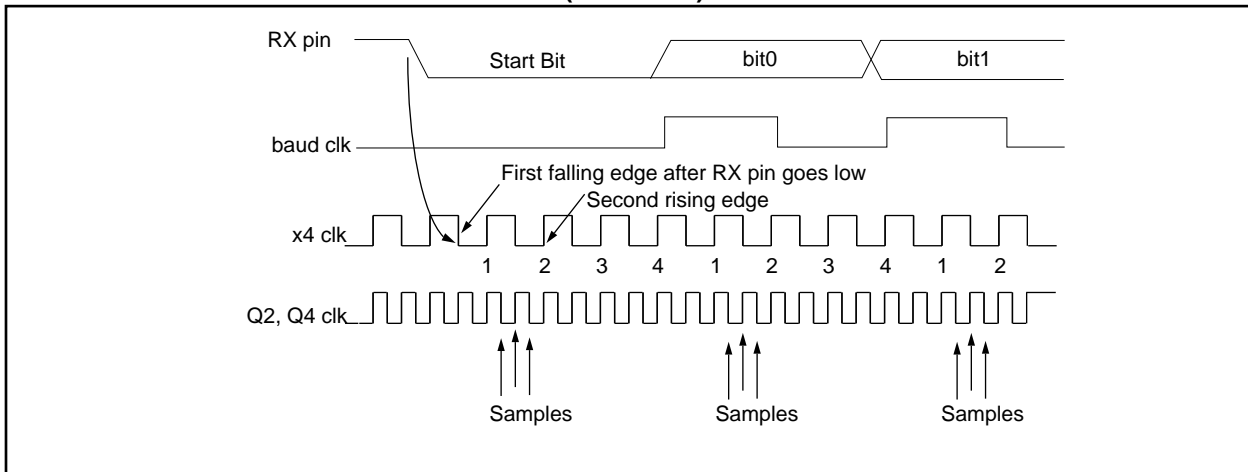
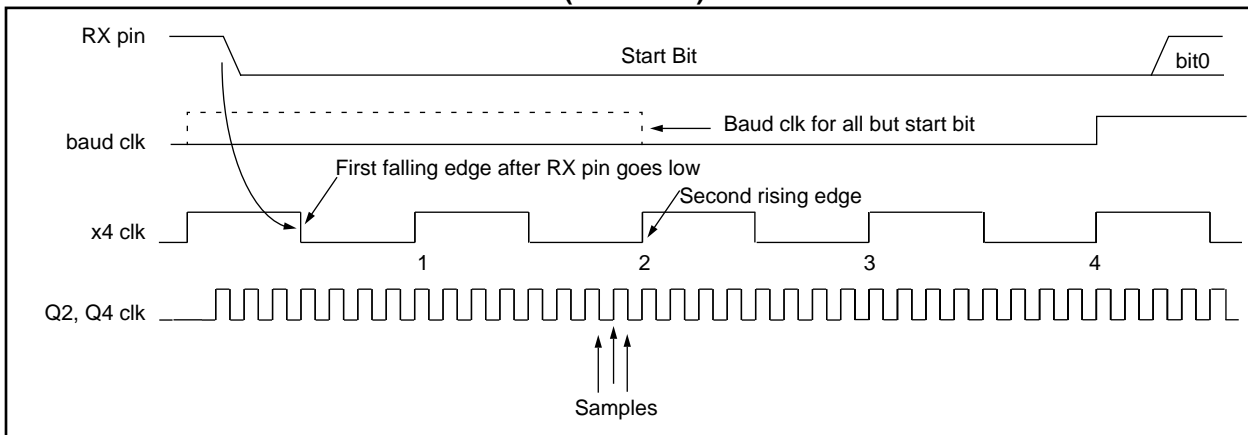


FIGURE 12-5: RX PIN SAMPLING SCHEME (BRGH = 1)



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

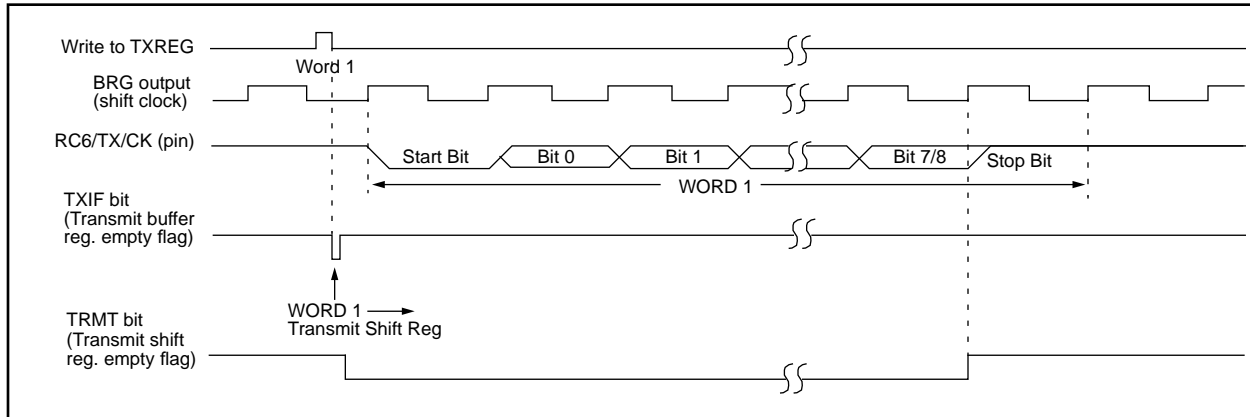


FIGURE 12-8: ASYNCHRONOUS MASTER TRANSMISSION (BACK TO BACK)

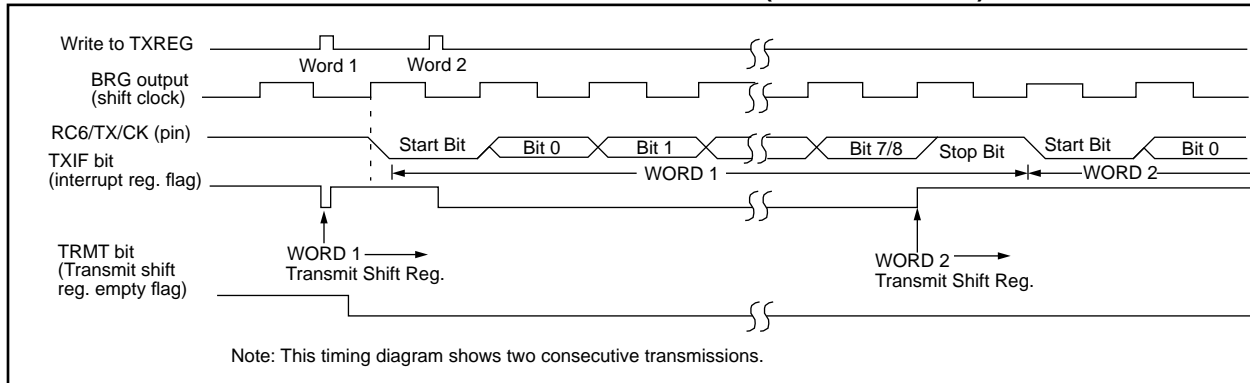


TABLE 12-6: REGISTERS ASSOCIATED WITH ASYNCHRONOUS TRANSMISSION

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 ⁽¹⁾	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 ⁽¹⁾	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 or disabled by setting/clearing enable bit RCIE (PIE1<5>). Flag bit RCIF is a read only bit which is reset 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

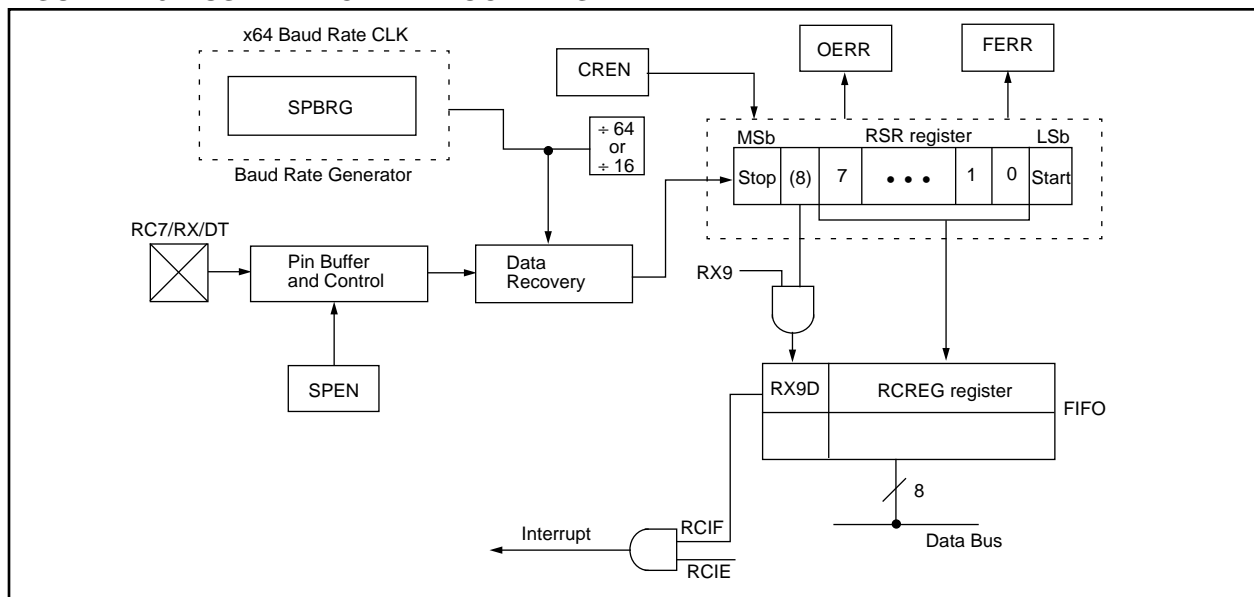
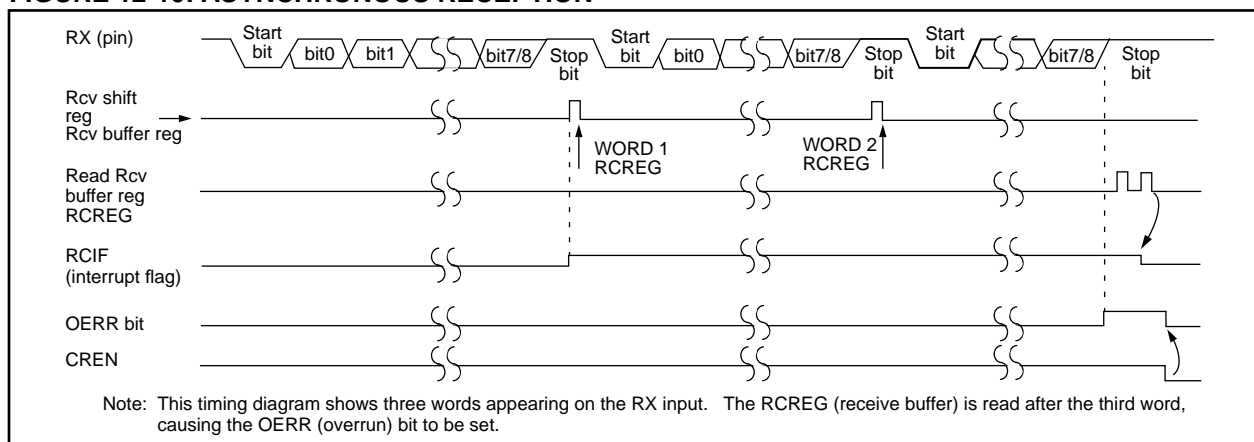


FIGURE 12-10: ASYNCHRONOUS RECEPTION



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 were 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 ⁽¹⁾	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 ⁽¹⁾	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							
70	71	71A	72	73	73A	74	74A

In Master Synchronous 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. The 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 an interrupt bit, TXIF (PIR1<4>) is set. The interrupt can be enabled or 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 are 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 ⁽¹⁾	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 ⁽¹⁾	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

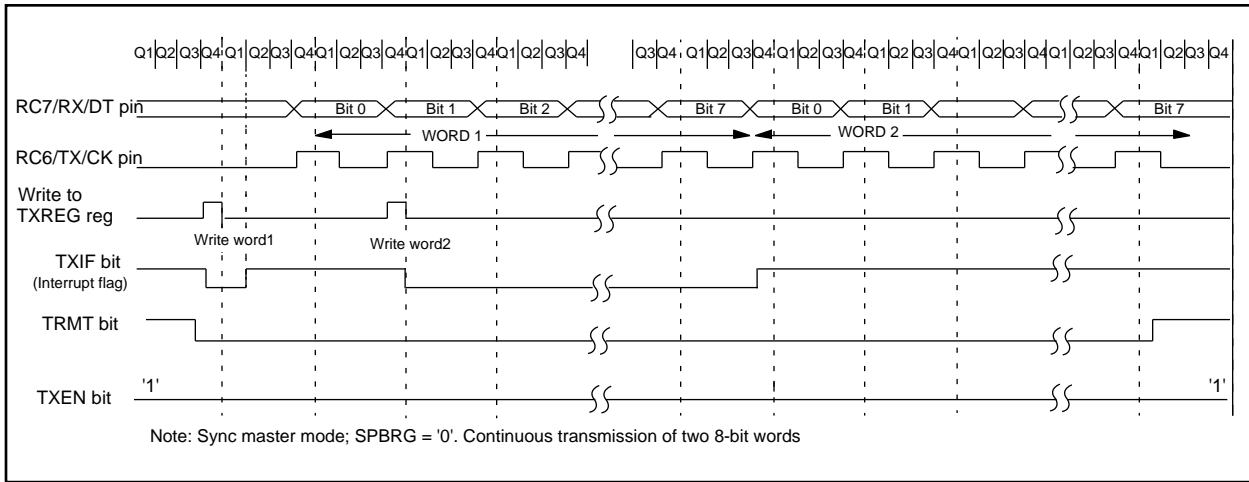
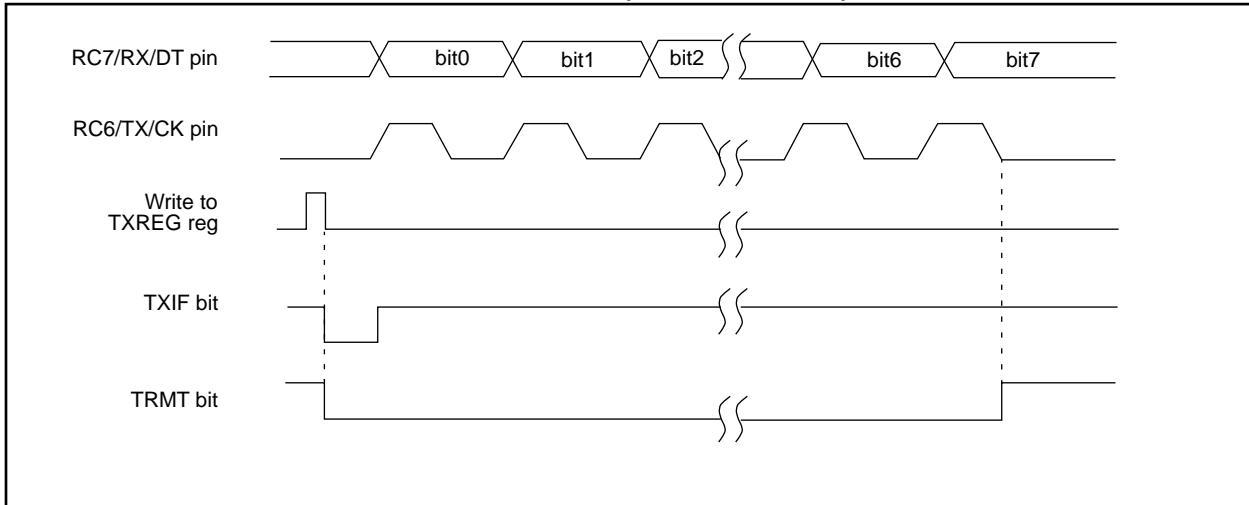


FIGURE 12-12: SYNCHRONOUS TRANSMISSION (THROUGH TXEN)



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.

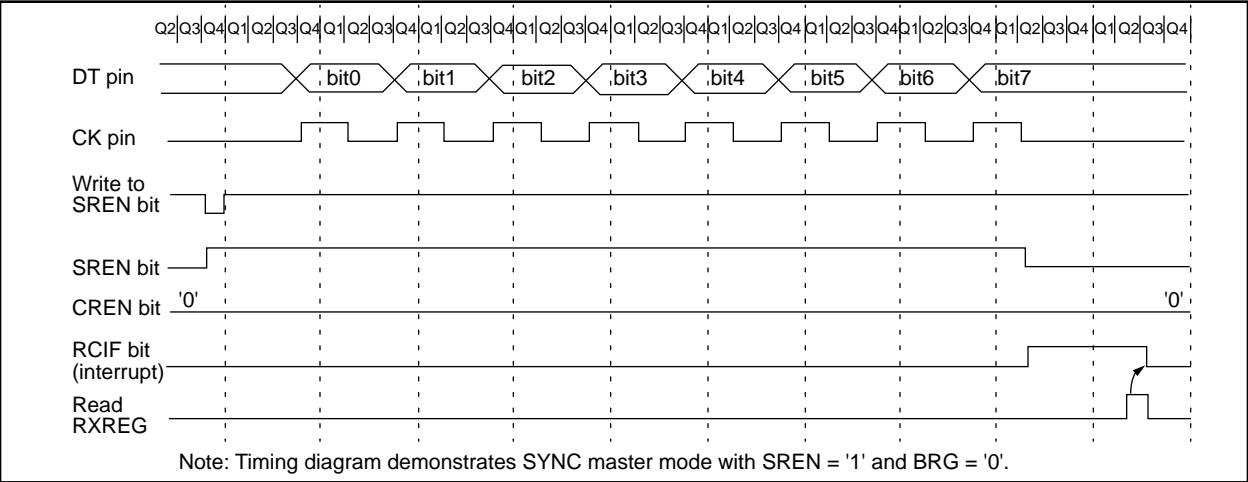
TABLE 12-9: REGISTERS ASSOCIATED WITH SYNCHRONOUS MASTER RECEPTION

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 ⁽¹⁾	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 ⁽¹⁾	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.

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



12.4 USART Synchronous Slave Mode

Applicable Devices

70	71	71A	72	73	73A	74	74A
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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 the 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 ⁽¹⁾	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 ⁽¹⁾	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 ⁽¹⁾	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 ⁽¹⁾	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

70	71	71A	72	73	73A	74	74A
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The analog-to-digital (A/D) converter module has four analog inputs for the PIC16C70/71/71A, 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, PIC16C70/71/71A (ADDRESS 08h)

R/W-0	R/W-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
ADCS1	ADCS0	___ (1)	CHS1	CHS0	GO/DONE	ADIF	ADON
bit7							bit0
<p>bit 7-6: ADCS1:ADCS0: A/D Conversion Clock Select bits 00 = FOSC/2 01 = FOSC/8 10 = FOSC/32 11 = FRC (clock derived from an RC oscillation)</p> <p>bit 5: Unimplemented: Read as '0'.</p> <p>bit 4-3: CHS2:CHS0: Analog Channel Select bits 00 = channel 0, (RA0/AN0) 01 = channel 1, (RA1/AN1) 10 = channel 2, (RA2/AN2) 11 = channel 3, (RA3/AN3)</p> <p>bit 2: GO/DONE: A/D Conversion Status bit If ADON = 1 1 = A/D conversion in progress (setting this bit starts the A/D conversion) 0 = A/D conversion not in progress (This bit is automatically cleared by hardware when the A/D conversion is complete)</p> <p>bit 1: ADIF: A/D Conversion Complete Interrupt Flag bit 1 = conversion is complete (must be cleared in software) 0 = conversion is not complete</p> <p>bit 0: ADON: A/D On bit 1 = A/D converter module is operating 0 = A/D converter module is shutoff and consumes no operating current</p> <p>Note 1: Bit5 of ADCON0 is a General Purpose R/W bit for the PIC16C71 only. For the PIC16C70/71A, this bit is unimplemented, read as '0'.</p>							

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

PIC16C7X

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

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	U-0	R/W-0
ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/DONE	—	ADON
bit7							bit0

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

bit 7-6: **ADCS1:ADCS0:** A/D Conversion Clock Select bits
00 = Fosc/2
01 = Fosc/8
10 = Fosc/32
11 = FRC (clock derived from an RC oscillation)

bit 5-3: **CHS2:CHS0:** Analog Channel Select bits
000 = channel 0, (RA0/AN0)
001 = channel 1, (RA1/AN1)
010 = channel 2, (RA2/AN2)
011 = channel 3, (RA3/AN3)
100 = channel 4, (RA5/AN4)
101 = channel 5, (RE0/AN5)
110 = channel 6, (RE1/AN6)
111 = channel 7, (RE2/AN7)

bit 2: **GO/DONE:** A/D Conversion Status bit
If ADON = 1
1 = A/D conversion in progress (setting this bit starts the A/D conversion)
0 = A/D conversion not in progress (This bit is automatically cleared by hardware when the A/D conversion is complete)

bit 1: **Unimplemented:** Read as '0'

bit 0: **ADON:** A/D On bit
1 = A/D converter module is operating
0 = A/D converter module is shutoff and consumes no operating current

FIGURE 13-3: ADCON1 REGISTER FOR PIC16C70/71/71A (ADDRESS 88h)

U-0	U-0	U-0	U-0	U-0	U-0	R/W-0	R/W-0
—	—	—	—	—	—	PCFG1	PCFG0
bit7							bit0

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

bit 7-2: **Unimplemented:** Read as '0'

bit 1-0: **PCFG1:PCFG0:** A/D Port Configuration Control bits

PCFG1:PCFG0	RA1 & RA0	RA2	RA3	VREF
00	A	A	A	VDD
01	A	A	VREF	RA3
10	A	D	D	VDD
11	D	D	D	VDD

A = Analog input
D = Digital I/O

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

U-0	U-0	U-0	U-0	U-0	R/W-0	R/W-0	R/W-0		
—	—	—	—	—	PCFG2	PCFG1	PCFG0		
bit7					bit0				

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

bit 7-3: **Unimplemented:** Read as '0'

bit 2-0: **PCFG2:PCFG0:** A/D Port Configuration Control bits

PCFG2:PCFG0	RA0	RA1	RA2	RA5	RA3	RE0	RE1	RE2	VREF
000	A	A	A	A	A	A	A	A	VDD
001	A	A	A	A	VREF	A	A	A	RA3
010	A	A	A	A	A	D	D	D	VDD
011	A	A	A	A	VREF	D	D	D	RA3
100	A	A	D	D	A	D	D	D	VDD
101	A	A	D	D	VREF	D	D	D	RA3
11x	D	D	D	D	D	D	D	D	—

A = Analog input
D = Digital I/O

PIC16C7X

The ADRES register contains the result of the A/D conversion. When the A/D conversion is completed, 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 sampled 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 sample 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 sampling 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 cleared
 - OR
 - 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 T_{AD} . A minimum wait of $2T_{AD}$ is required before next sampling starts.

FIGURE 13-5: A/D BLOCK DIAGRAM, PIC16C70/71/71A

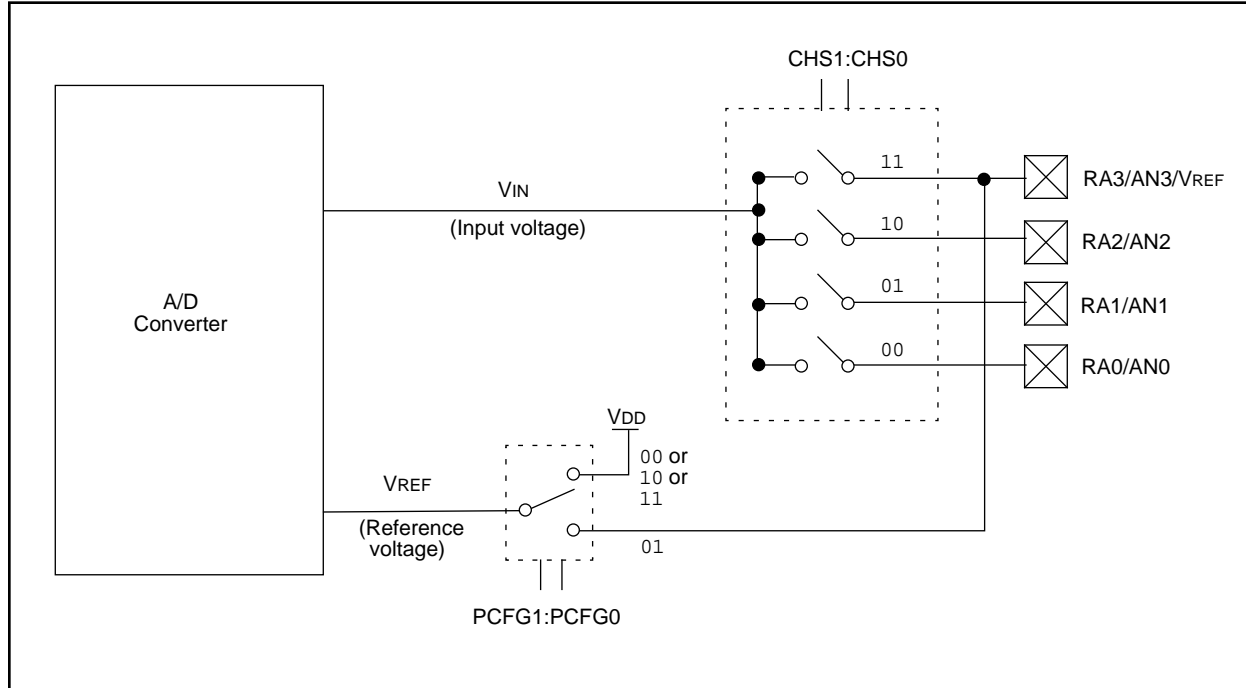
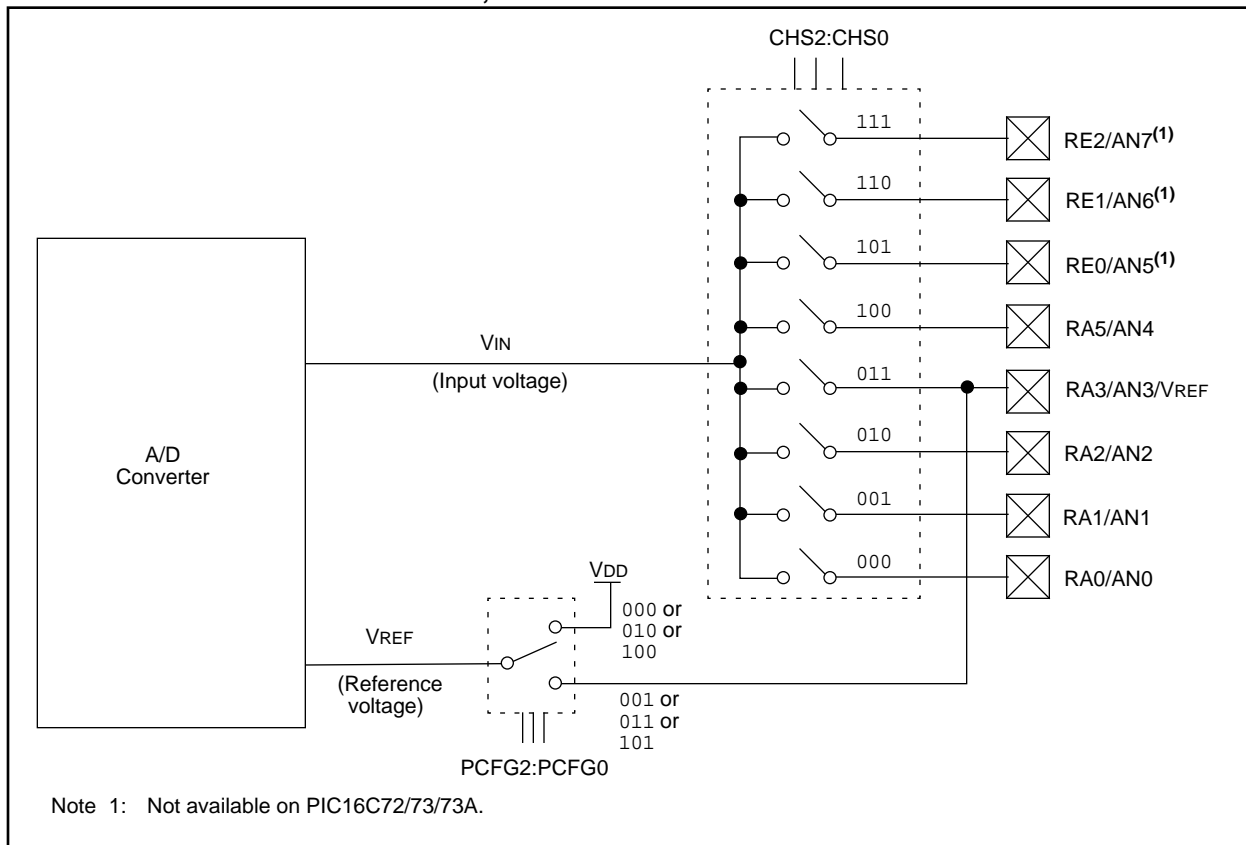


FIGURE 13-6: A/D BLOCK DIAGRAM, PIC16C72/73/73A/74/74A



13.1 A/D Sampling Requirements

Applicable Devices

70	71	71A	72	73	73A	74	74A
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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 sampling must be done before the conversion can be started.

To calculate the minimum sampling 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

$$V_{HOLD} = (V_{REF} - (V_{REF}/512)) \cdot (1 - e^{(-T_c/CHOLD(RIC + RSS + RS))})$$

or

$$T_c = -(51.2 \text{ pF})(1 \text{ k}\Omega + RSS + RS) \ln(1/511)$$

Example 13-1 shows the calculation of the minimum required sample time TSMP. 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 sampling 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

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

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

$$T_c = -CHOLD (RIC + RSS + RS) \ln(1/512)$$

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

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

$$-0.921 \mu s (-6.2146)$$

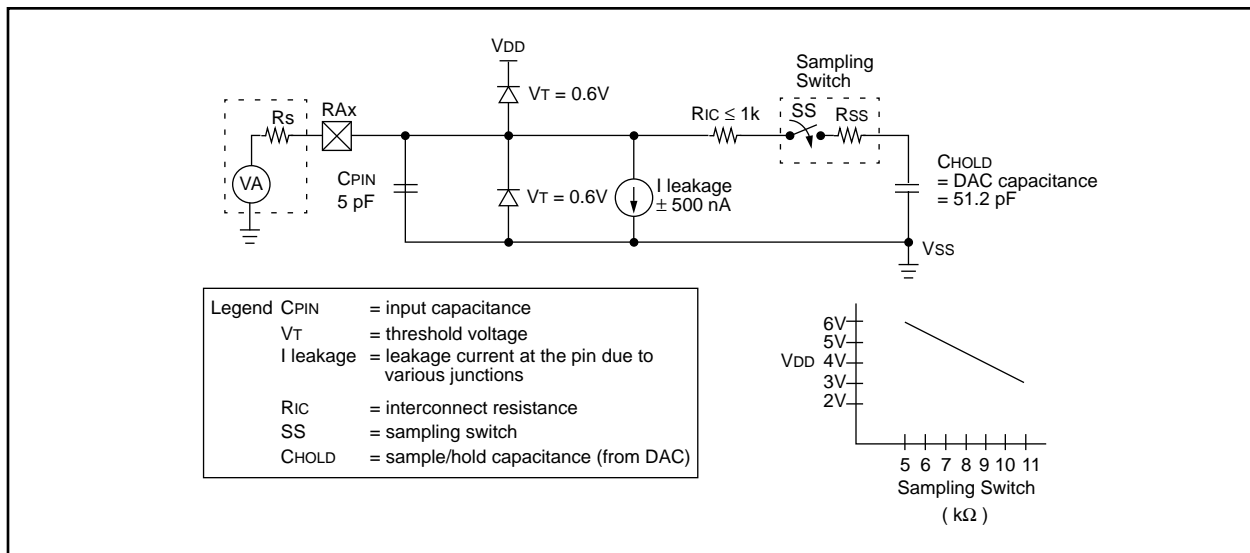
$$5.724 \mu s$$

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

$$10.724 \mu s + 1.25 \mu s$$

$$11.974 \mu s$$

FIGURE 13-7: ANALOG INPUT MODEL



13.2 Selecting the A/D Conversion Clock

Applicable Devices							
70	71	71A	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 µs for the PIC16C71

1.6 µs 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							
70	71	71A	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 ⁽²⁾	125 ns ⁽²⁾	500 ns ⁽²⁾	2.0 µs	6 µs
8TOSC	01	400 ns ⁽²⁾	500 ns ⁽²⁾	2.0 µs	8.0 µs	24 µs ⁽³⁾
32TOSC	10	1.6 µs ⁽²⁾	2.0 µs	8.0 µs	32.0 µs ⁽³⁾	96 µs ⁽³⁾
RC	11	2 - 6 µs ^(1,4)	2 - 6 µs ^(1,4)	2 - 6 µs ^(1,4)	2 - 6 µs ⁽¹⁾	2 - 6 µs ⁽¹⁾

Note 1: The RC source has a typical TAD time of 4 µs.

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.

TABLE 13-2: TAD vs. DEVICE OPERATING FREQUENCIES, PIC16C70/71A/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 ⁽²⁾	400 ns ⁽²⁾	1.6 µs	6 µs
8TOSC	01	400 ns ⁽²⁾	1.6 µs	6.4 µs	24 µs ⁽³⁾
32TOSC	10	1.6 µs	6.4 µs	25.6 µs ⁽³⁾	96 µs ⁽³⁾
RC	11	2 - 6 µs ^(1,4)	2 - 6 µs ^(1,4)	2 - 6 µs ^(1,4)	2 - 6 µs ⁽¹⁾

Note 1: The RC source has a typical TAD time of 4 µs.

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.

PIC16C7X

13.4 A/D Conversions

Applicable Devices

70	71	71A	72	73	73A	74	74A
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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 sampling is started. After this 2TAD wait, sampling is automatically started on the selected channel.

EXAMPLE 13-2: DOING AN A/D CONVERSION (PIC16C70/71/71A)

```
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    PIR1, ADIF          ; 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 sampling 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) ⁽¹⁾	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.

13.5 A/D Operation During Sleep

Applicable Devices							
70	71	71A	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							
70	71	71A	72	73	73A	74	74A

The overall accuracy of the A/D is less than ± 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 derived from the device oscillator, 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							
70	71	71A	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							
70	71	71A	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 sampling period with minimal software overhead (moving the ADRES to the desired location). The appropriate analog input channel must be selected and the minimum sampling 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

70	71	71A	72	73	73A	74	74A
----	----	-----	----	----	-----	----	-----

If the input voltage exceeds the rail values (VSS or VDD) by greater than 0.2V, then the accuracy of the conversion is out of specification.

Note: For the PIC16C70/71/71A, 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 Ω 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

70	71	71A	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

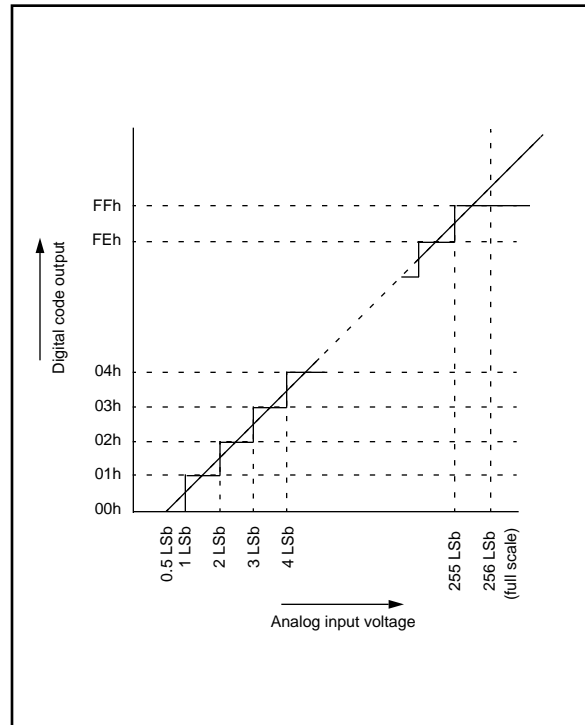
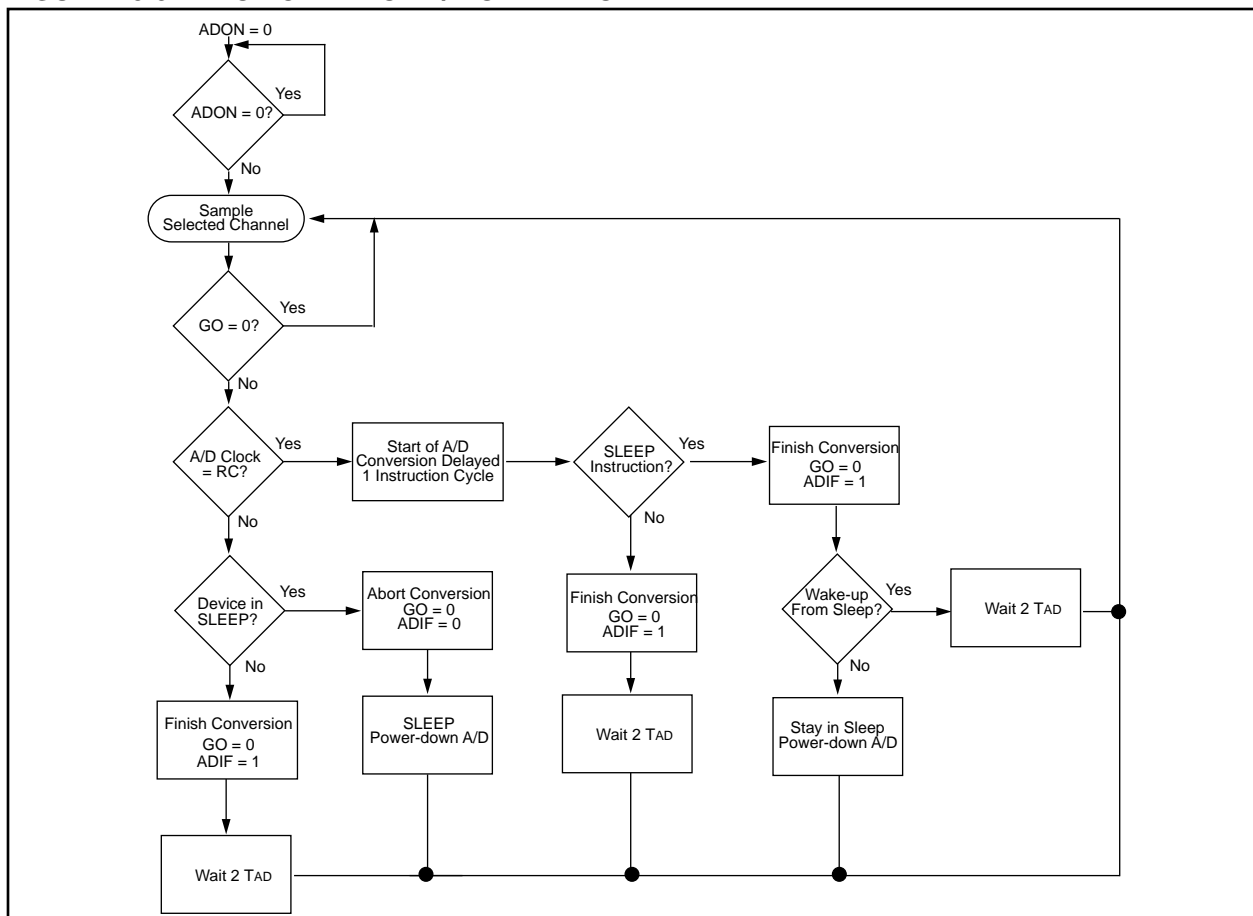


FIGURE 13-9: FLOWCHART OF A/D OPERATION



PIC16C7X

TABLE 13-3: SUMMARY OF A/D REGISTERS, PIC16C70/71/71A

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 xxxx	---u uuuu
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	--xx xxxx	--uu uuuu
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 ⁽¹⁾	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
8Ch	PIE1	PSPIE ⁽¹⁾	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	--xx xxxx	--uu uuuu
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							
70	71	71A	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:

- OSC 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.

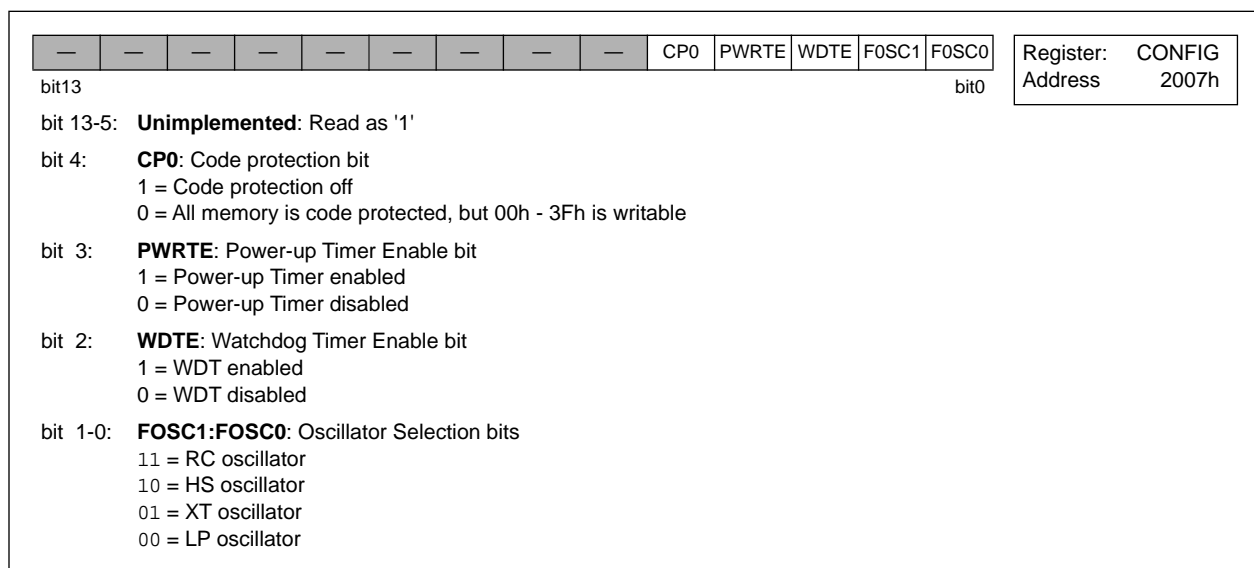
14.1 Configuration Bits

Applicable Devices							
70	71	71A	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 PIC16C70/71A

CP0	CP0	CP0	CP0	CP0	CP0	CP0	BODEN	CP0	CP0	PWRT \overline{E}	WDTE	F0SC1	F0SC0	Register: CONFIG Address 2007h
bit13										bit0				
bit 13-7 CP0 : Code protection bits ⁽²⁾														
5-4: 1 = Code protection off														
0 = All memory is code protected, but 00h - 3Fh is writable														
bit 6: BODEN : Brown-out Reset Enable bit ⁽¹⁾														
1 = BOR enabled														
0 = BOR disabled														
bit 3: PWRT\overline{E} : Power-up Timer Enable bit ⁽¹⁾														
1 = PWRT disabled														
0 = PWRT enabled														
bit 2: WDTE : Watchdog Timer Enable bit														
1 = WDT enabled														
0 = WDT disabled														
bit 1-0: F0SC1:F0SC0 : 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 PWRT\overline{E} . Ensure the Power-up Timer is enabled anytime Brown-out Reset is enabled.														
2: All of the CP0 bits have to be given the same value to enable the code protection scheme listed.														

FIGURE 14-3: CONFIGURATION WORD FOR PIC16C73/74

—	—	—	—	—	—	—	—	CP1	CP0	PWRT \overline{E}	WDTE	F0SC1	F0SC0	Register: CONFIG
bit13													bit0	Address 2007h
bit 13-5: Unimplemented: Read as '1'														
bit 4: CP1:CP0: Code protection bits														
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 3: PWRT\overline{E}: Power-up Timer Enable bit														
1 = Power-up Timer enabled														
0 = Power-up Timer disabled														
bit 2: WDTE: Watchdog Timer Enable bit														
1 = WDT enabled														
0 = WDT disabled														
bit 1-0: F0SC1:F0SC0: Oscillator Selection bits														
11 = RC oscillator														
10 = HS oscillator														
01 = XT oscillator														
00 = LP oscillator														

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: CP1:CP0: Code Protection bits ⁽²⁾ 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: Unimplemented: Read as '1'														
bit 6: BODEN: Brown-out Reset Enable bit ⁽¹⁾ 1 = BOR enabled 0 = BOR disabled														
bit 3: PWRT\overline{E}: Power-up Timer Enable bit ⁽¹⁾ 1 = PWRT disabled 0 = PWRT enabled														
bit 2: WDTE: Watchdog Timer Enable bit 1 = WDT enabled 0 = WDT disabled														
bit 1-0: FOSC1:FOSC0: 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 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

70	71	71A	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)

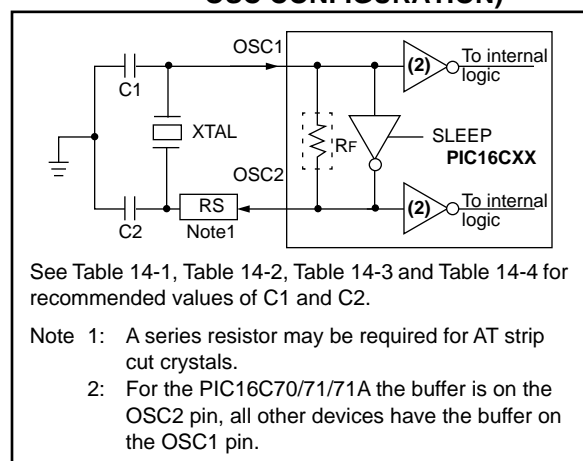
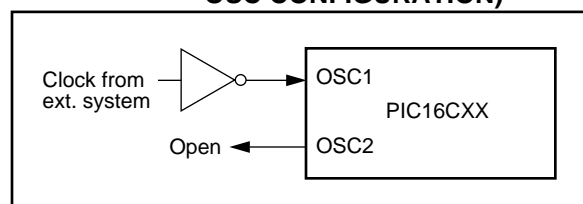


FIGURE 14-6: EXTERNAL CLOCK INPUT OPERATION (HS, XT OR LP OSC CONFIGURATION)



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.</p> <p>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
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.			

**TABLE 14-3: CERAMIC RESONATORS
PIC16C70/71A/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.</p> <p>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 PIC16C70/71A/72/73/73A/
74/74A**

Mode	Freq	OSC1	OSC2
LP	32 kHz ⁽¹⁾	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
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.			
Note 1: For VDD > 4.5V, C1 = C2 ≈ 30 pF is recommended.			

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 Ω resistor provides the negative feedback for stability. The 10 k Ω 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

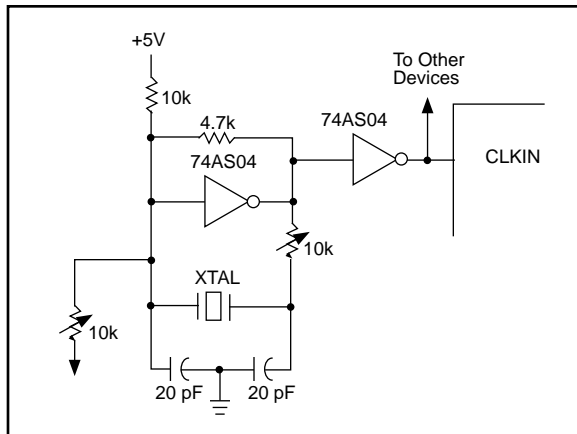
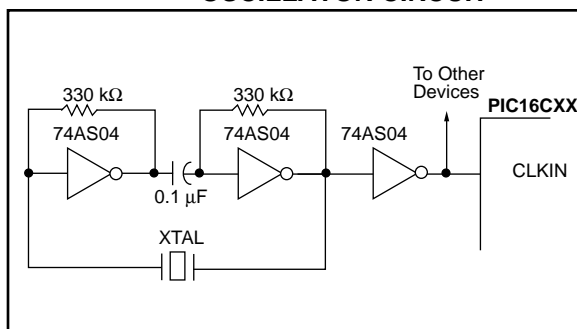


Figure 14-8 shows a series resonant oscillator circuit. This circuit is also designed to use the fundamental frequency of the crystal. The inverter performs a 180-degree phase shift in a series resonant oscillator circuit. The 330 k Ω resistors provide the negative feedback to bias the inverters in their 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 Ω , the oscillator operation may become unstable, or stop completely. For very high R_{ext} values (e.g. 1 M Ω), the oscillator becomes sensitive to noise, humidity and leakage. Thus, we recommend to keep R_{ext} between 3 k Ω and 100 k Ω .

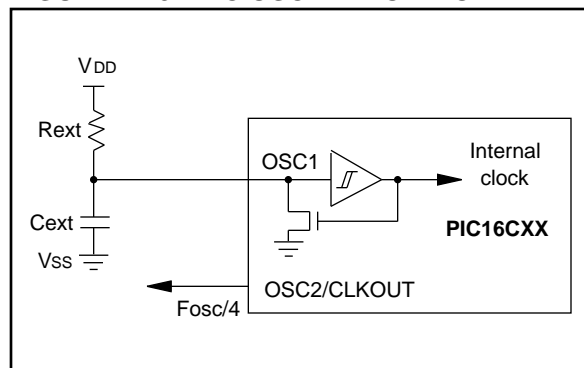
Although the oscillator will operate with no external capacitor (C_{ext} = 0 pF), we recommend using values above 20 pF for noise and stability reasons. With no or small external capacitance, the oscillation frequency can vary dramatically due to changes in external capacitances, such as PCB trace capacitance 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							
70	71	71A	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) (PIC16C70/71A/72/73A/74A only)

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

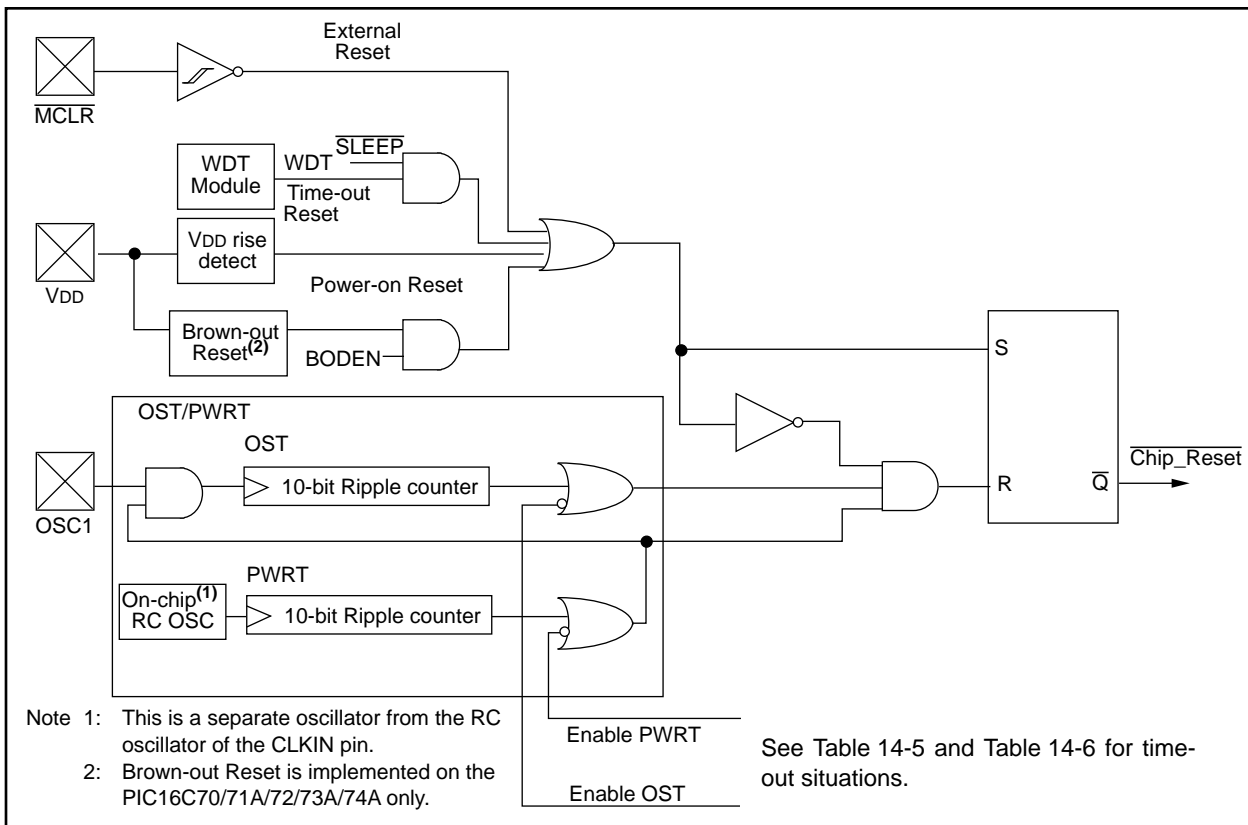
Table 14-7 and Table 14-8. These bits are used in software to determine the nature of the reset. See Table 14-10 for a full description of reset states of all registers.

A simplified block diagram of the on-chip reset circuit is shown in Figure 14-10.

The PIC16C70/71A/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

70	71	71A	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 and 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.

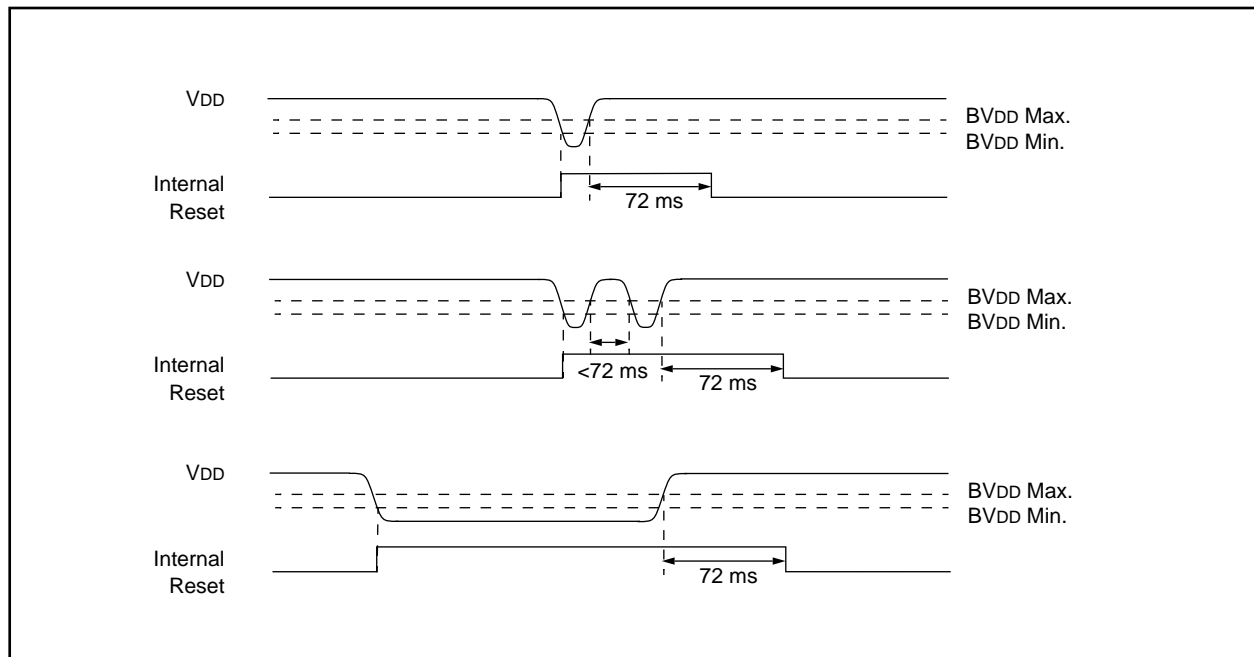
14.4.4 BROWN-OUT RESET (BOR)

Applicable Devices

70	71	71A	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 reset. 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



PIC16C7X

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 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							
70	71	71A	72	73	73A	74	74A

The Power Control/Status Register, PCON has up to 2 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
	PWRT = 1	PWRT = 0	
XT, HS, LP	72 ms + 1024Tosc	1024Tosc	1024 Tosc
RC	72 ms	—	—

TABLE 14-6: TIME-OUT IN VARIOUS SITUATIONS, PIC16C70/71A/72/73A/74A

Oscillator Configuration	Power-up		Brown-out	Wake-up from SLEEP
	PWRT = 0	PWRT = 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 ⁽¹⁾	$\overline{\text{TO}}$	$\overline{\text{PD}}$	
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	1	1	$\overline{\text{MCLR}}$ Reset during normal operation
1	1	0	$\overline{\text{MCLR}}$ Reset during SLEEP or interrupt wake-up from SLEEP

Note 1: Bit $\overline{\text{POR}}$ is not implemented on the PIC16C71.

TABLE 14-8: STATUS BITS AND THEIR SIGNIFICANCE, PIC16C70/71A/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	1	1	$\overline{\text{MCLR}}$ 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 PIC16C70/71A	PCON Register PIC16C73/74	PCON Register PIC16C72/73A/74A
Power-on Reset	000h	0001 1xxx	---- --0x	---- --0-	---- --0x
MCLR Reset during normal operation	000h	0001 1uuu	---- --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 ⁽¹⁾	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	70	71	71A	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
INDF	70	71	71A	72	73	73A	74	74A	N/A	N/A	N/A
TMR0	70	71	71A	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
PCL	70	71	71A	72	73	73A	74	74A	0000h	0000h	PC + 1 ⁽²⁾
STATUS	70	71	71A	72	73	73A	74	74A	0001 1xxx	000q quuu ⁽³⁾	uuuq quuu ⁽³⁾
FSR	70	71	71A	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
PORTA	70	71	71A	72	73	73A	74	74A	---x xxxx	---u uuuu	---u uuuu
	70	71	71A	72	73	73A	74	74A	--xx xxxx	--uu uuuu	--uu uuuu
PORTB	70	71	71A	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
PORTC	70	71	71A	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
PORTD	70	71	71A	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
PORTE	70	71	71A	72	73	73A	74	74A	---- -xxx	---- -uuu	---- -uuu
PCLATH	70	71	71A	72	73	73A	74	74A	---0 0000	---0 0000	---u uuuu
INTCON	70	71	71A	72	73	73A	74	74A	0000 000x	0000 000u	uuuu uuuu ⁽¹⁾
PIR1	70	71	71A	72	73	73A	74	74A	-0-- 0000	-0-- 0000	-u-- uuuu ⁽¹⁾
	70	71	71A	72	73	73A	74	74A	-000 0000	-000 0000	-uuu uuuu ⁽¹⁾
	70	71	71A	72	73	73A	74	74A	0000 0000	0000 0000	uuuu uuuu ⁽¹⁾
PIR2	70	71	71A	72	73	73A	74	74A	---- ---0	---- ---0	---- ---u ⁽¹⁾
TMR1L	70	71	71A	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
TMR1H	70	71	71A	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
T1CON	70	71	71A	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.

PIC16C7X

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	70	71	71A	72	73	73A	74	74A	0000 0000	0000 0000	uuuu uuuu
T2CON	70	71	71A	72	73	73A	74	74A	-000 0000	-000 0000	-uuu uuuu
SSPBUF	70	71	71A	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
SSPCON	70	71	71A	72	73	73A	74	74A	0000 0000	0000 0000	uuuu uuuu
CCPR1L	70	71	71A	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
CCPR1H	70	71	71A	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
CCP1CON	70	71	71A	72	73	73A	74	74A	--00 0000	--00 0000	--uu uuuu
RCSTA	70	71	71A	72	73	73A	74	74A	0000 -00x	0000 -00x	uuuu -uuu
TXREG	70	71	71A	72	73	73A	74	74A	0000 0000	0000 0000	uuuu uuuu
RCREG	70	71	71A	72	73	73A	74	74A	0000 0000	0000 0000	uuuu uuuu
CCPR2L	70	71	71A	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
CCPR2H	70	71	71A	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
CCP2CON	70	71	71A	72	73	73A	74	74A	0000 0000	0000 0000	uuuu uuuu
ADRES	70	71	71A	72	73	73A	74	74A	xxxx xxxx	uuuu uuuu	uuuu uuuu
ADCON0	70	71	71A	72	73	73A	74	74A	00-0 0000	00-0 0000	uu-u uuuu
	70	71	71A	72	73	73A	74	74A	0000 00-0	0000 00-0	uuuu uu-u
OPTION	70	71	71A	72	73	73A	74	74A	1111 1111	1111 1111	uuuu uuuu
TRISA	70	71	71A	72	73	73A	74	74A	---1 1111	---1 1111	---u uuuu
	70	71	71A	72	73	73A	74	74A	--11 1111	--11 1111	--uu uuuu
TRISB	70	71	71A	72	73	73A	74	74A	1111 1111	1111 1111	uuuu uuuu
TRISC	70	71	71A	72	73	73A	74	74A	1111 1111	1111 1111	uuuu uuuu
TRISD	70	71	71A	72	73	73A	74	74A	1111 1111	1111 1111	uuuu uuuu
TRISE	70	71	71A	72	73	73A	74	74A	0000 -111	0000 -111	uuuu -uuu
PIE1	70	71	71A	72	73	73A	74	74A	-0-- 0000	-0-- 0000	-u-- uuuu
	70	71	71A	72	73	73A	74	74A	-000 0000	-000 0000	-uuu uuuu
	70	71	71A	72	73	73A	74	74A	0000 0000	0000 0000	uuuu uuuu
PIE2	70	71	71A	72	73	73A	74	74A	---- --0	---- --0	---- --u
PCON	70	71	71A	72	73	73A	74	74A	---- --0-	---- --u-	---- --u-
	70	71	71A	72	73	73A	74	74A	---- --0u	---- --uu	---- --uu
PR2	70	71	71A	72	73	73A	74	74A	1111 1111	1111 1111	1111 1111
SSPADD	70	71	71A	72	73	73A	74	74A	0000 0000	0000 0000	uuuu uuuu
SSPSTAT	70	71	71A	72	73	73A	74	74A	--00 0000	--00 0000	--uu uuuu
TXSTA	70	71	71A	72	73	73A	74	74A	0000 -010	0000 -010	uuuu -uuu
SPBRG	70	71	71A	72	73	73A	74	74A	0000 0000	0000 0000	uuuu uuuu
ADCON1	70	71	71A	72	73	73A	74	74A	---- --00	---- --00	---- --uu
	70	71	71A	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_{DD}): CASE 1

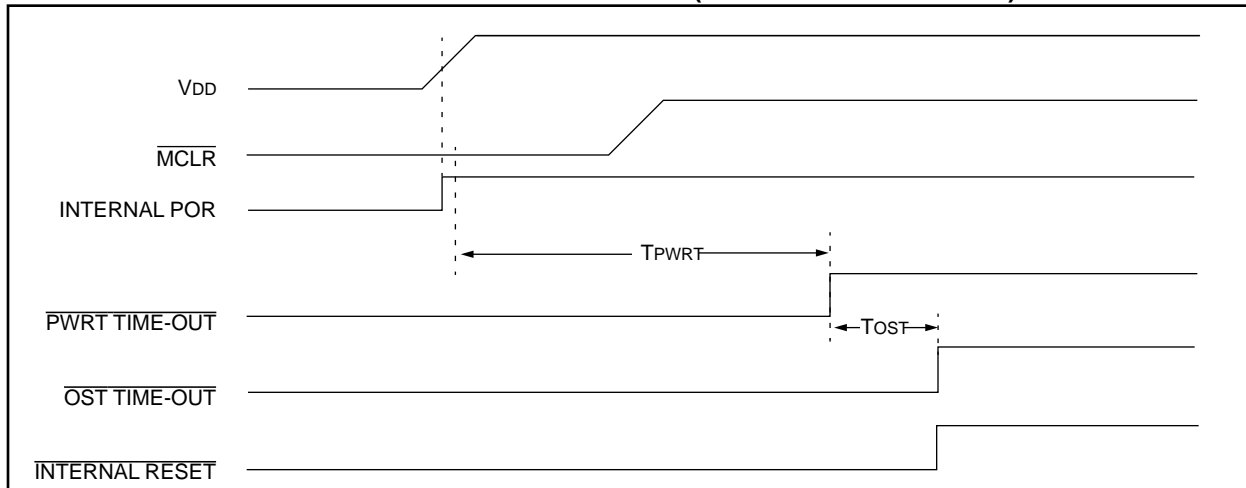


FIGURE 14-13: TIME-OUT SEQUENCE ON POWER-UP ($\overline{\text{MCLR}}$ NOT TIED TO V_{DD}): CASE 2

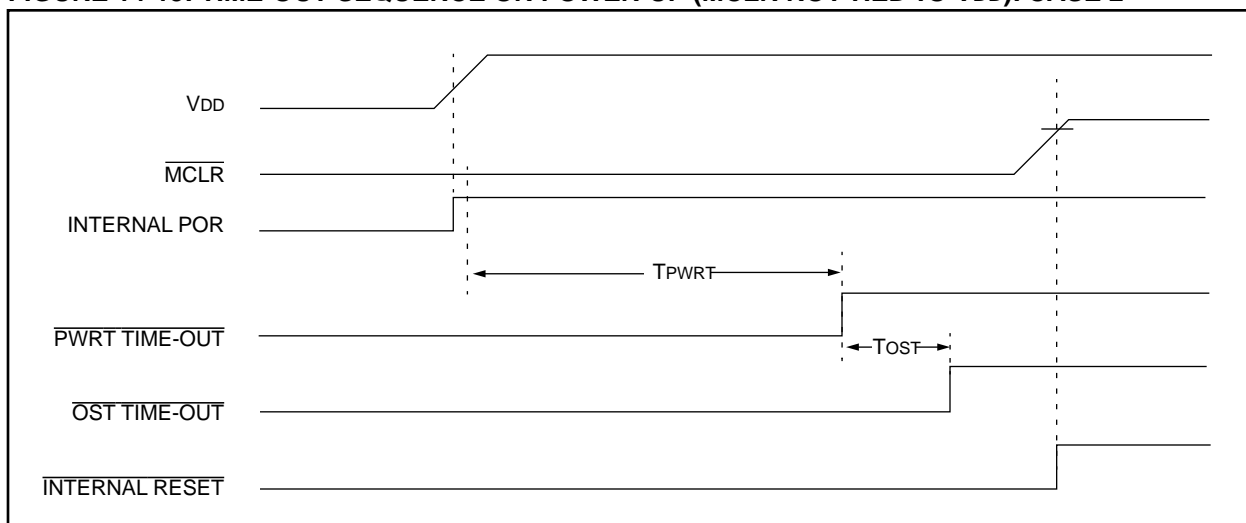


FIGURE 14-14: TIME-OUT SEQUENCE ON POWER-UP ($\overline{\text{MCLR}}$ TIED TO V_{DD})

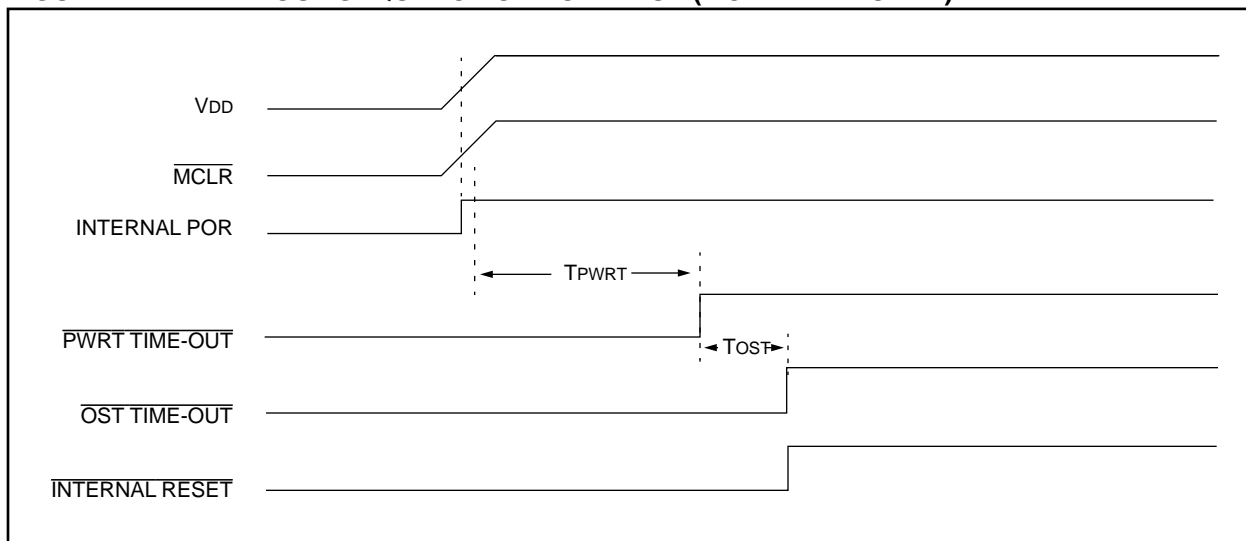


FIGURE 14-15: EXTERNAL POWER-ON RESET CIRCUIT (FOR SLOW VDD POWER-UP)

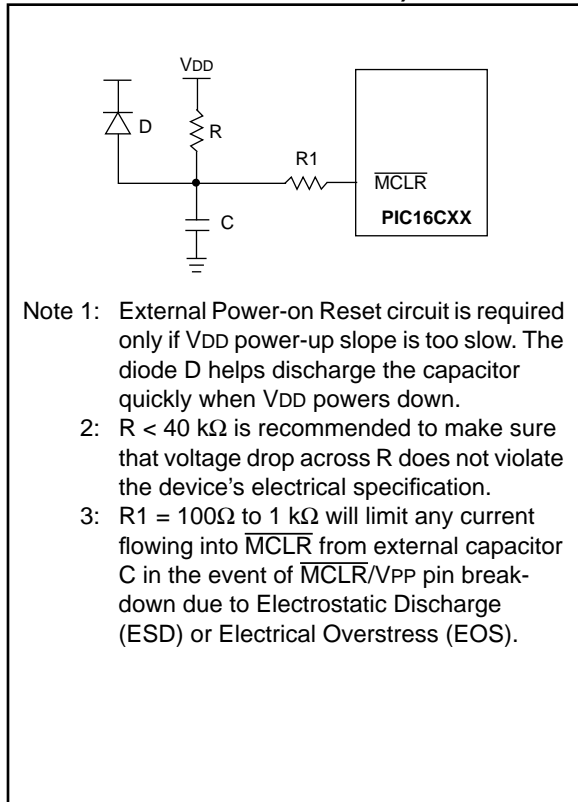


FIGURE 14-16: EXTERNAL BROWN-OUT PROTECTION CIRCUIT 1

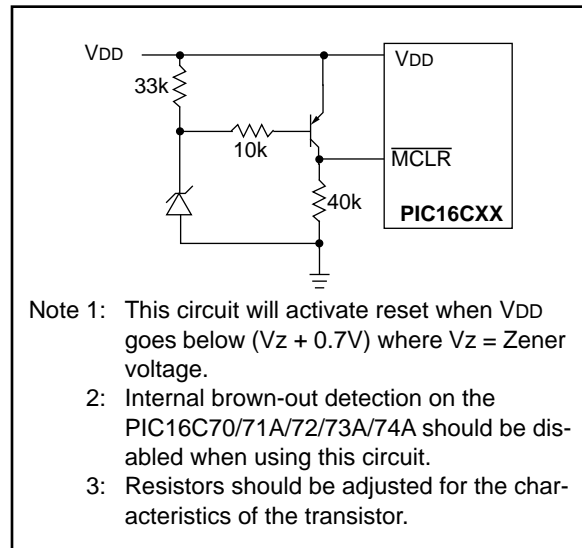
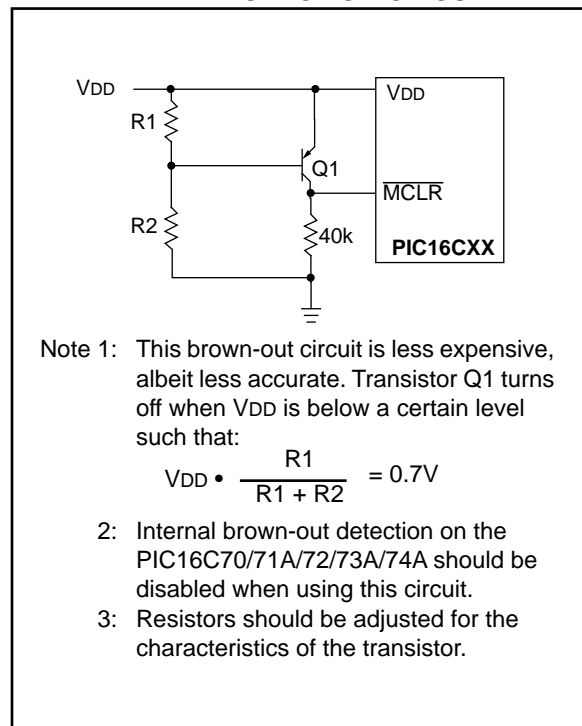


FIGURE 14-17: EXTERNAL BROWN-OUT PROTECTION CIRCUIT 2



14.5 Interrupts

Applicable Devices							
70	71	71A	72	73	73A	74	74A

The PIC16C7X family has up to 12 sources of interrupt:

Interrupt Sources	Applicable Devices							
External interrupt RB0/INT	70	71	71A	72	73	73A	74	74A
TMR0 overflow interrupt	70	71	71A	72	73	73A	74	74A
PORTB change interrupts (pins RB7:RB4)	70	71	71A	72	73	73A	74	74A
A/D Interrupt	70	71	71A	72	73	73A	74	74A
TMR1 overflow interrupt	70	71	71A	72	73	73A	74	74A
TMR2 matches period interrupt	70	71	71A	72	73	73A	74	74A
CCP1 interrupt	70	71	71A	72	73	73A	74	74A
CCP2 interrupt	70	71	71A	72	73	73A	74	74A
USART Receive	70	71	71A	72	73	73A	74	74A
USART Transmit	70	71	71A	72	73	73A	74	74A
Synchronous serial port interrupt	70	71	71A	72	73	73A	74	74A
Parallel slave port read/write interrupt	70	71	71A	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 only, 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 PIC16C70/71/71A

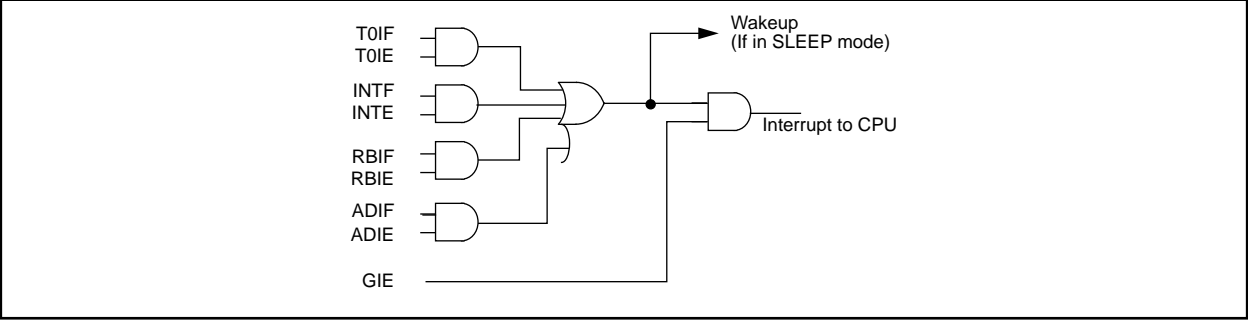


FIGURE 14-19: INTERRUPT LOGIC FOR PIC16C72

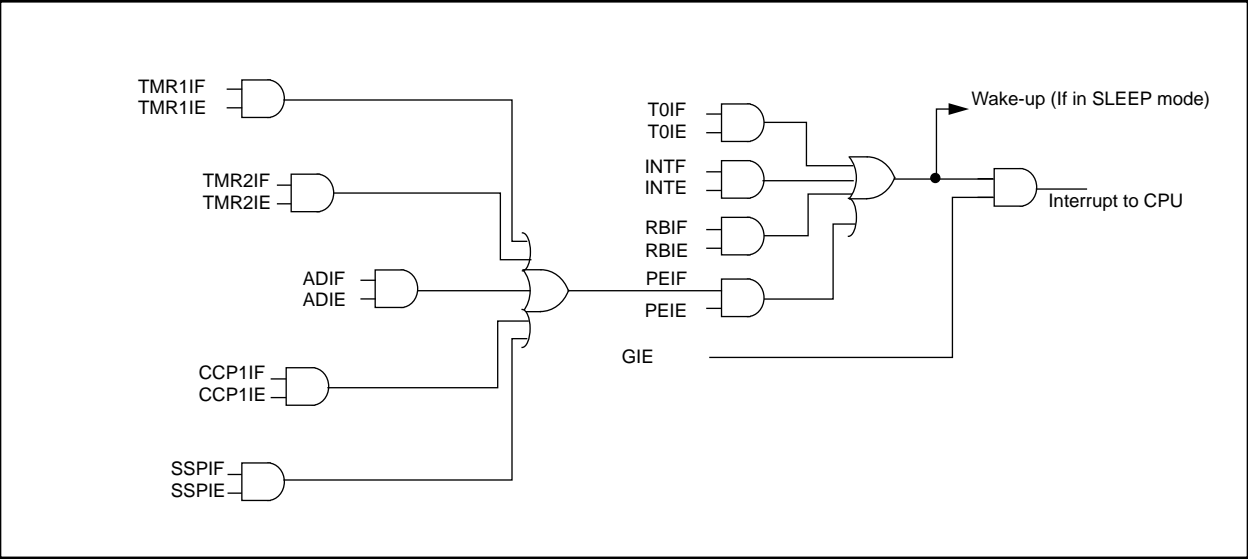


FIGURE 14-20: INTERRUPT LOGIC FOR PIC16C73/73A

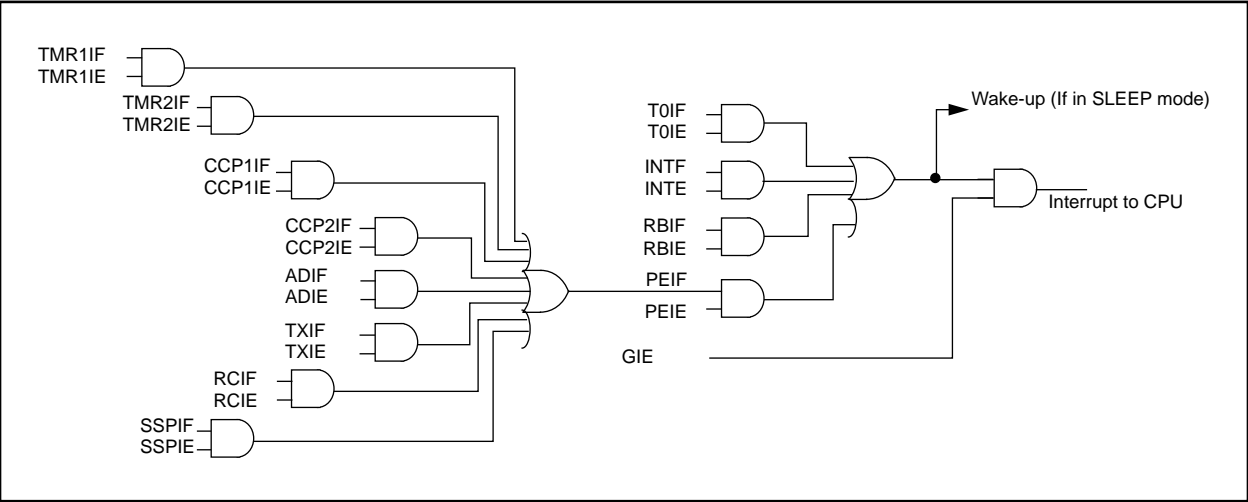


FIGURE 14-21: INTERRUPT LOGIC FOR PIC16C74/74A

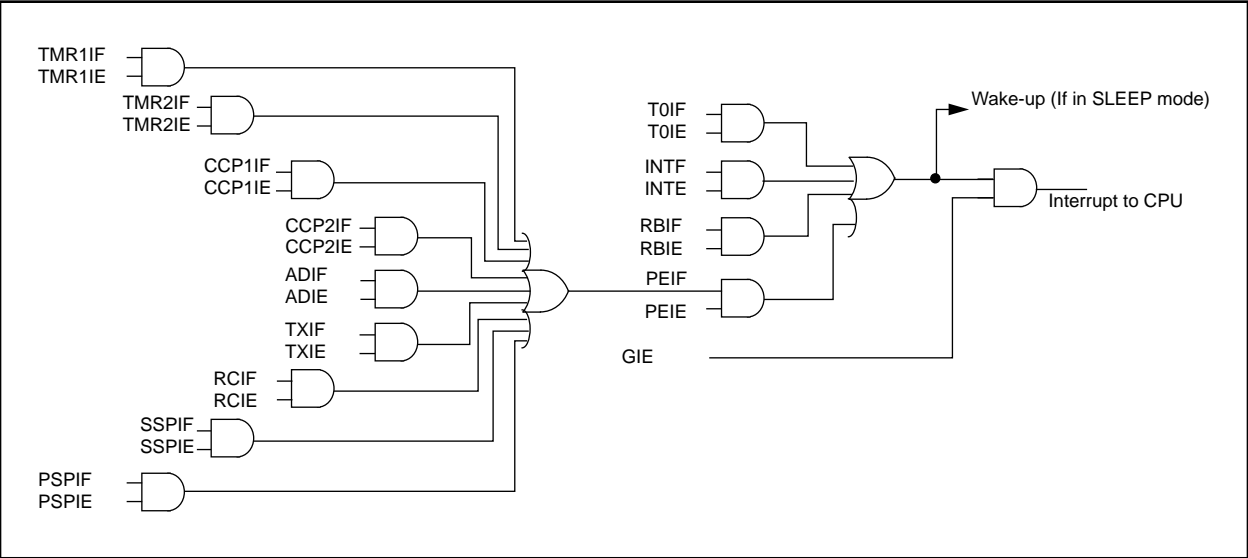
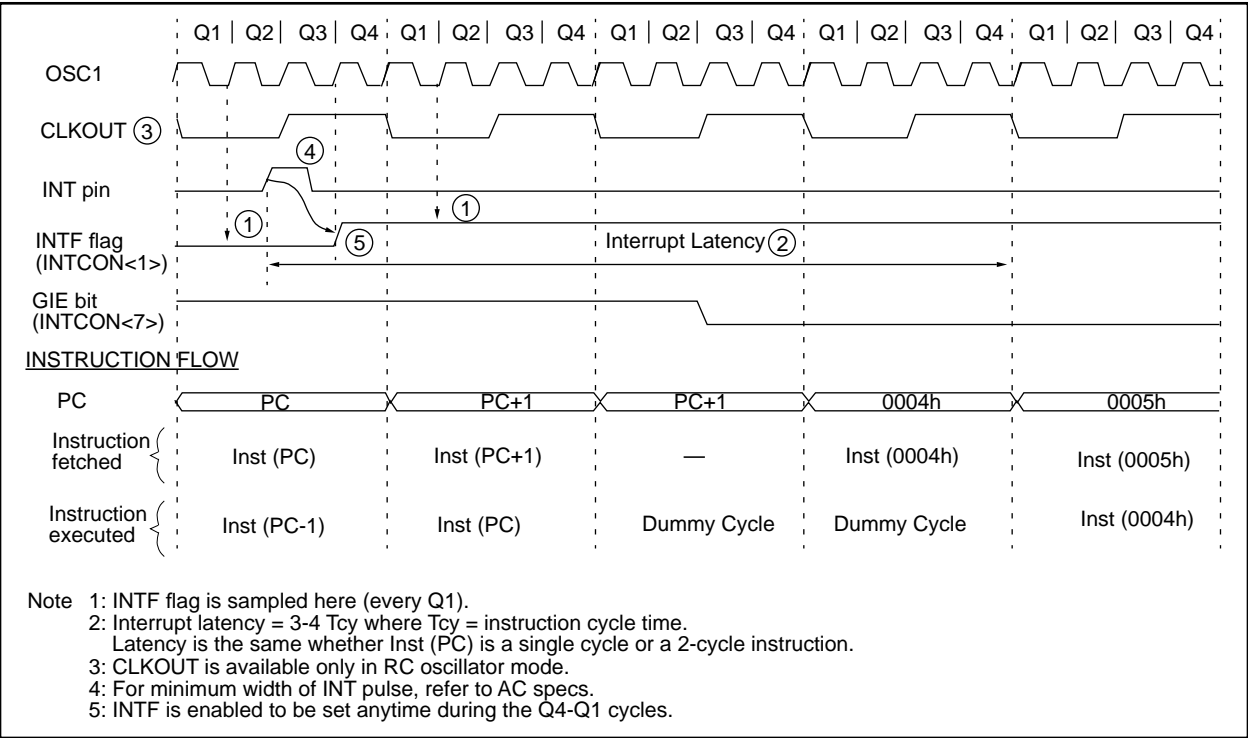


FIGURE 14-22: INT PIN INTERRUPT TIMING



PIC16C7X

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 T0IF (INTCON<2>). The interrupt can be enabled/disabled by setting/clearing enable bit T0IE (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 only, 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

70	71	71A	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 PIC16C70/71/71A, 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 (PIC16C70/71/71A)

```
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

70	71	71A	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.

FIGURE 14-23: WATCHDOG TIMER BLOCK DIAGRAM

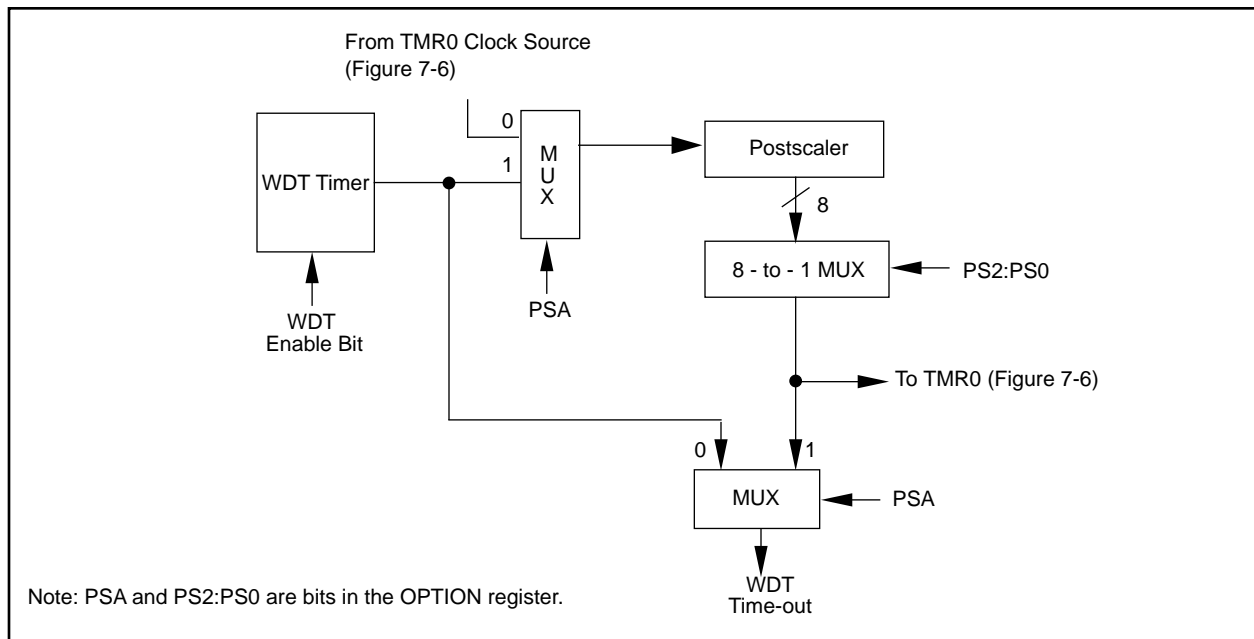


FIGURE 14-24: SUMMARY OF WATCHDOG TIMER REGISTERS

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
2007h	Config. bits	(1)	BODEN ⁽¹⁾	CP1	CP0	PWRTE ⁽¹⁾	WDTE	FOSC1	FOSC0
81h	OPTION	RBPUP	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.

PIC16C7X

14.8 Power-down Mode (SLEEP)

Applicable Devices

70	71	71A	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 V_{DD} , or V_{SS} , 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 T_{OCLK} input should also be at V_{DD} or V_{SS} 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 (V_{IHMC}).

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 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/I²C).
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).

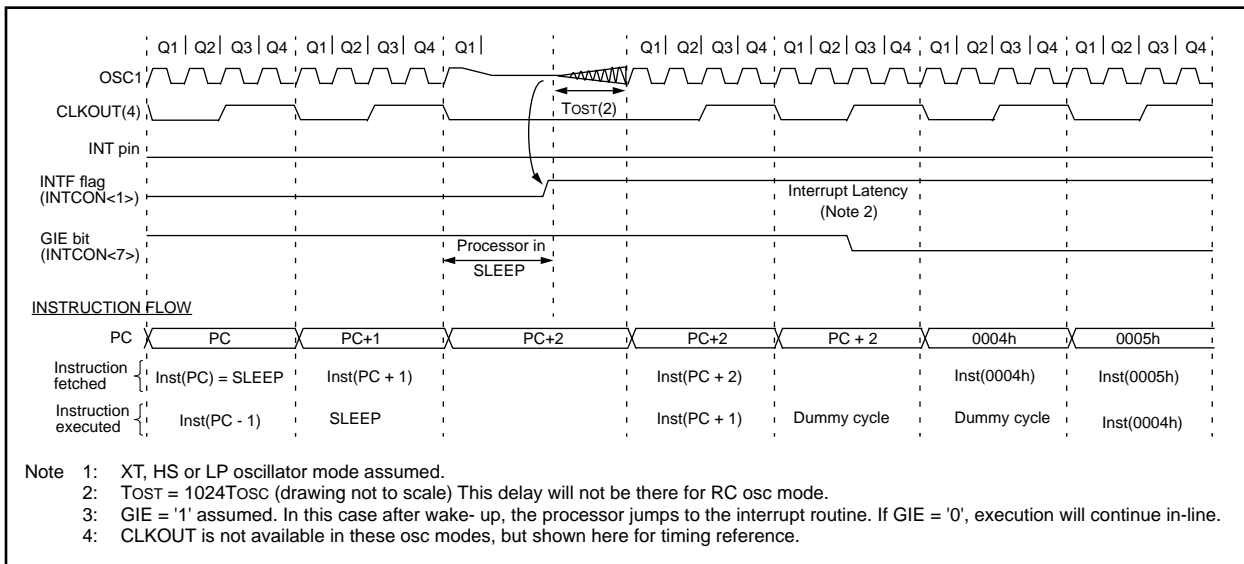
Other peripherals can not generate interrupts since during **SLEEP**, no on-chip Q clocks are present.

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.

Note: Interrupts that are capable of waking the device from **SLEEP** will still set the individual flag bits regardless of the state of the global enable bit, GIE.

The WDT is cleared when the device wakes-up from sleep, regardless of the source of wake-up.

FIGURE 14-25: WAKE-UP FROM SLEEP THROUGH INTERRUPT



14.9 Program Verification/Code Protection

Applicable Devices							
70	71	71A	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							
70	71	71A	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 ID location are used.

14.11 In-Circuit Serial Programming

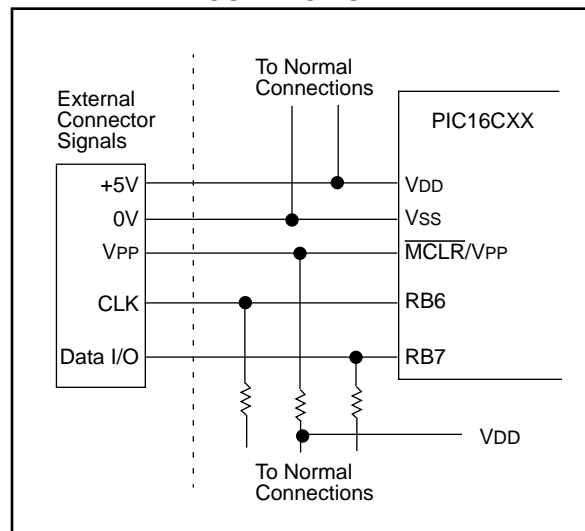
Applicable Devices							
70	71	71A	72	73	73A	74	74A

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 $\overline{\text{MCLR}}$ (VPP) pin from VIL to VIH (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



PIC16C7X

NOTES:

15.0 INSTRUCTION SET SUMMARY

Applicable Devices							
70	71	71A	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
TO	Time-out bit
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)

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 μs. If a conditional test is true or the program counter is changed as a result of an instruction, the instruction execution time is 2 μs.

Table 15-2 lists the instructions recognized by the MPASM assembler.

Figure 15-1 shows the three general formats that the instructions can have.

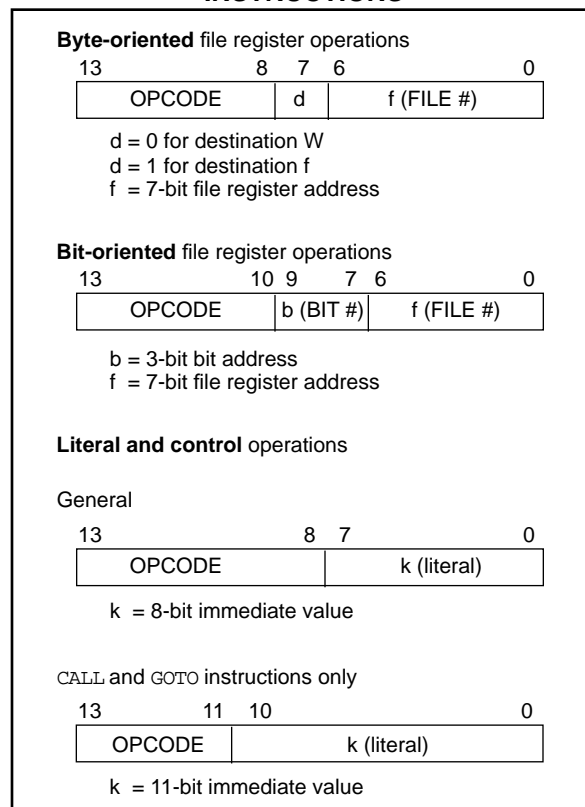
Note: To maintain upward compatibility with future PIC16CXX products, do not use the `OPTION` and `TRIS` instructions.

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



PIC16C7X

TABLE 15-2: PIC16CXX INSTRUCTION SET

Mnemonic, Operands	Description	Cycles	14-Bit Opcode				Status Affected	Notes	
			MSb		LSb				
BYTE-ORIENTED FILE REGISTER OPERATIONS									
ADDWF	f, d	Add W and f	1	00	0111	dfff	ffff	C,DC,Z	1,2
ANDWF	f, d	AND W with f	1	00	0101	dfff	ffff	Z	1,2
CLRF	f	Clear f	1	00	0001	1fff	ffff	Z	2
CLRW	-	Clear W	1	00	0001	0xxx	xxxx	Z	
COMF	f, d	Complement f	1	00	1001	dfff	ffff	Z	1,2
DECF	f, d	Decrement f	1	00	0011	dfff	ffff	Z	1,2
DECFSZ	f, d	Decrement f, Skip if 0	1(2)	00	1011	dfff	ffff		1,2,3
INCF	f, d	Increment f	1	00	1010	dfff	ffff	Z	1,2
INCFSZ	f, d	Increment f, Skip if 0	1(2)	00	1111	dfff	ffff		1,2,3
IORWF	f, d	Inclusive OR W with f	1	00	0100	dfff	ffff	Z	1,2
MOVF	f, d	Move f	1	00	1000	dfff	ffff	Z	1,2
MOVWF	f	Move W to f	1	00	0000	1fff	ffff		
NOP	-	No Operation	1	00	0000	0xx0	0000		
RLF	f, d	Rotate Left f through Carry	1	00	1101	dfff	ffff	C	1,2
RRF	f, d	Rotate Right f through Carry	1	00	1100	dfff	ffff	C	1,2
SUBWF	f, d	Subtract W from f	1	00	0010	dfff	ffff	C,DC,Z	1,2
SWAPF	f, d	Swap nibbles in f	1	00	1110	dfff	ffff		1,2
XORWF	f, d	Exclusive OR W with f	1	00	0110	dfff	ffff	Z	1,2
BIT-ORIENTED FILE REGISTER OPERATIONS									
BCF	f, b	Bit Clear f	1	01	00bb	bfff	ffff		1,2
BSF	f, b	Bit Set f	1	01	01bb	bfff	ffff		1,2
BTFSC	f, b	Bit Test f, Skip if Clear	1 (2)	01	10bb	bfff	ffff		3
BTFSS	f, b	Bit Test f, Skip if Set	1 (2)	01	11bb	bfff	ffff		3
LITERAL AND CONTROL OPERATIONS									
ADDLW	k	Add literal and W	1	11	111x	kkkk	kkkk	C,DC,Z	
ANDLW	k	AND literal with W	1	11	1001	kkkk	kkkk	Z	
CALL	k	Call subroutine	2	10	0kkk	kkkk	kkkk		
CLRWDT	-	Clear Watchdog Timer	1	00	0000	0110	0100	$\overline{TO}, \overline{PD}$	
GOTO	k	Go to address	2	10	1kkk	kkkk	kkkk		
IORLW	k	Inclusive OR literal with W	1	11	1000	kkkk	kkkk	Z	
MOVLW	k	Move literal to W	1	11	00xx	kkkk	kkkk		
RETFIE	-	Return from interrupt	2	00	0000	0000	1001		
RETLW	k	Return with literal in W	2	11	01xx	kkkk	kkkk		
RETURN	-	Return from Subroutine	2	00	0000	0000	1000		
SLEEP	-	Go into standby mode	1	00	0000	0110	0011	$\overline{TO}, \overline{PD}$	
SUBLW	k	Subtract W from literal	1	11	110x	kkkk	kkkk	C,DC,Z	
XORLW	k	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.

15.1 Instruction Descriptions

ADDLW Add Literal and W

Syntax:	[<i>label</i>] ADDLW k				
Operands:	$0 \leq k \leq 255$				
Operation:	$(W) + k \rightarrow (W)$				
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	<pre>ADDLW 0x15</pre> <div>Before Instruction</div> <div>W = 0x10</div> <div>After Instruction</div> <div>W = 0x25</div>				

ANDLW And Literal with W

Syntax:	[<i>label</i>] ANDLW k				
Operands:	$0 \leq k \leq 255$				
Operation:	(W) .AND. (k) \rightarrow (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	<pre>ANDLW 0x5F</pre> <div>Before Instruction</div> <div>W = 0xA3</div> <div>After Instruction</div> <div>W = 0x03</div>				

ADDWF Add W and f

Syntax:	[<i>label</i>] ADDWF f,d												
Operands:	$0 \leq f \leq 127$ $d \in [0,1]$												
Operation:	$(W) + (f) \rightarrow (dest)$												
Status Affected:	C, DC, Z												
Encoding:	<table><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	<pre>ADDWF FSR, 0</pre> <p>Before Instruction</p> <table><tr><td>W</td><td>=</td><td>0x17</td></tr><tr><td>FSR</td><td>=</td><td>0xC2</td></tr></table> <p>After Instruction</p> <table><tr><td>W</td><td>=</td><td>0xD9</td></tr><tr><td>FSR</td><td>=</td><td>0xC2</td></tr></table>	W	=	0x17	FSR	=	0xC2	W	=	0xD9	FSR	=	0xC2
W	=	0x17											
FSR	=	0xC2											
W	=	0xD9											
FSR	=	0xC2											

ANDWF AND W with f

Syntax:	[<i>label</i>] ANDWF f,d												
Operands:	$0 \leq f \leq 127$ $d \in [0,1]$												
Operation:	(W) .AND. (f) \rightarrow (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	<pre>ANDWF FSR, 1</pre> <p>Before Instruction</p> <table><tr><td>W</td><td>=</td><td>0x17</td></tr><tr><td>FSR</td><td>=</td><td>0xC2</td></tr></table> <p>After Instruction</p> <table><tr><td>W</td><td>=</td><td>0x17</td></tr><tr><td>FSR</td><td>=</td><td>0x02</td></tr></table>	W	=	0x17	FSR	=	0xC2	W	=	0x17	FSR	=	0x02
W	=	0x17											
FSR	=	0xC2											
W	=	0x17											
FSR	=	0x02											

PIC16C7X

BCF		Bit Clear f						
Syntax:	[<i>label</i>] BCF f,b							
Operands:	$0 \leq f \leq 127$ $0 \leq b \leq 7$							
Operation:	$0 \rightarrow (f)$							
Status Affected:	None							
Encoding:	<table border="1"><tr><td>01</td><td>00bb</td><td>bfff</td><td>ffff</td></tr></table>				01	00bb	bfff	ffff
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							

BSF		Bit Set f			
Syntax:	[<i>label</i>] 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				

BTFSC		Bit Test, Skip if Clear			
Syntax:	[<i>label</i>] BTFSC f,b				
Operands:	0 ≤ f ≤ 127 0 ≤ b ≤ 7				
Operation:	skip if (f) = 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 FALSE TRUE	BTFSC GOTO • • •	FLAG, 1 PROCESS_CODE		
Before Instruction					
PC = address HERE					
After Instruction					
if FLAG<1> = 0,					
PC = address TRUE					
if FLAG<1> = 1,					
PC = address FALSE					

BTFSS		Bit Test f, Skip if Set		
Syntax:	[<i>label</i>] BTFSS f,b			
Operands:	$0 \leq f \leq 127$ $0 \leq b < 7$			
Operation:	skip if (f) = 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	BTFSC	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:	[<i>label</i>] CALL k								
Operands:	0 ≤ k ≤ 2047								
Operation:	(PC)+ 1 → TOS, k → PC<10:0>, (PCLATH<4:3>) → PC<12:11>								
Status Affected:	None								
Encoding:	<table border="1"><tr><td>10</td><td>0kkk</td><td>kkkk</td><td>kkkk</td></tr></table>					10	0kkk	kkkk	kkkk
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:	[<i>label</i>] CLRF f							
Operands:	$0 \leq f \leq 127$							
Operation:	00h \rightarrow (f) 1 \rightarrow Z							
Status Affected:	Z							
Encoding:	<table><tr><td>00</td><td>0001</td><td>1fff</td><td>ffff</td></tr></table>				00	0001	1fff	ffff
00	0001	1fff	ffff					
Description:	The contents of register 'f' are cleared and the Z bit is set.							
Words:	1							
Cycles:	1							
Example	<div>CLRFFLAG_REG</div> <div>Before Instruction</div> <div>FLAG_REG = 0x5A</div> <div>After Instruction</div> <div>FLAG_REG = 0x00</div> <div>Z = 1</div>							

CLR W					
Syntax:	[<i>label</i>] CLRW				
Operands:	None				
Operation:	00h → (W) 1 → Z				
Status Affected:	Z				
Encoding:	<table><tr><td>00</td><td>0001</td><td>0xxx</td><td>xxxx</td></tr></table>	00	0001	0xxx	xxxx
00	0001	0xxx	xxxx		
Description:	W register is cleared. Zero bit (Z) is set.				
Words:	1				
Cycles:	1				
Example	<pre>CLR W</pre> <p>Before Instruction</p> <p>W = 0x5A</p> <p>After Instruction</p> <p>W = 0x00</p> <p>Z = 1</p>				

PIC16C7X

CLRWDT Clear Watchdog Timer

Syntax:	[<i>label</i>] CLRWDT				
Operands:	None				
Operation:	00h → WDT 0 → WDT prescaler, 1 → \overline{TO} 1 → \overline{PD}				
Status Affected:	\overline{TO} , \overline{PD}				
Encoding:	<table><tr><td>00</td><td>0000</td><td>0110</td><td>0100</td></tr></table>	00	0000	0110	0100
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:	[<i>label</i>] COMF f,d			
Operands:	$0 \leq f \leq 127$ $d \in [0,1]$			
Operation:	$(\bar{f}) \rightarrow (\text{dest})$			
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:	[<i>label</i>] DECF f,d			
Operands:	$0 \leq f \leq 127$ $d \in [0,1]$			
Operation:	(f) - 1 \rightarrow (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:	[<i>label</i>] DECFSZ f,d			
Operands:	$0 \leq f \leq 127$ $d \in [0,1]$			
Operation:	(f) - 1 \rightarrow (dest); skip if result = 0			
Status Affected:	None			
Encoding:	00	1011	dfff	ffff
Description:	<p>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.</p>			
Words:	1			

Before Instruction
PC = address HERE
After Instruction
CNT = CNT - 1
if CNT = 0,
PC = address CONTINUE
if CNT ≠ 0,
PC = address HERE+1

GOTO		Unconditional Branch							
Syntax:	[<i>label</i>] 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:	<table><tr><td>10</td><td>1kkk</td><td>kkkk</td><td>kkkk</td></tr></table>					10	1kkk	kkkk	kkkk
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:	[<i>label</i>] 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

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:	[<i>label</i>] 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:	[<i>label</i>] IORLW k								
Operands:	$0 \leq k \leq 255$								
Operation:	$(W) .OR. k \rightarrow (W)$								
Status Affected:	Z								
Encoding:	<table><tr><td>11</td><td>1000</td><td>kkkk</td><td>kkkk</td></tr></table>					11	1000	kkkk	kkkk
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								

PIC16C7X

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 dependant 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

NOP No Operation

Syntax: [*label*] NOP

Operands: None

Operation: No operation

Status Affected: None

Encoding:

00	0000	0xx0	0000
----	------	------	------

Description: No operation.

Words: 1

Cycles: 1

Example NOP

RETFIE Return from Interrupt

Syntax: [*label*] RETFIE

Operands: None

Operation: TOS → PC,
1 → GIE

Status Affected: None

Encoding:

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 RETFIE

After Interrupt

PC = TOS
GIE = 1

OPTION Load Option Register

Syntax: [*label*] OPTION

Operands: None

Operation: (W) → OPTION

Status Affected: None

Encoding:

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

To maintain upward compatibility with future PIC16CXX products, do not use this instruction.

RETLW Return with Literal in W

Syntax: [*label*] RETLW k

Operands: $0 \leq k \leq 255$

Operation: k → (W);
TOS → PC

Status Affected: None

Encoding:

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

```
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

PIC16C7X

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: $0 \leq f \leq 127$
 $d \in [0,1]$

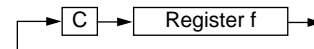
Operation: See description below

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: $0 \leq f \leq 127$
 $d \in [0,1]$

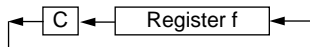
Operation: See description below

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 → $\overline{\text{TO}}$,
0 → $\overline{\text{PD}}$

Status Affected: $\overline{\text{TO}}$, $\overline{\text{PD}}$

Encoding:

00	0000	0110	0011
----	------	------	------

Description: The power-down status bit, $\overline{\text{PD}}$ is cleared. Time-out status bit, $\overline{\text{TO}}$ 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

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

PIC16C7X

SWAPF		Swap Nibbles in f							
Syntax:	[<i>label</i>] SWAPF f,d								
Operands:	$0 \leq f \leq 127$ $d \in [0,1]$								
Operation:	$(f<3:0>) \rightarrow (dest<7:4>),$ $(f<7:4>) \rightarrow (dest<3:0>)$								
Status Affected:	None								
Encoding:	<table><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	SWAPF REG, 0								
Before Instruction									
REG1 = 0xA5									
After Instruction									
REG1 = 0xA5									
W = 0x5A									

TRIS	Load TRIS Register				
Syntax:	[<i>label</i>] TRIS f				
Operands:	$5 \leq f \leq 7$				
Operation:	(W) → TRIS register f;				
Status Affected:	None				
Encoding:	<table><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	<div>To maintain upward compatibility with future PIC16CXX products, do not use this instruction.</div>				

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><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:	XORLW 0xAF				
	Before Instruction				
	W = 0xB5				
	After Instruction				
	W = 0x1A				

XORWF	Exclusive OR W with f												
Syntax:	[<i>label</i>] XORWF f,d												
Operands:	$0 \leq f \leq 127$ $d \in [0,1]$												
Operation:	(W) .XOR. (f) \rightarrow (dest)												
Status Affected:	Z												
Encoding:	<table><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> <table><tr><td>REG</td><td>=</td><td>0xAF</td></tr><tr><td>W</td><td>=</td><td>0xB5</td></tr></table> <p>After Instruction</p> <table><tr><td>REG</td><td>=</td><td>0x1A</td></tr><tr><td>W</td><td>=</td><td>0xB5</td></tr></table>	REG	=	0xAF	W	=	0xB5	REG	=	0x1A	W	=	0xB5
REG	=	0xAF											
W	=	0xB5											
REG	=	0x1A											
W	=	0xB5											

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™ Real-Time In-Circuit Emulator
- PRO MATE™ Universal Programmer
- PICSTART™ Low-Cost Prototype Programmer
- PICDEM-1 Low-Cost Demonstration Board
- PICDEM-2 Low-Cost Demonstration Board
- MPASM Assembler
- MPSIM Software Simulator
- C Compiler (MP-C)
- 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 PIC16C5X, PIC16CXX 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. A PICMASTER System configuration is shown in Figure 16-1.

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 PIC16C5X, PIC16CXX and PIC17CXX 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 better) machine platform and Microsoft Windows™ 3.x environment was chosen to best make these features available to you, the end user.

The PICMASTER Universal Emulator System consists primarily of four major components:

- Host-Interface Card
- Emulator Control Pod
- Target-Specific Emulator Probe
- PC-Host Emulation Control Software

The Windows operating system allows the developer to take full advantage of the many powerful features and functions of the PICMASTER system.

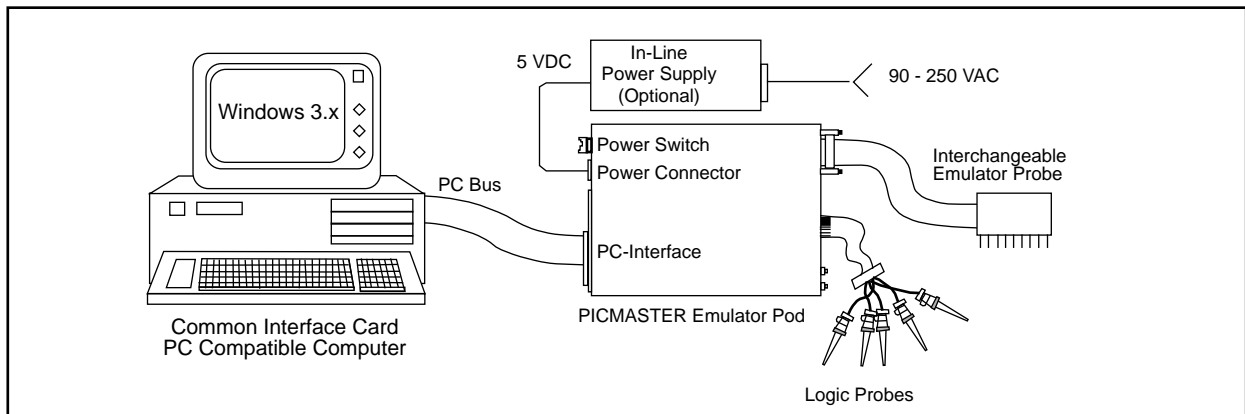
PICMASTER emulation can operate in one window, while a text editor is running in a second window.

PC-Host Emulation Control software takes full advantage of Dynamic Data Exchange (DDE), a feature of Windows. DDE allows data to be dynamically transferred between two or more Windows programs. With this feature, data collected with PICMASTER can be automatically transferred to a spreadsheet or database program for further analysis.

Under Windows, as many as four PICMASTER emulators can be run simultaneously from the same PC making development of multi-microcontroller systems possible (e.g., a system containing a PIC16CXX processor and a PIC17CXX processor).

The PICMASTER probes specifications are shown in Table 16-1.

FIGURE 16-1: PICMASTER SYSTEM CONFIGURATION



PIC16C7X

TABLE 16-1: PICMASTER PROBE SPECIFICATION

Devices	PICMASTER PROBE	PROBE	
		Maximum Frequency	Operating Voltage
PIC16C54	PROBE-16D	20 MHz	4.5V - 5.5V
PIC16C54A	PROBE-16D	20 MHz	4.5V - 5.5V
PIC16CR54	PROBE-16D	20 MHz	4.5V - 5.5V
PIC16CR54A	PROBE-16D ⁽¹⁾	20 MHz	4.5V - 5.5V
PIC16CR54B	PROBE-16D ⁽¹⁾	20 MHz	4.5V - 5.5V
PIC16C55	PROBE-16D	20 MHz	4.5V - 5.5V
PIC16CR55	PROBE-16D ⁽¹⁾	20 MHz	4.5V - 5.5V
PIC16C56	PROBE-16D	20 MHz	4.5V - 5.5V
PIC16CR56	PROBE-16D ⁽¹⁾	20 MHz	4.5V - 5.5V
PIC16C57	PROBE-16D	20 MHz	4.5V - 5.5V
PIC16CR57A	PROBE-16D	20 MHz	4.5V - 5.5V
PIC16CR57B	PROBE-16D ⁽¹⁾	20 MHz	4.5V - 5.5V
PIC16C58A	PROBE-16D	20 MHz	4.5V - 5.5V
PIC16CR58A	PROBE-16D	20 MHz	4.5V - 5.5V
PIC16CR58B	PROBE-16D ⁽¹⁾	20 MHz	4.5V - 5.5V
PIC16C61	PROBE-16G	10 MHz	4.5V - 5.5V
PIC16C62	PROBE-16E	10 MHz	4.5V - 5.5V
PIC16C62A	PROBE-16E ⁽¹⁾	10 MHz	4.5V - 5.5V
PIC16CR62	PROBE-16E ⁽¹⁾	10 MHz	4.5V - 5.5V
PIC16C63	PROBE-16F ⁽¹⁾	10 MHz	4.5V - 5.5V
PIC16C64	PROBE-16E	10 MHz	4.5V - 5.5V

TABLE 16-1: PICMASTER PROBE SPECIFICATION (Cont'd)

Devices	PICMASTER PROBE	PROBE	
		Maximum Frequency	Operating Voltage
PIC16C64A	PROBE-16E ⁽¹⁾	10 MHz	4.5V - 5.5V
PIC16CR64	PROBE-16E ⁽¹⁾	10 MHz	4.5V - 5.5V
PIC16C65	PROBE-16F	10 MHz	4.5V - 5.5V
PIC16C65A	PROBE-16F ⁽¹⁾	10 MHz	4.5V - 5.5V
PIC16C620	PROBE-16H	10 MHz	4.5V - 5.5V
PIC16C621	PROBE-16H	10 MHz	4.5V - 5.5V
PIC16C622	PROBE-16H	10 MHz	4.5V - 5.5V
PIC16C70	PROBE-16B ⁽¹⁾	10 MHz	4.5V - 5.5V
PIC16C71	PROBE-16B	10 MHz	4.5V - 5.5V
PIC16C71A	PROBE-16B ⁽¹⁾	10 MHz	4.5V - 5.5V
PIC16C72	PROBE-16F ⁽¹⁾	10 MHz	4.5V - 5.5V
PIC16C73	PROBE-16F	10 MHz	4.5V - 5.5V
PIC16C73A	PROBE-16F ⁽¹⁾	10 MHz	4.5V - 5.5V
PIC16C74	PROBE-16F	10 MHz	4.5V - 5.5V
PIC16C74A	PROBE-16F ⁽¹⁾	10 MHz	4.5V - 5.5V
PIC16C83	PROBE-16C	10 MHz	4.5V - 5.5V
PIC16C84	PROBE-16C	10 MHz	4.5V - 5.5V
PIC17C42	PROBE-17B	20 MHz	4.5V - 5.5V
PIC17C43	PROBE-17B	20 MHz	4.5V - 5.5V
PIC17C44	PROBE-17B	20 MHz	4.5V - 5.5V

Note 1: This PICMASTER probe can be used to functionally emulate the device listed in the previous column. Contact your Microchip sales office for details.

16.3 PRO MATE: Universal Programmer

The PRO MATE Universal Programmer is a full-featured programmer capable of operating in stand-alone mode as well as PC-hosted mode.

The PRO MATE 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 can read, verify or program PIC16C5X, PIC16CXX and PIC17CXX devices. It can also set configuration and code-protect bits in this mode.

In PC-hosted mode, the PRO MATE connects to the PC via one of the COM (RS-232) ports. PC based user-interface software makes using the programmer simple and efficient. The user interface is full-screen and menu-based. Full screen display and editing of data, easy selection of bit configuration and part type, easy selection of VDD min, VDD max and VPP levels, load and store to and from disk files (Intel® hex format) are some of the features of the software. Essential commands such as read, verify, program and blank check can be issued from the screen. Additionally, serial programming support is possible where each part is programmed with a different serial number, sequential or random.

The PRO MATE has a modular "programming socket module". Different socket modules are required for different processor types and/or package types.

PRO MATE supports all PIC16C5X, PIC16CXX and PIC17CXX processors.

16.4 PICSTART Low-Cost Development System

The PICSTART programmer is an easy to use, very low-cost prototype programmer. It connects to the PC via one of the COM (RS-232) ports. A PC-based user interface software makes using the programmer simple and efficient. The user interface is full-screen and menu-based. PICSTART is not recommended for production programming.

16.5 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 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.

16.6 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 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 I²C bus and separate headers for connection to an LCD module and a keypad.

16.7 MPLAB™ Integrated Development Environment Software.

The MPLAB 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 (available soon)
- 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 (available soon) 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.

16.8 Assembler (MPASM)

The MPASM Cross Assembler is a PC-hosted symbolic assembler. It supports all microcontroller series including the PIC16C5X, PIC16CXX 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 allows 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.

- **Data Directives** are those that control the allocation of memory and provide a way to refer to data items symbolically, i.e., by meaningful names.
- **Control Directives** control the MPASM listing display. They allow the specification of titles and subtitles, page ejects and other listing control. This eases the readability of the printed output file.
- **Conditional Directives** permit sections of conditionally assembled code. This is most useful where additional functionality may wished to be added depending on the product (less functionality for the low end product, then for the high end product). Also this is very helpful in the debugging of a program.
- **Macro Directives** control the execution and data allocation within macro body definitions. This makes very simple the re-use of functions in a program as well as between programs.

16.9 Software Simulator (MPSIM)

The MPSIM 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. MPSIM fully supports symbolic debugging using MP-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.

16.10 C Compiler (MP-C)

The MP-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 PICMASTER Universal Emulator memory display (PICMASTER emulator software versions 1.13 and later).

The MP-C Code Development System is supplied directly by Byte Craft Limited of Waterloo, Ontario, Canada. If you have any questions, please contact your regional Microchip FAE or Microchip technical support personnel at (602) 786-7627.

16.11 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™ demonstration board for hands-on experience with fuzzy logic systems implementation.

16.12 Development Systems

For convenience, the development tools are packaged into comprehensive systems as listed in Table 16-2.

TABLE 16-2: DEVELOPMENT SYSTEM PACKAGES

Item	Name	System Description
1.	PICMASTER System	PICMASTER In-Circuit Emulator, PRO MATE Programmer, Assembler, Software Simulator, Samples and your choice of Target Probe.
2.	PICSTART System	PICSTART Low-Cost Prototype Programmer, Assembler, Software Simulator and Samples.
3.	PRO MATE System	PRO MATE Universal Programmer, full featured stand-alone or PC-hosted programmer, Assembler, Simulator

PIC16C7X

NOTES:

17.0 ELECTRICAL CHARACTERISTICS FOR PIC16C70 AND PIC16C71A

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)	-0.6V to (VDD + 0.6V)
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 _{IK} (V _I < 0 or V _I > VDD)	±20 mA
Output clamp current, I _{OK} (V _O < 0 or V _O > 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	70	71	71A	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	PIC16C70-04 PIC16C71A-04	PIC16C70-10 PIC16C71A-10	PIC16C70-20 PIC16C71A-20	PIC16C70-04 PIC16C71A-04	JW Devices
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.

Applicable Devices	70	71	71A	72	73	73A	74	74A
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17.1 DC Characteristics:

PIC16C70-04 (Commercial, Industrial, Automotive⁽⁵⁾)
PIC16C71A-04 (Commercial, Industrial, Automotive⁽⁵⁾)
PIC16C70-10 (Commercial, Industrial, Automotive⁽⁵⁾)
PIC16C71A-10 (Commercial, Industrial, Automotive⁽⁵⁾)
PIC16C70-20 (Commercial, Industrial, Automotive⁽⁵⁾)
PIC16C71A-20 (Commercial, Industrial, Automotive⁽⁵⁾)

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 Power-on Reset	VPOR	-	VSS	-	V	See section on Power-on Reset for details	
D004	VDD rise rate to ensure Power-on Reset	SVDD	0.05*	-	-	V/ms	See section on Power-on Reset for details	
D010	Supply Current (Note 2)	IDD	-	2.7	5	mA	XT, RC osc configuration (PIC16C70/71A-04) FOSC = 4 MHz, VDD = 5.5V (Note 4)	
D013				13.5	30	mA	HS osc configuration (PIC16C70/71A-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 $I_r = VDD/2R_{ext}$ (mA) with Rext in kOhm.

5: Automotive operating range is Advanced 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 70 71 71A 72 73 73A 74 74A

17.2 DC Characteristics: PIC16LC70-04 (Commercial, Industrial, Automotive⁽⁵⁾) PIC16LC71A-04 (Commercial, Industrial, Automotive⁽⁵⁾)

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	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 Power-on Reset	VPOR	-	VSS	-	V	See section on Power-on Reset for details
D004	VDD rise rate to ensure Power-on Reset	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	LP osc configuration FOSC = 32 kHz, VDD = 3.0V, WDT disabled
D015	Brown-out Reset Current (Note 6)	ΔIBOR	-	300*	500	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
D021B			-	0.9	10	μA	VDD = 3.0V, WDT disabled, -40°C to +125°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: Automotive operating range is Advanced 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.

17.3 DC Characteristics:

PIC16C70-04 (Commercial, Industrial, Automotive⁽⁴⁾)
PIC16C71A-04 (Commercial, Industrial, Automotive⁽⁴⁾)
PIC16C70-10 (Commercial, Industrial, Automotive⁽⁴⁾)
PIC16C71A-10 (Commercial, Industrial, Automotive⁽⁴⁾)
PIC16C70-20 (Commercial, Industrial, Automotive⁽⁴⁾)
PIC16C71A-20 (Commercial, Industrial, Automotive⁽⁴⁾)
PIC16LC70-04 (Commercial, Industrial, Automotive⁽⁴⁾)
PIC16LC71A-04 (Commercial, Industrial, Automotive⁽⁴⁾)

DC CHARACTERISTICS 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 VDD range as described in DC spec Section 17.1 and Section 17.2.							
Param No.	Characteristic	Sym	Min	Typ †	Max	Units	Conditions
D030	Input Low Voltage I/O ports	V _{IL}	V _{SS}	-	0.5V	V	Note1
D031	with TTL buffer		V _{SS}	-	0.2V _{DD}	V	
D032	with Schmitt Trigger buffer		V _{SS}	-	0.2V _{DD}	V	
D033	MCLR, RA4/T0CKI, OSC1 (in RC mode) OSC1 (in XT, HS and LP)		V _{SS}	-	0.3V _{DD}	V	
D040	Input High Voltage I/O ports	V _{IH}	2.0	-	V _{DD}	V	Note1
D040A	with TTL buffer		0.8V _{DD}	-	V _{DD}	V	
D041	with Schmitt Trigger buffer		0.8V _{DD}	-	V _{DD}	V	
D042	MCLR, RA4/T0CKI RB0/INT		0.8V _{DD}	-	V _{DD}	V	
D042A	OSC1 (XT, HS and LP)		0.7V _{DD}	-	V _{DD}	V	
D043	OSC1 (in RC mode)		0.9V _{DD}	-	V _{DD}	V	
D070	PORTB weak pull-up current	I _{PURB}	50	250	400	μA	V _{DD} = 5V, V _{PIN} = V _{SS}
D060	Input Leakage Current (Notes 2, 3) I/O ports	I _{IL}	-	-	±1	μA	V _{SS} ≤ V _{PIN} ≤ V _{DD} , Pin at hi-impedance
D061	MCLR, RA4/T0CKI		-	-	±5	μA	V _{SS} ≤ V _{PIN} ≤ V _{DD}
D063	OSC1		-	-	±5	μA	V _{SS} ≤ V _{PIN} ≤ V _{DD} , XT, HS and LP osc configuration
D080	Output Low Voltage I/O ports	V _{OL}	-	-	0.6	V	I _{OL} = 8.5 mA, V _{DD} = 4.5V, -40°C to +85°C
D080A			-	-	0.6	V	I _{OL} = 7.0 mA, V _{DD} = 4.5V, -40°C to +125°C
D083	OSC2/CLKOUT (RC osc config)		-	-	0.6	V	I _{OL} = 1.6 mA, V _{DD} = 4.5V, -40°C to +85°C
D083A			-	-	0.6	V	I _{OL} = 1.2 mA, V _{DD} = 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 Advanced information for this device.

PIC16C7X

Applicable Devices 70 71 71A 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	Output High Voltage 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°C to $+85^{\circ}\text{C}$ $I_{OH} = -2.5\text{ mA}$, $V_{DD} = 4.5\text{V}$, -40°C to $+125^{\circ}\text{C}$ $I_{OH} = -1.3\text{ mA}$, $V_{DD} = 4.5\text{V}$, -40°C to $+85^{\circ}\text{C}$ $I_{OH} = -1.0\text{ mA}$, $V_{DD} = 4.5\text{V}$, -40°C to $+125^{\circ}\text{C}$
D090A			$V_{DD} - 0.7$	-	-	V	
D092			$V_{DD} - 0.7$	-	-	V	
D092A			$V_{DD} - 0.7$	-	-	V	
D100	Capacitive Loading Specs on Output Pins 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/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 Advanced information for this device.

Applicable Devices	70	71	71A	72	73	73A	74	74A
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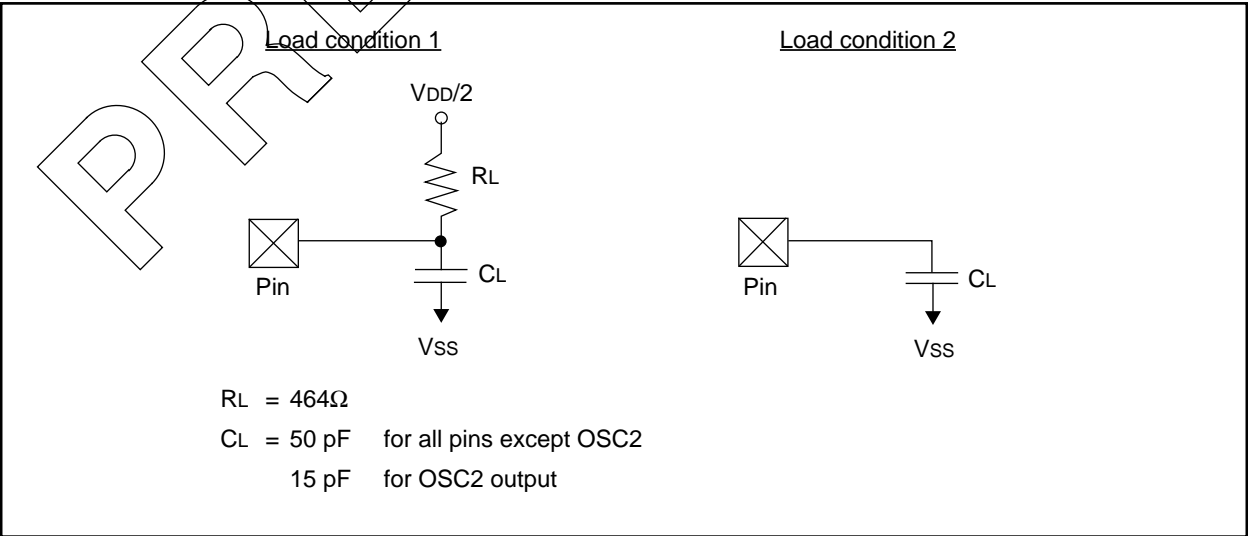
17.4 Timing Parameter Symbology

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

1. TppS2ppS
2. TppS
3. Tcc:ST (I²C specifications only)
4. Ts (I²C specifications only)

T									
F	Frequency			T	Time				
Lowercase letters (pp) and their meanings:									
pp									
cc	CCP1			osc	OSC1				
ck	CLKOUT			rd	\overline{RD}				
cs	\overline{CS}			rw	\overline{RD} or \overline{WR}				
di	SDI			sc	SCK				
do	SDO			ss	\overline{SS}				
dt	Data in			t0	T0CKI				
io	I/O port			t1	T1CKI				
mc	\overline{MCLR}			wr	\overline{WR}				
Uppercase letters and their meanings:									
S				P	Period				
F	Fall			R	Rise				
H	High			V	Valid				
I	Invalid (Hi-impedance)			Z	Hi-impedance				
L	Low								
I²C only				High	High				
AA	output access			Low	Low				
BUF	Bus free								
Tcc:ST (I ² C specifications only)									
CC				SU	Setup				
HD	Hold								
ST				STO	STOP condition				
DAT	DATA input hold								
STA	START condition								

FIGURE 17-1: LOAD CONDITIONS



PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

17.5 Timing Diagrams and Specifications

FIGURE 17-2: EXTERNAL CLOCK TIMING

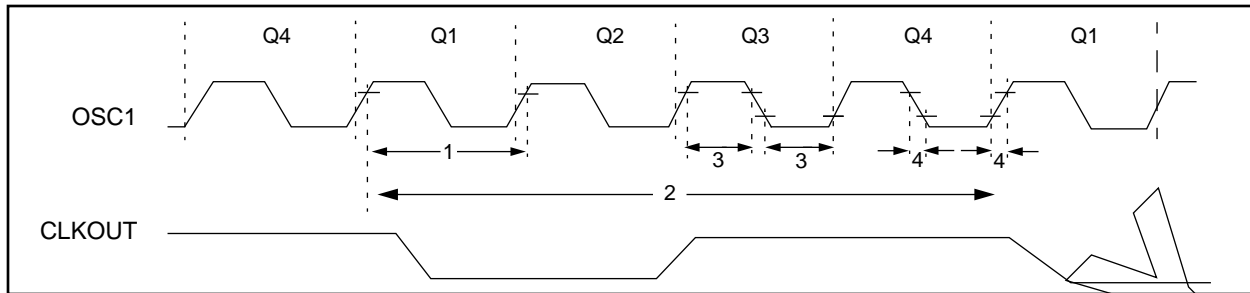


TABLE 17-2: CLOCK TIMING REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
	Fos	External CLKIN Frequency (Note 1)	DC	—	4	MHz	XT and RC osc mode
			DC	—	4	MHz	HS osc mode (PIC16C70/71A-04,)
			DC	—	20	MHz	HS osc mode (PIC16C70/71A-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 (PIC16C70/71A-04)
			4	—	10	MHz	HS osc mode (PIC16C70/71A-10)
			4	—	20	MHz	HS osc mode (PIC16C70/71A-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 (PIC16C70/71A-04)
			100	—	—	ns	HS osc mode (PIC16C70/71A-10)
			50	—	—	ns	HS osc mode (PIC16C70/71A-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 (PIC16C70/71A-04)
			100	—	250	ns	HS osc mode (PIC16C70/71A-10)
			50	—	250	ns	HS osc mode (PIC16C70/71A-20)
2	Tcy	Instruction Cycle Time (Note 1)	200	—	DC	ns	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 PIC16C70/71A.

FIGURE 17-3: CLKOUT AND I/O TIMING

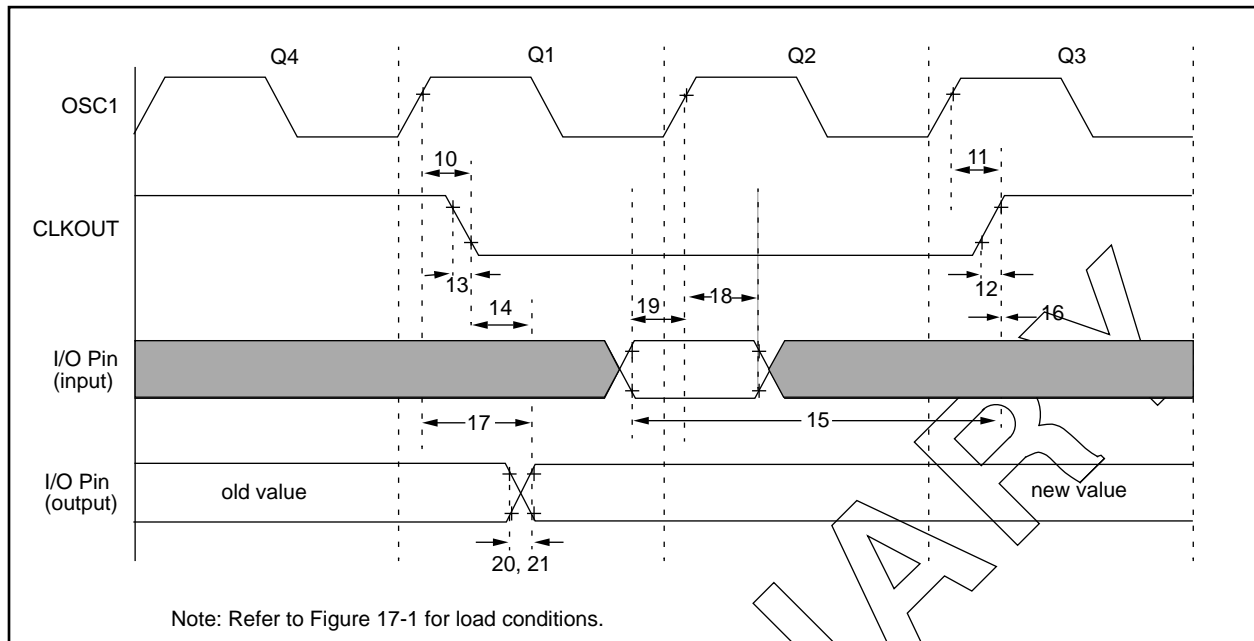


TABLE 17-3: CLKOUT AND I/O TIMING REQUIREMENTS

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 _{CY} + 20	ns	Note 1
15*	TioV2ckH	Port in valid before CLKOUT ↑	0.25T _{CY} + 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	PIC16C70/71A	—	10	25	ns
			PIC16LC70/71A	—	—	60	ns
21*	TioF	Port output fall time	PIC16C70/71A	—	10	25	ns
			PIC16LC70/71A	—	—	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_{osc}.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

FIGURE 17-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER TIMING

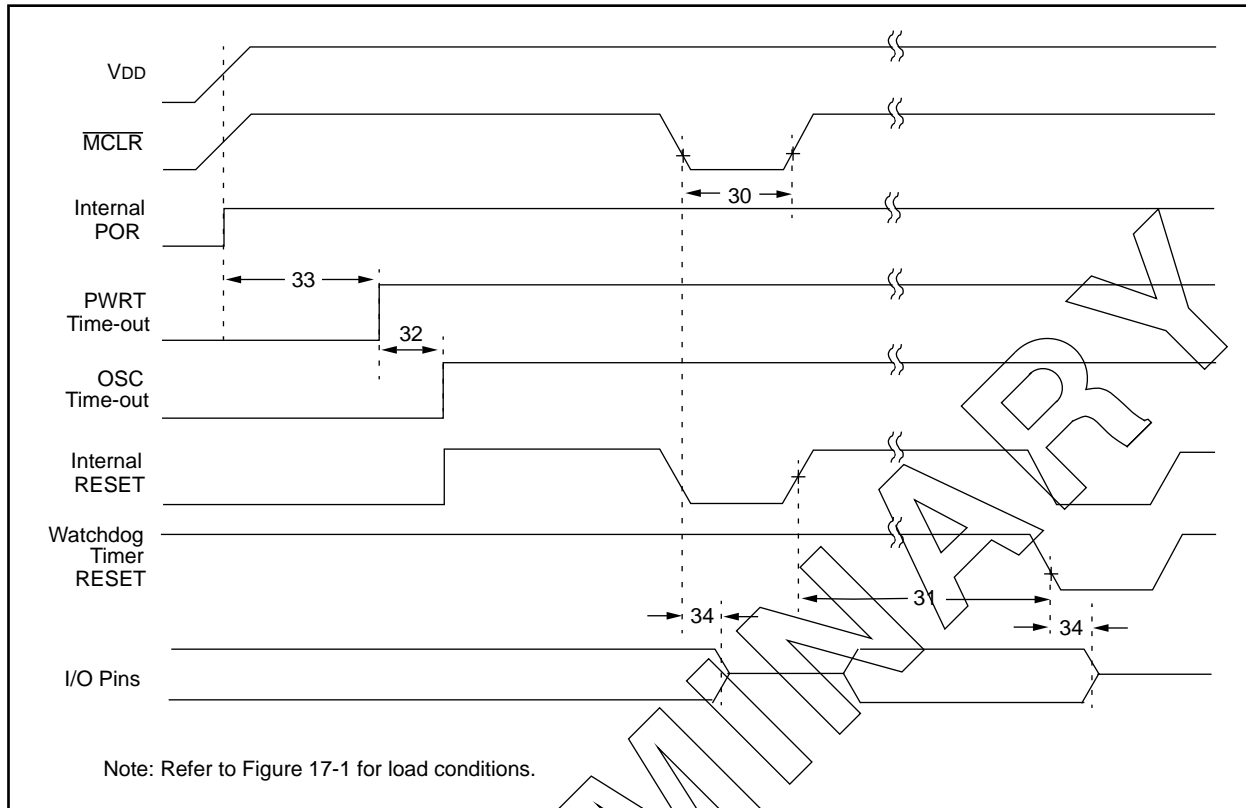


FIGURE 17-5: BROWN-OUT RESET TIMING

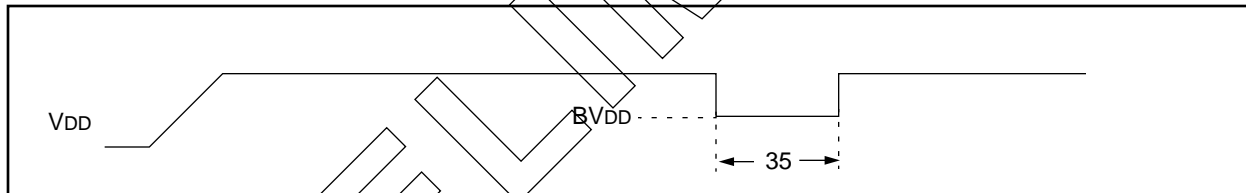


TABLE 17-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
30	Tmcl	MCLR Pulse Width (low)	1	—	—	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	Twrt	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	—	—	1.1	μs	
35	TBOR	Brown-out Reset pulse width	100	—	—	μs	3.8V ≤ VDD ≤ 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

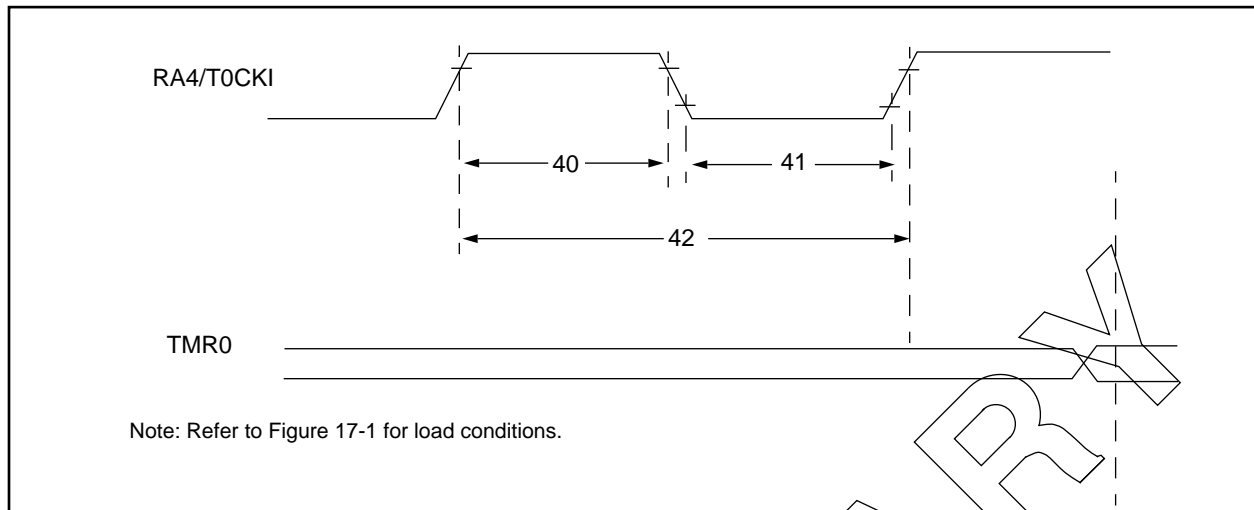


TABLE 17-5: TIMER0 CLOCK REQUIREMENTS

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 70 71 71A 72 73 73A 74 74A

TABLE 17-6: A/D CONVERTER CHARACTERISTICS:

PIC16C70-04 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽³⁾)
 PIC16C71A-04 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽³⁾)
 PIC16C70-10 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽³⁾)
 PIC16C71A-10 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽³⁾)
 PIC16C70-20 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽³⁾)
 PIC16C71A-20 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽³⁾)

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 ± 1 LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NDIF	Differential error	—	—	less than ± 1 LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NFS	Full scale error	—	—	less than ± 1 LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NOFF	Offset error	—	—	less than ± 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 Ω	
	IAD	A/D conversion current (V_{DD})	—	180	—	μA	Average current consumption when A/D is on. (Note 1)
	IREF	VREF input current (Note 2)	—	—	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: 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 Advanced information for this device.

TABLE 17-7: A/D CONVERTER CHARACTERISTICS:
PIC16LC70-04 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽⁴⁾)
PIC16LC71A-04 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽⁴⁾)

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.

4: Automotive operating range is Advanced information for this device.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

FIGURE 17-7: A/D CONVERSION TIMING

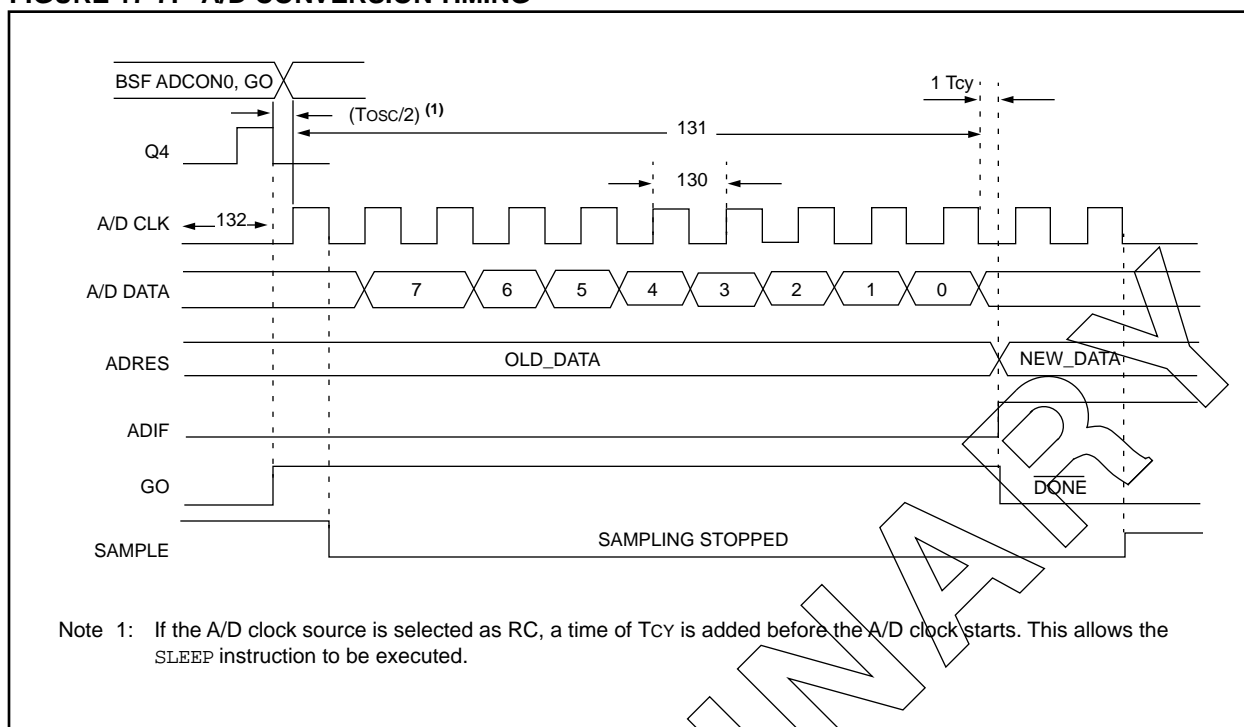


TABLE 17-8: A/D CONVERSION REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
130	TAD	A/D clock period	1.6 2.0	—	—	μs μs	VREF ≥ 3.0V VREF full range
130	TAD	A/D Internal RC Oscillator source	3.0 2.0	6.0 4.0	9.0 6.0	μs μs	ADCS1:ADCS0 = 11 (RC oscillator source) PIC16LC70, VDD = 3.0V PIC16C70
131	TCNV	Conversion time (not including S/H time). Note 1	—	9.5TAD	—	—	
132	TSMP	Sampling 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.

Note 2: See Section 13.1 for min conditions.

Applicable Devices	70	71	71A	72	73	73A	74	74A
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18.0 DC AND AC CHARACTERISTICS GRAPHS AND TABLES FOR PIC16C70
AND PIC16C71A

NOT AVAILABLE AT THIS TIME

PIC16C7X

Applicable Devices	70	71	71A	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 $\overline{\text{MCLR}}$)	-0.6V to (VDD + 0.6V)
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 _{IK} (V _I < 0 or V _I > VDD)	±20 mA
Output clamp current, I _{OK} (V _O < 0 or V _O > 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.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

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 guarantee Power-on Reset	VPO R	-	VSS	-	V	See section on Power-on Reset for details
D004	VDD rise rate to guarantee Power-on Reset	SVD D	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 Power-on Reset	VPOR	-	VSS	-	V	See section on Power-on Reset for details
D004	VDD rise rate to ensure Power-on Reset	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.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

19.3 DC Characteristics:

PIC16C71-04 (Commercial, Industrial)

PIC16C71-20 (Commercial, Industrial)

PIC16LC71-04 (Commercial, Industrial)

Standard Operating Conditions (unless otherwise stated) Operating temperature -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 19.1 and Section 19.2.							
DC CHARACTERISTICS							
Param No.	Characteristic	Sym	Min	Typ †	Max	Units	Conditions
D030	Input Low Voltage I/O ports	VIL					
D031	with TTL buffer		VSS	-	0.5V	V	
D032	with Schmitt Trigger buffer		VSS	-	0.2VDD	V	
D033	MCLR, RA4/T0CKI, OSC1 (in RC mode)		VSS	-	0.2VDD	V	
D033	OSC1 (in XT, HS and LP)		VSS	-	0.3VDD	V	Note1
D040	Input High Voltage I/O ports (Note 4)	VIH		-			
D040A	with TTL buffer		0.36VDD	-	VDD	V	4.5 ≤ VDD ≤ 5.5V
D041	with Schmitt Trigger buffer		0.45VDD	-	VDD	V	For VDD > 5.5V or VDD < 4.5V
D042	MCLR RA4/T0CKI		0.85VDD	-	VDD	V	For entire VDD range
D042A	OSC1 (XT, HS and LP)		0.85VDD	-	VDD	V	
D043	OSC1 (in RC mode)		0.7VDD	-	VDD	V	Note1
D070	PORTB weak pull-up current	IPURB	50	250	†400	µA	VDD = 5V, VPIN = VSS
D060	Input Leakage Current (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	Output Low Voltage I/O ports	VOL	-	-	0.6	V	IoL = 8.5mA, VDD = 4.5V, -40°C to +85°C
D083	OSC2/CLKOUT (RC osc config)		-	-	0.6	V	IoL = 1.6mA, VDD = 4.5V, -40°C to +85°C
D090	Output High Voltage I/O ports (Note 3)	VOH	VDD - 0.7	-	-	V	IoH = -3.0mA, VDD = 4.5V, -40°C to +85°C
D092	OSC2/CLKOUT (RC osc config)		VDD - 0.7	-	-	V	IoH = -1.3mA, VDD = 4.5V, -40°C to +85°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 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 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.

PIC16C7X

Applicable Devices	70	71	71A	72	73	73A	74	74A
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DC CHARACTERISTICS <div> Standard Operating Conditions (unless otherwise stated) 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 VDD range as described in DC spec Section 19.1 and Section 19.2. </div>							
Param No.	Characteristic	Sym	Min	Typ †	Max	Units	Conditions
D100	Capacitive Loading Specs on Output Pins 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 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 **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.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

19.4 Timing Parameter Symbolology

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

1. TppS2ppS
2. TppS
3. Tcc:ST (I²C specifications only)
4. Ts (I²C specifications only)

T			
F	Frequency	T	Time

Lowercase letters (pp) and their meanings:

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

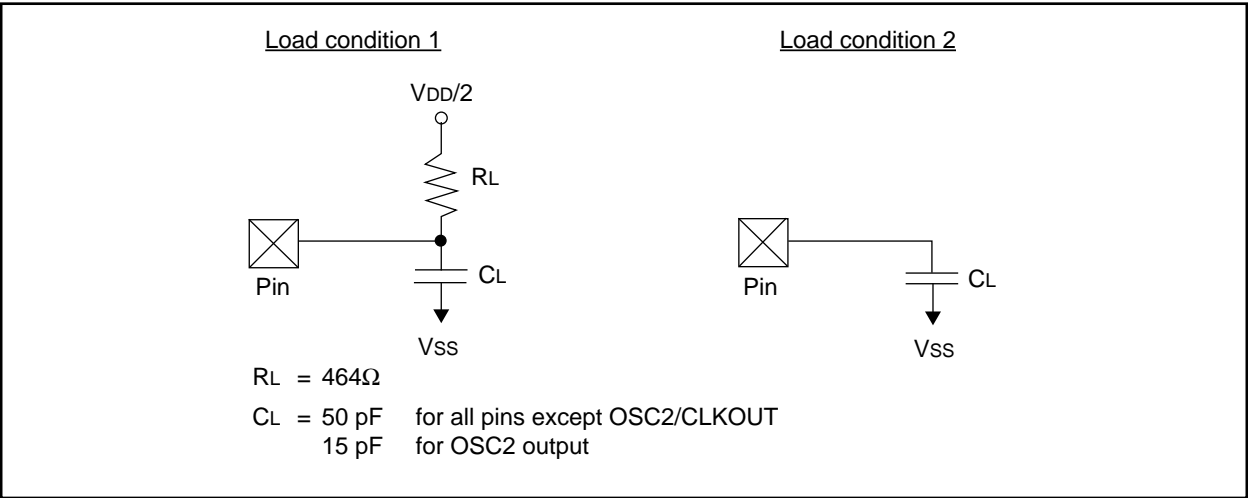
Uppercase letters and their meanings:

S			
F	Fall	P	Period
H	High	R	Rise
I	Invalid (Hi-impedance)	V	Valid
L	Low	Z	Hi-impedance
I²C only			
AA	output access	High	High
BUF	Bus free	Low	Low

Tcc:ST (I²C specifications only)

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

FIGURE 19-1: LOAD CONDITIONS



19.5 Timing Diagrams and Specifications

FIGURE 19-2: EXTERNAL CLOCK TIMING

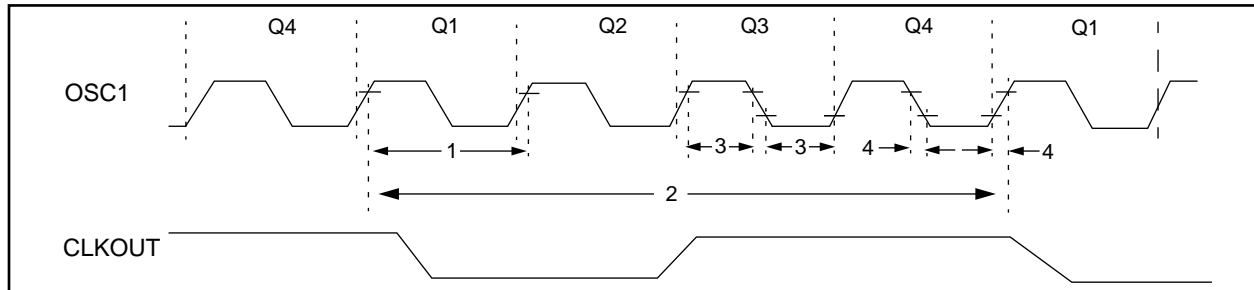


TABLE 19-2: EXTERNAL CLOCK TIMING REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
	Fos	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)
	2	Instruction Cycle Time (Note 1)	1.0	—	DC	μs	Tcy = 4/Fosc
			1.0	—	DC	μs	Tcy = 4/Fosc
3	TosL, TosH	Clock in (OSC1) High or Low Time	50	—	—	ns	XT oscillator
			2.5	—	—	μs	LP oscillator
			10	—	—	ns	HS oscillator
4	TosR, TosF	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.

PIC16C7X

Applicable Devices **70** **71** **71A** **72** **73** **73A** **74** **74A**

FIGURE 19-3: CLKOUT AND I/O TIMING

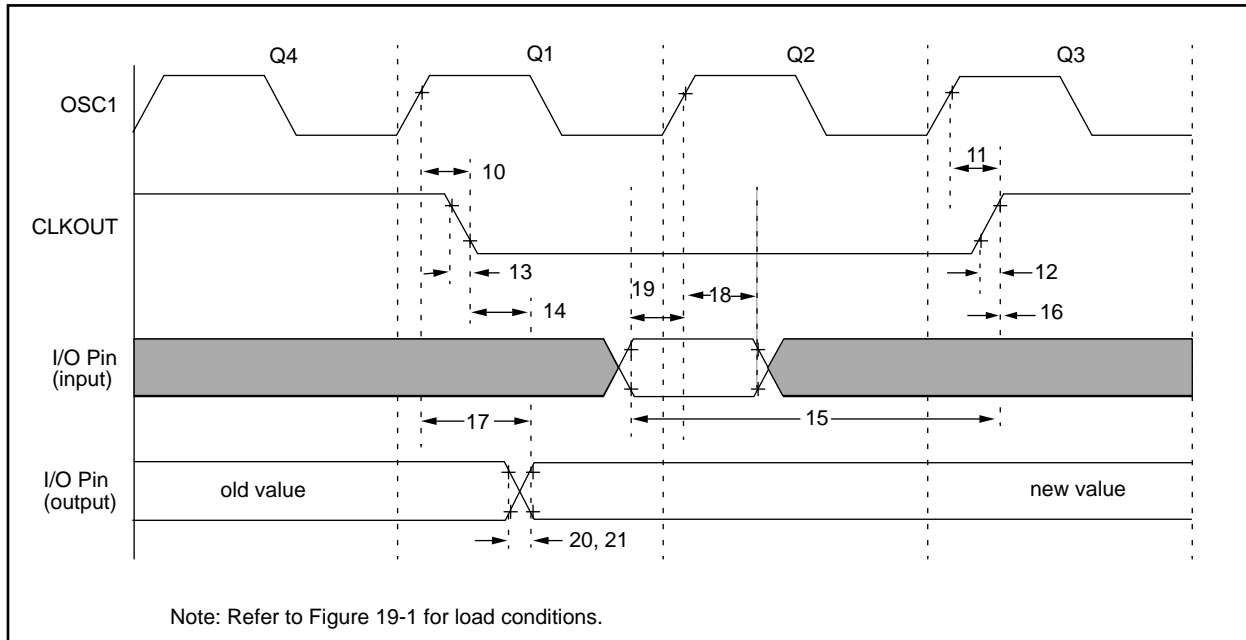


TABLE 19-3: CLKOUT AND I/O TIMING REQUIREMENTS

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	—	—	0.5Tcy + 20	ns	Note 1
15*	TioV2ckH	Port in valid before CLKOUT ↑	0.25Tcy + 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	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 Tosc.

FIGURE 19-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER TIMING

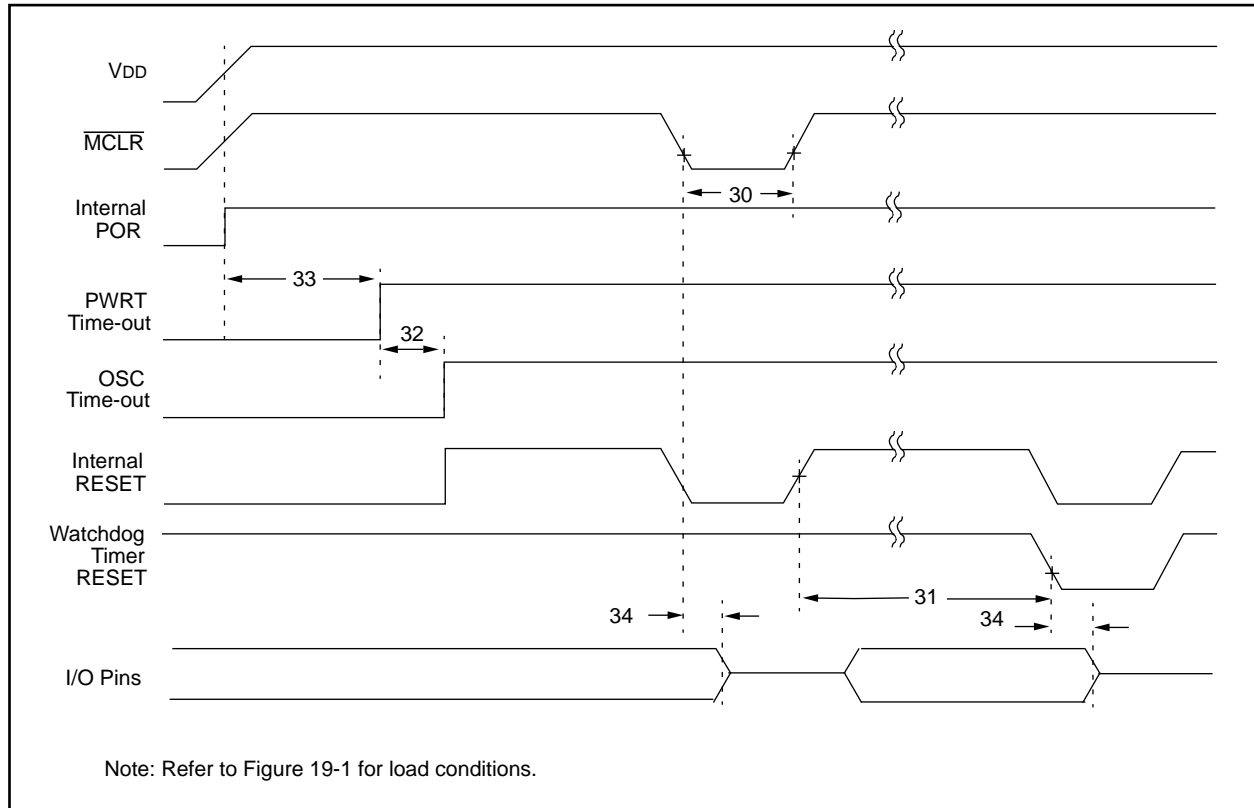


TABLE 19-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
30	Tmcl	MCLR Pulse Width (low)	200	—	—	ns	VDD = 5V, -40°C to +85°C
31	Twdt	Watchdog Timer Time-out Period (No Prescaler)	7*	18	33*	ms	VDD = 5V, -40°C to +85°C
32	Tost	Oscillation Start-up Timer Period		1024 TOSC			TOSC = OSC1 period
33	Tpwrt	Power-up Timer Period	28*	72	132*	ms	VDD = 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.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

FIGURE 19-5: TIMER0 CLOCK TIMINGS

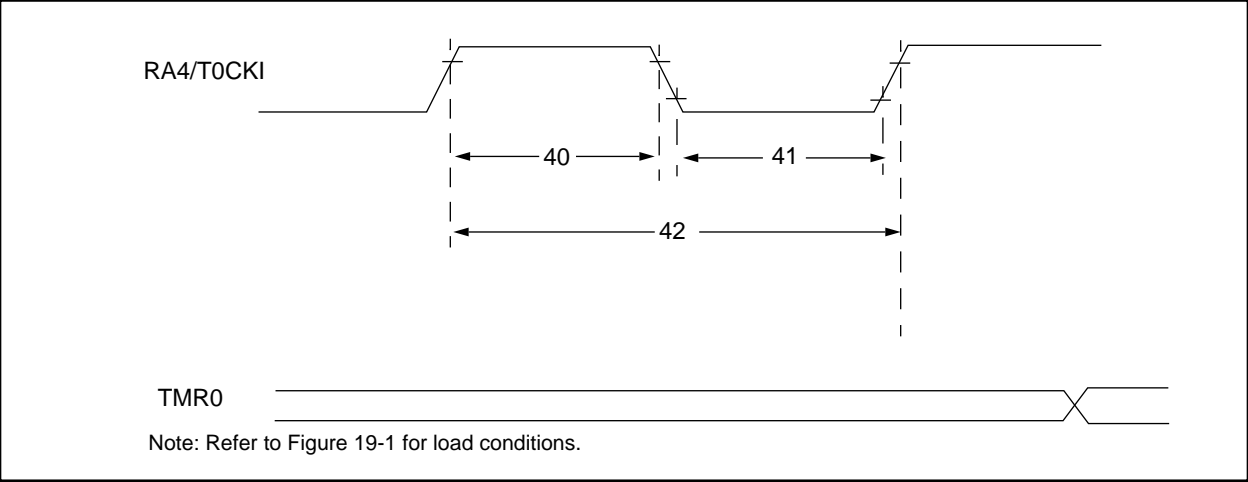


TABLE 19-5: TIMER0 CLOCK REQUIREMENTS

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.

**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	—	$V_{REF} = V_{DD} = 5.12V$, $V_{SS} \leq AIN \leq V_{REF}$
	NINT	Integral error	—	—	less than ± 1 LSb	—	$V_{REF} = V_{DD} = 5.12V$, $V_{SS} \leq AIN \leq V_{REF}$
	NDIF	Differential error	—	—	less than ± 1 LSb	—	$V_{REF} = V_{DD} = 5.12V$, $V_{SS} \leq AIN \leq V_{REF}$
	NFS	Full scale error	—	—	less than ± 1 LSb	—	$V_{REF} = V_{DD} = 5.12V$, $V_{SS} \leq AIN \leq V_{REF}$
	NOFF	Offset error	—	—	less than ± 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}	V	
	ZAIN	Recommended impedance of analog voltage source	—	—	10.0	k Ω	
	IAD	A/D conversion current (VDD)	—	180	—	μA	Average current consumption when A/D is on. (Note 1)
	IREF	VREF input current (Note 2)	—	—	1 40	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: 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.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

**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)	—	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.

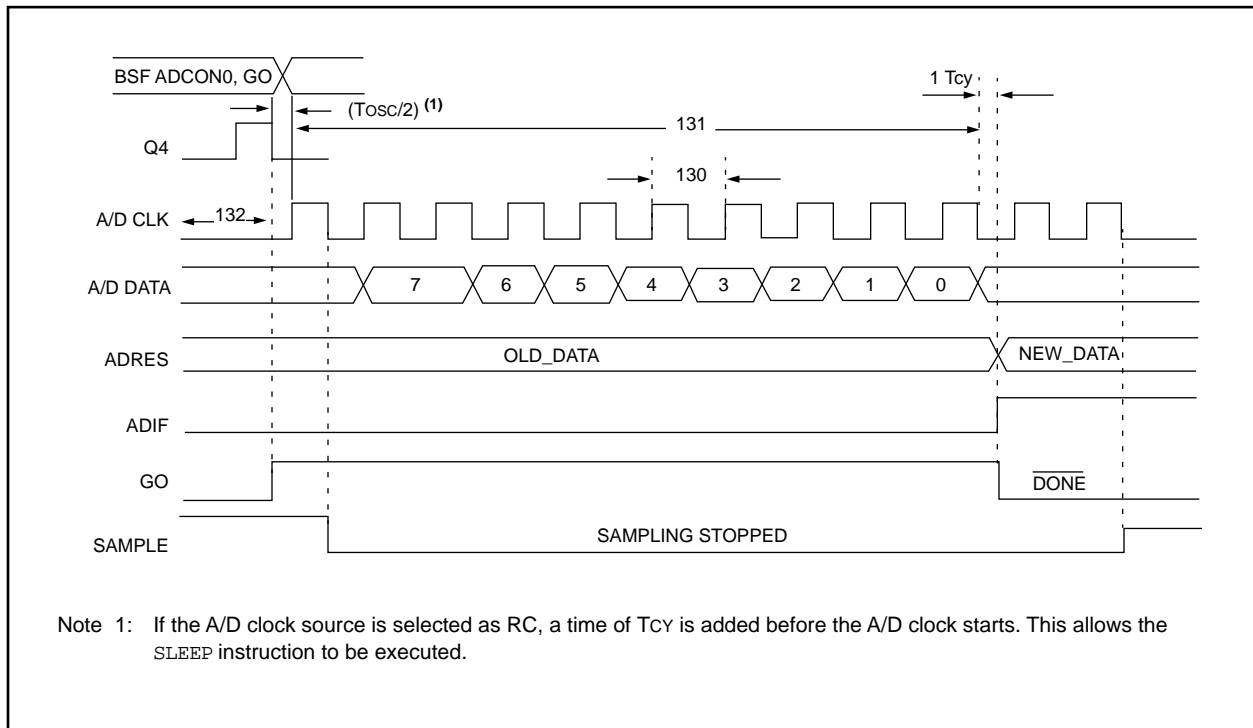
† Data in "Typ" column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

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 19-6: A/D CONVERSION TIMING

**TABLE 19-8: A/D CONVERSION REQUIREMENTS**

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
130	T _{AD}	A/D clock period	2.0		—	μs	
130	T _{AD}	A/D Internal RC Oscillator source	3.0	6.0	9.0	μs	ADCS1:ADCS0 = 11 (RC oscillator source)
			2.0	4.0	6.0	μs	PIC16LC71, V _{DD} = 3.0V
							PIC16C71
131	T _{CNV}	Conversion time (not including S/H time) (Note 1)	—	10T _{AD}	—	—	
132	T _{SMP}	Sampling 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.

PIC16C7X

NOTES:

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. 'Typical' represents the mean of the distribution while 'max' or 'min' represents (mean + 3σ) and (mean - 3σ) respectively where σ is standard deviation.

FIGURE 20-1: TYPICAL RC OSCILLATOR FREQUENCY vs. TEMPERATURE

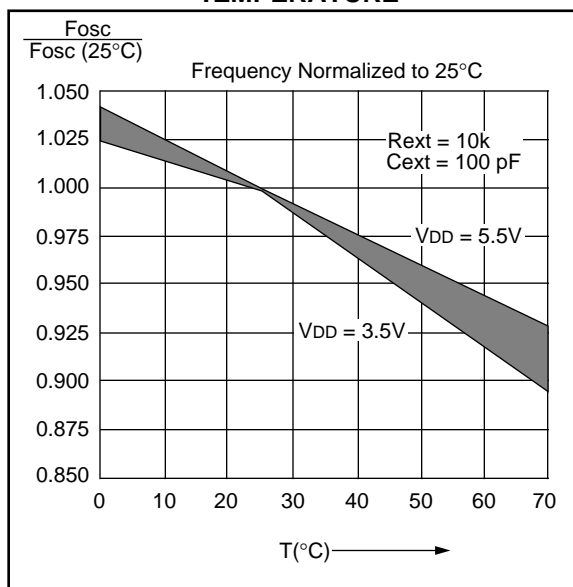


FIGURE 20-2: TYPICAL RC OSCILLATOR FREQUENCY vs. V_{DD}

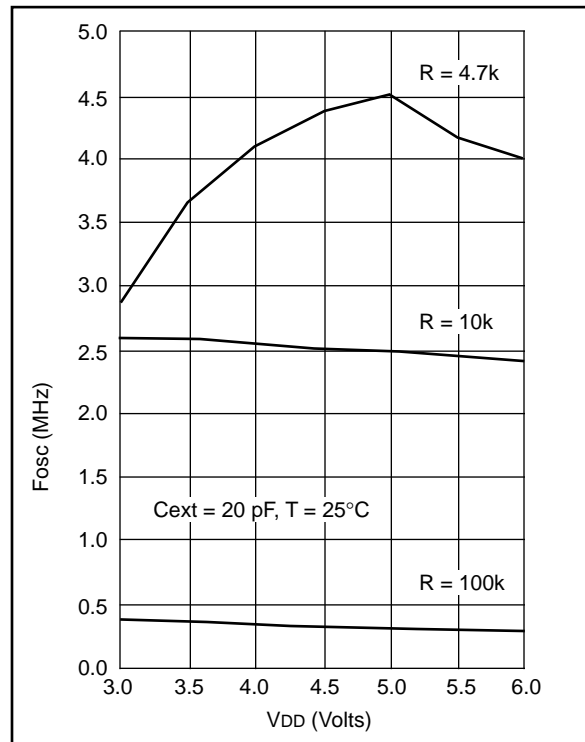
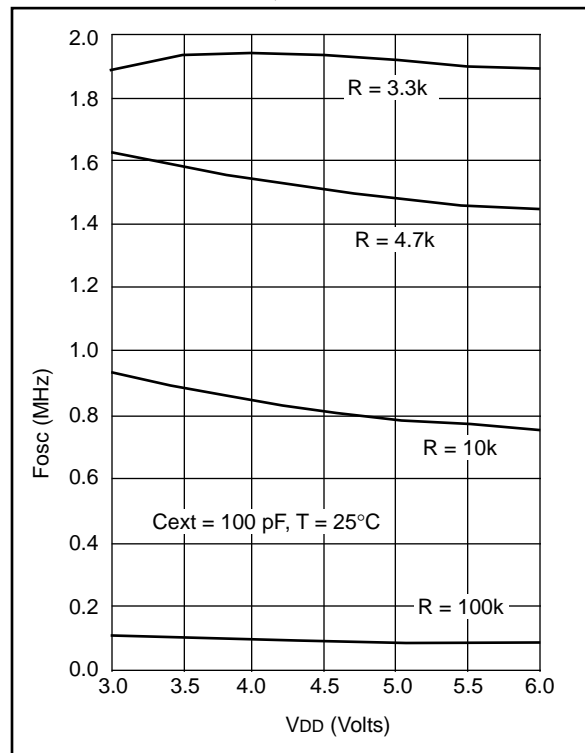


FIGURE 20-3: TYPICAL RC OSCILLATOR FREQUENCY vs. V_{DD}



PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

FIGURE 20-4: TYPICAL RC OSCILLATOR
FREQUENCY vs. VDD

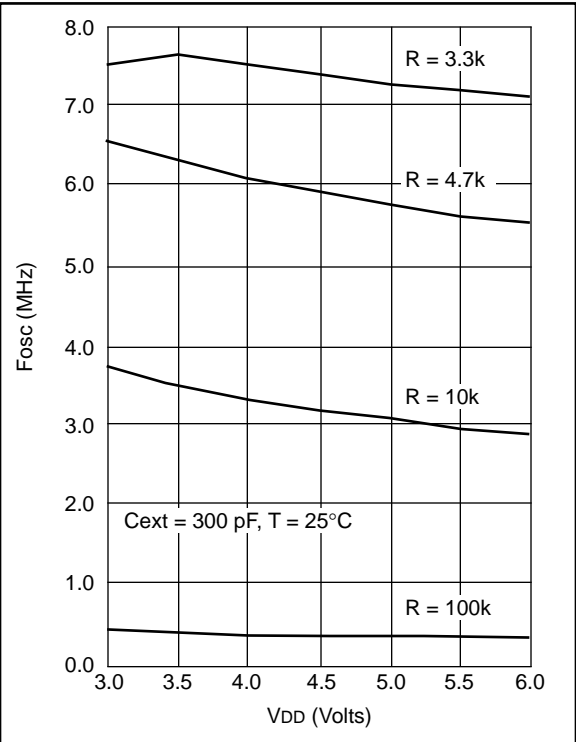


FIGURE 20-5: TYPICAL IPD vs. VDD
WATCHDOG TIMER
DISABLED 25°C

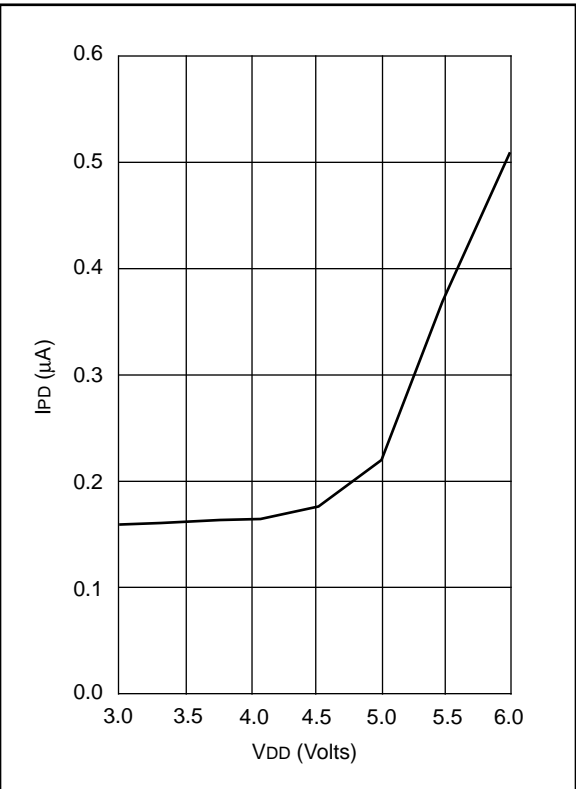
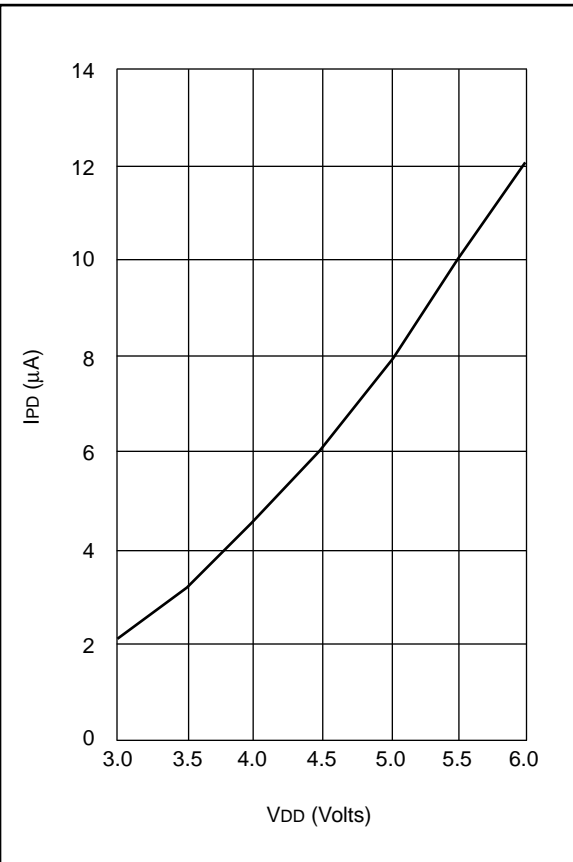


TABLE 20-1: RC OSCILLATOR
FREQUENCIES

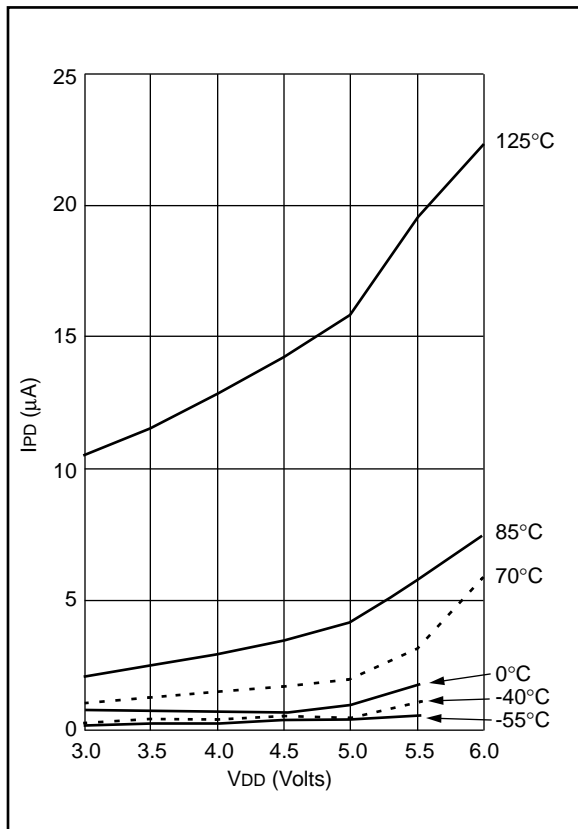
Cext	Rext	Average	
		Fosc @ 5V, 25°C	
20 pf	4.7k	4.52 MHz	±17.35%
	10k	2.47 MHz	±10.10%
	100k	290.86 kHz	±11.90%
100 pf	3.3k	1.92 MHz	±9.43%
	4.7k	1.49 MHz	±9.83%
	10k	788.77 kHz	±10.92%
	100k	88.11 kHz	±16.03%
300 pf	3.3k	726.89 kHz	±10.97%
	4.7k	573.95 kHz	±10.14%
	10k	307.31 kHz	±10.43%
	100k	33.82 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 VDD = 5V.

FIGURE 20-6: TYPICAL IPD vs. VDD
WATCHDOG TIMER ENABLED
25°C



**FIGURE 20-7: MAXIMUM I_{PD} vs. V_{DD}
WATCHDOG DISABLED**



**FIGURE 20-8: MAXIMUM I_{PD} vs. V_{DD}
WATCHDOG ENABLED**

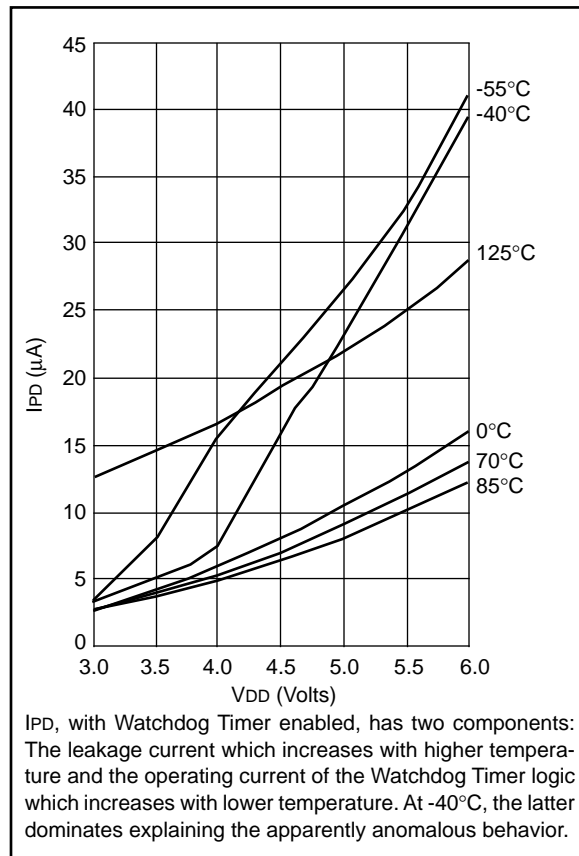
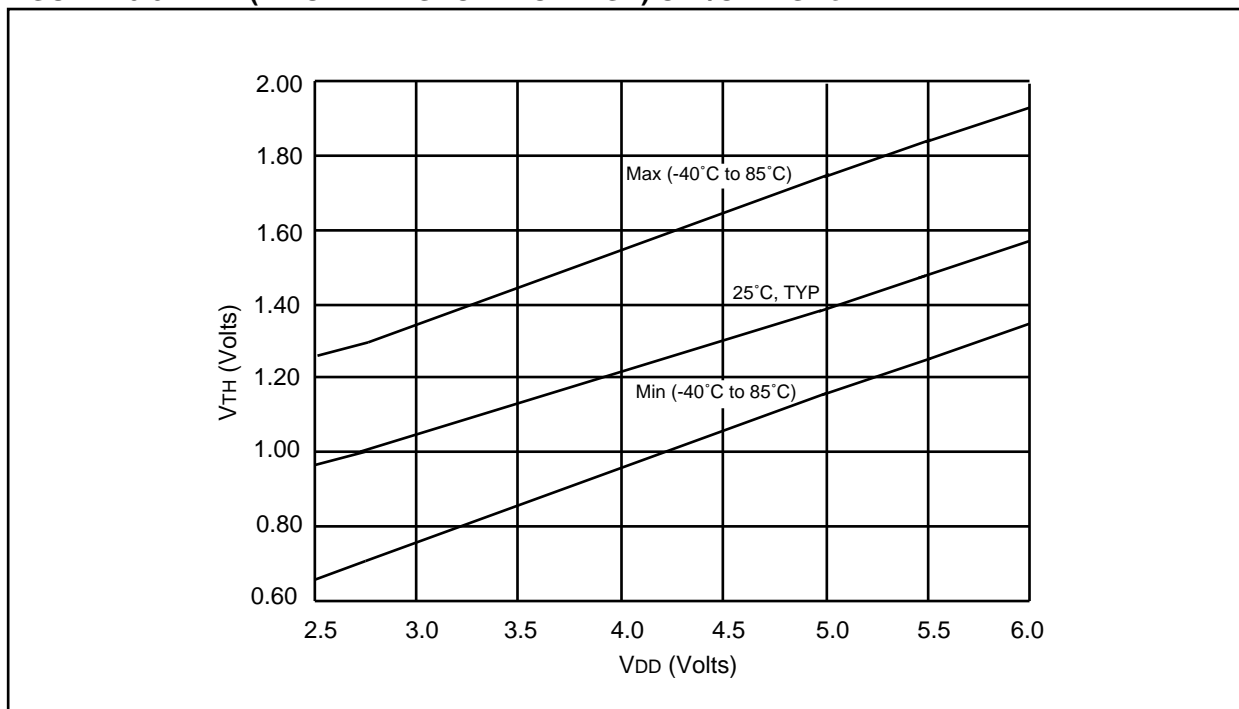


FIGURE 20-9: V_{TH} (INPUT THRESHOLD VOLTAGE) OF I/O PINS vs. V_{DD}



PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

FIGURE 20-10: V_{IH} , V_{IL} OF MCLR, T0CKI AND OSC1 (IN RC MODE) vs. V_{DD}

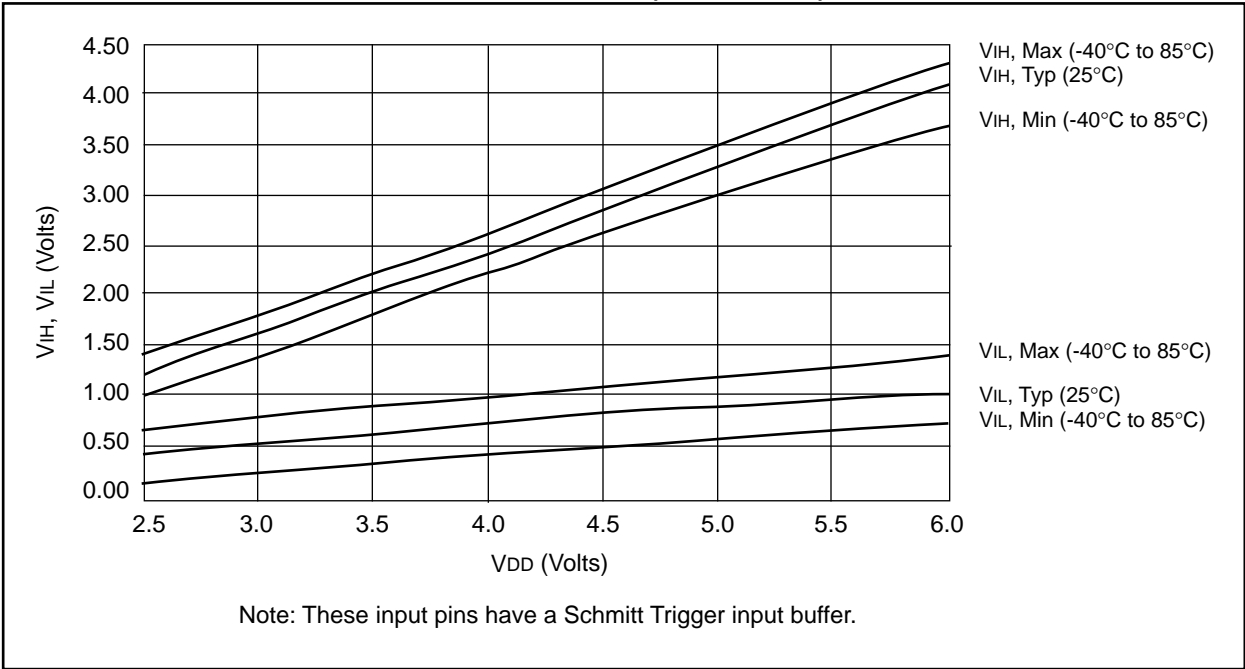


FIGURE 20-11: V_{TH} (INPUT THRESHOLD VOLTAGE) OF OSC1 INPUT (IN XT, HS, AND LP MODES) vs. V_{DD}

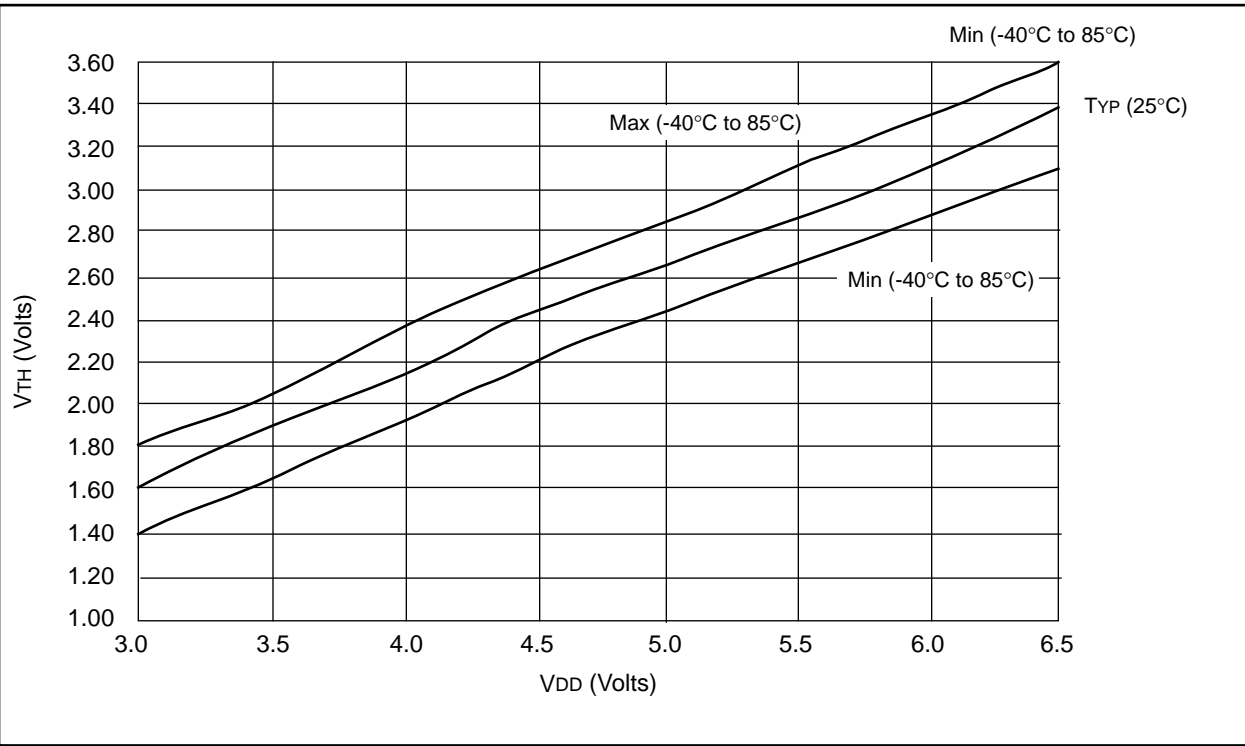


FIGURE 20-12: TYPICAL I_{DD} vs. FREQ (EXT CLOCK, 25°C)

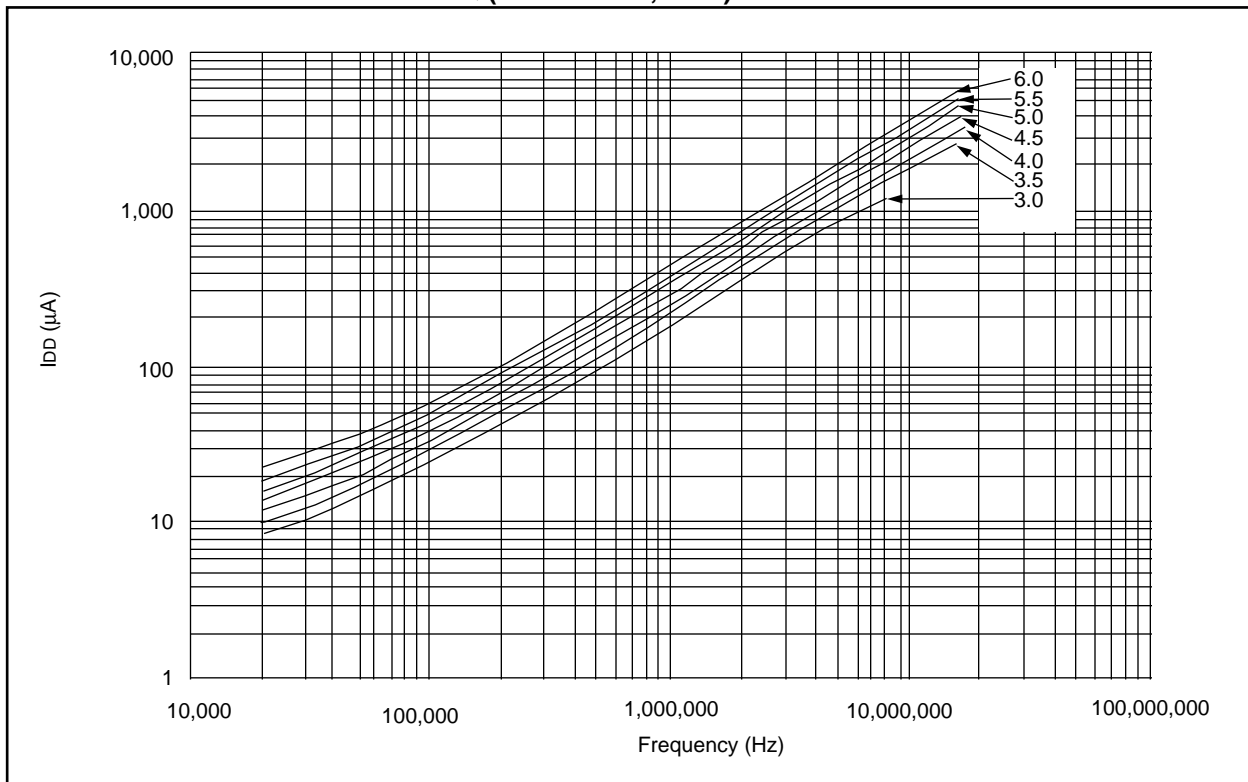
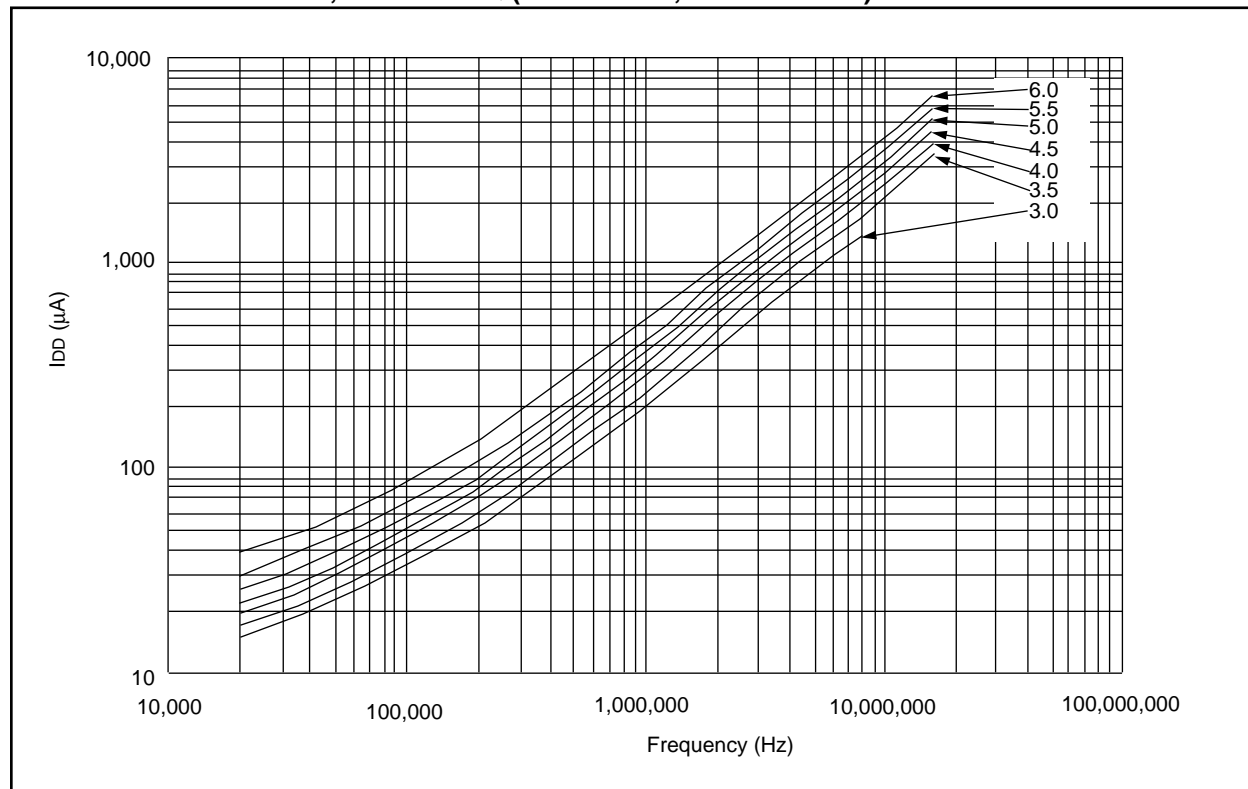


FIGURE 20-13: MAXIMUM I_{DD} vs. FREQ (EXT CLOCK, -40° TO +85°C)



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° TO +125°C)

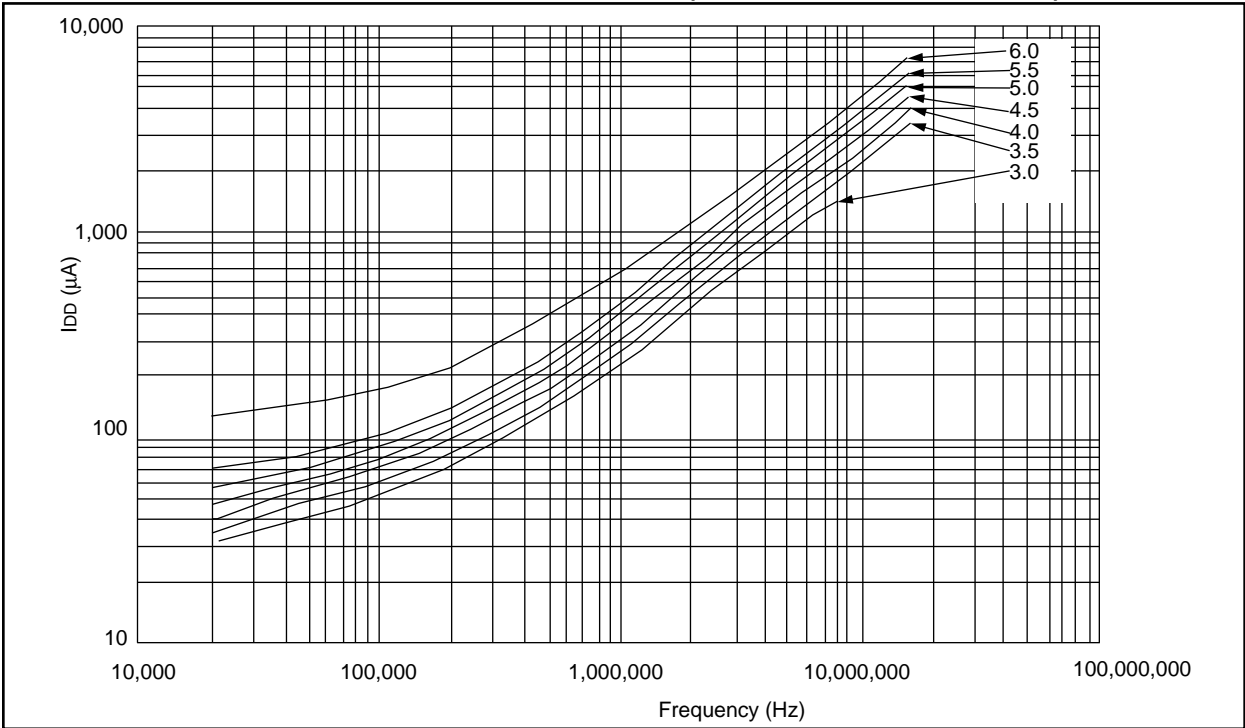


FIGURE 20-15: WDT TIMER TIME-OUT PERIOD vs. V_{DD}

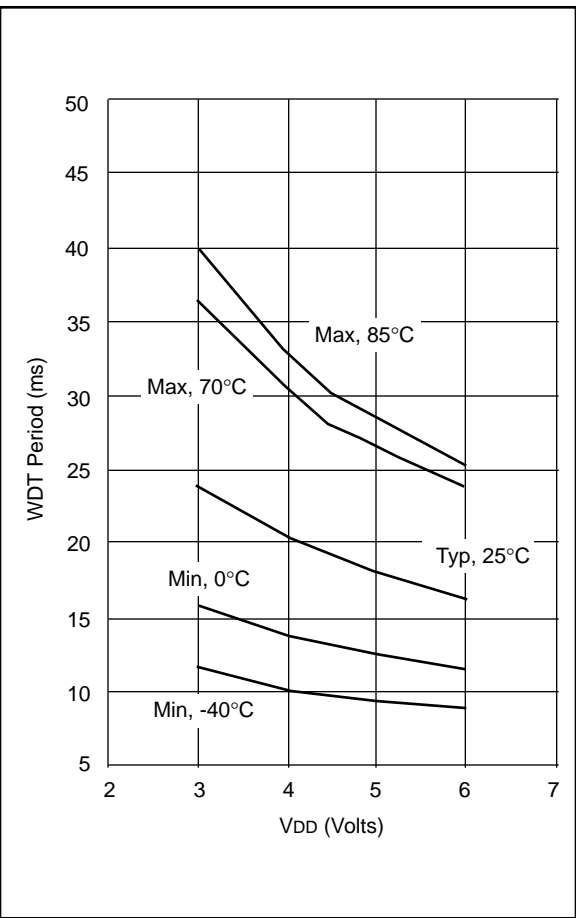


FIGURE 20-16: TRANSCONDUCTANCE (gm) OF HS OSCILLATOR vs. V_{DD}

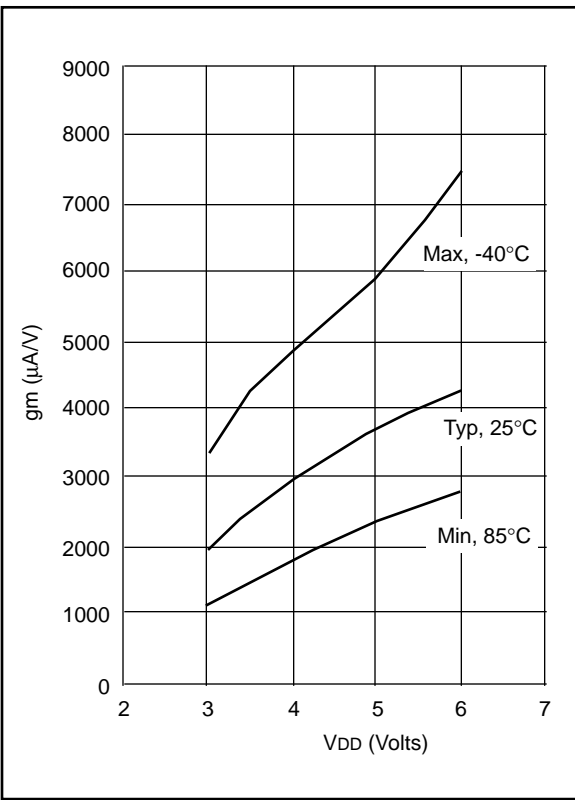


FIGURE 20-17: TRANSCONDUCTANCE (gm) OF LP OSCILLATOR vs. VDD

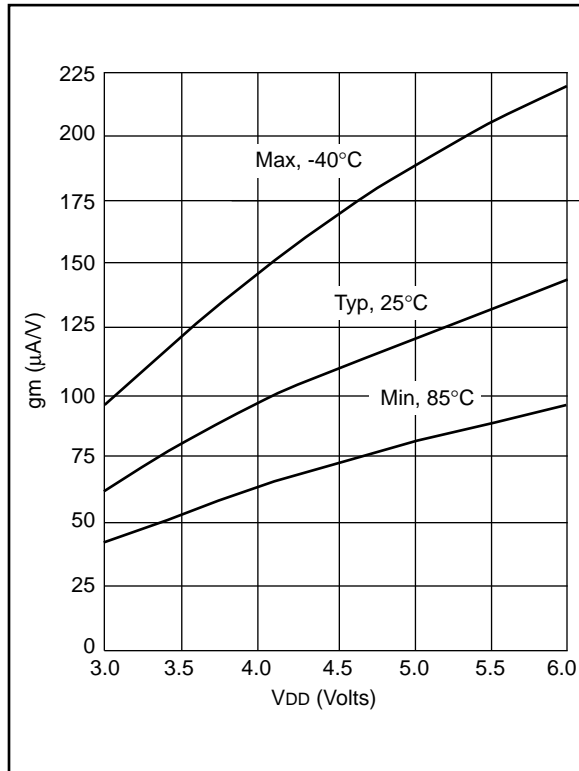


FIGURE 20-19: I_{OH} vs. V_{OH}, V_{DD} = 3V

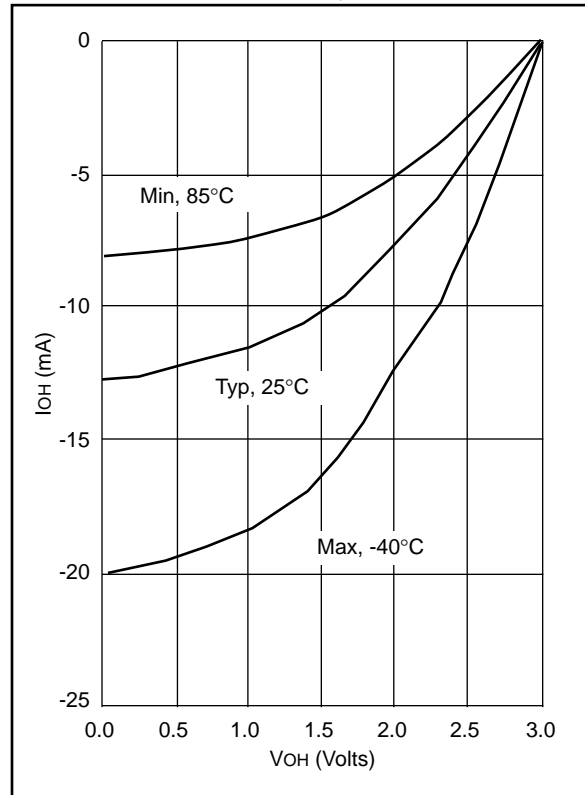


FIGURE 20-18: TRANSCONDUCTANCE (gm) OF XT OSCILLATOR vs. VDD

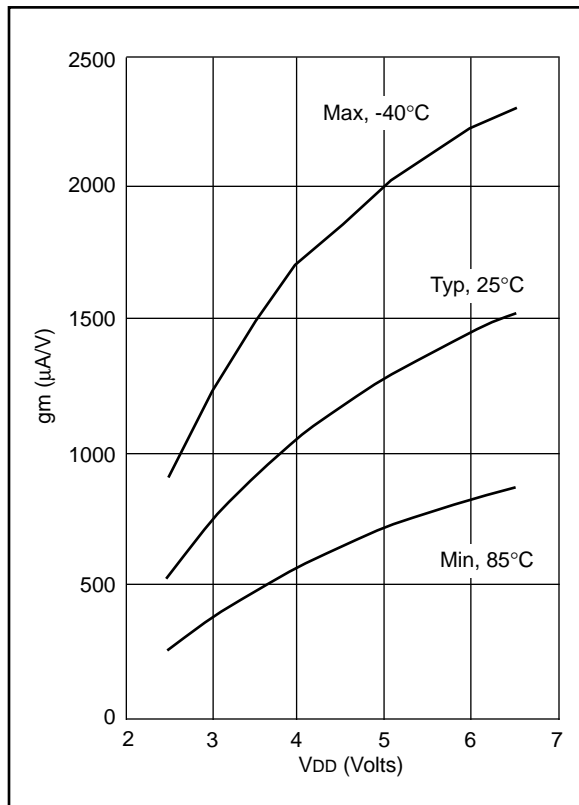
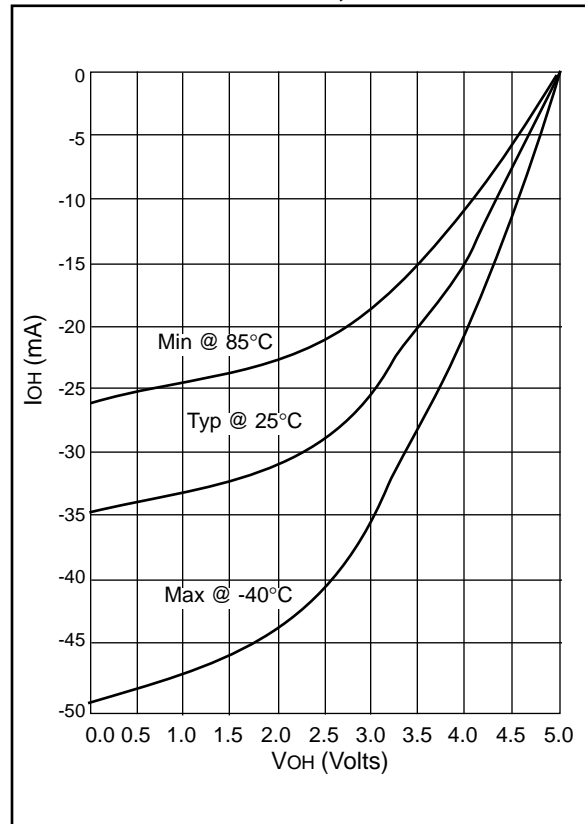


FIGURE 20-20: I_{OH} vs. V_{OH}, V_{DD} = 5V



PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

FIGURE 20-21: IOL vs. VOL, VDD = 3V

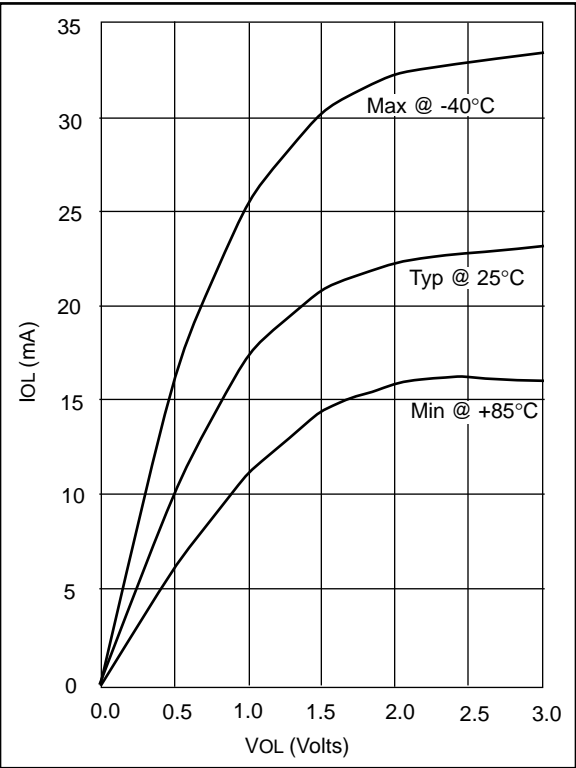
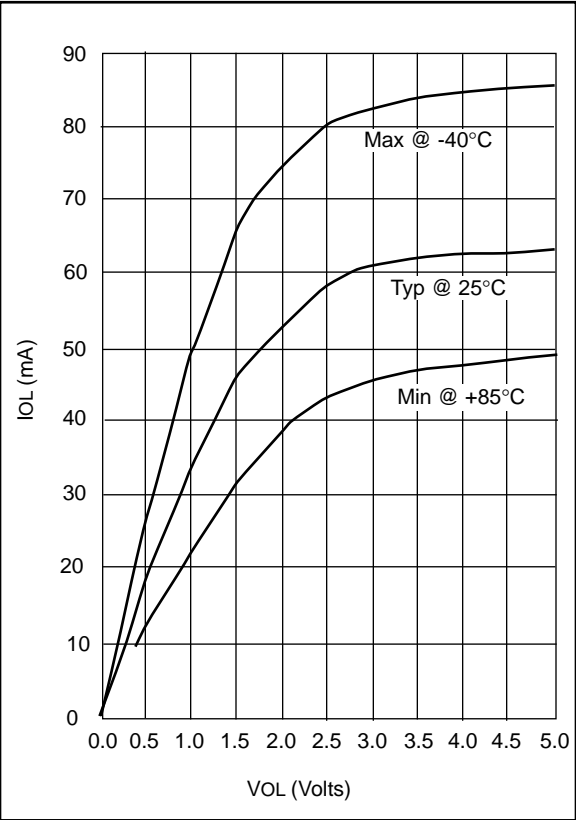


TABLE 20-2: INPUT CAPACITANCE*

Pin Name	Typical Capacitance (pF)	
	18L PDIP	18L SOIC
RA port	5.0	4.3
RB port	5.0	4.3
MCLR	17.0	17.0
OSC1/CLKN	4.0	3.5
OSC2/CLKOUT	4.3	3.5
TMR0	3.2	2.8

*All capacitance values are typical at 25°C. A part-to-part variation of ±25% (three standard deviations) should be taken into account.

FIGURE 20-22: IOL vs. VOL, VDD = 5V



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 MCLR)	-0.6V to (VDD + 0.6V)
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 _{IK} (V _I < 0 or V _I > VDD)	±20 mA
Output clamp current, I _{OK} (V _O < 0 or V _O > 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 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	70	71	71A	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: 21 μ 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 μ 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 μ A typ. at 4V Freq: 4 MHz max.	VDD: 3.0V to 6.0V IDD: 2.0 mA typ. at 3.0V IPD: 0.9 μ A typ. at 3V Freq: 4 MHz max.	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 21 μ A max. at 4V Freq: 4 MHz max.
XT	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 21 μ 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 μ 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 μ A typ. at 4V Freq: 4 MHz max.	VDD: 3.0V to 6.0V IDD: 2.0 mA typ. at 3.0V IPD: 0.9 μ A typ. at 3V Freq: 4 MHz max.	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 21 μ 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 μ A typ. at 4.5V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 30 mA max. at 5.5V IPD: 1.5 μ 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 μ 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 μ A typ. at 4.5V Freq: 10 MHz max.
LP	VDD: 4.0V to 6.0V IDD: 52.5 μ A typ. at 32 kHz, 4.0V IPD: 0.9 μ 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 μ A max. at 32 kHz, 3.0V IPD: 5.0 μ A max. at 3.0V Freq: 200 kHz max.	VDD: 3.0V to 6.0V IDD: 48 μ A max. at 32 kHz, 3.0V IPD: 5.0 μ 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.

21.1 DC Characteristics:

PIC16C72-04 (Commercial, Industrial, Automotive⁽⁶⁾)
PIC16C72-10 (Commercial, Industrial, Automotive⁽⁶⁾)
PIC16C72-20 (Commercial, Industrial, Automotive⁽⁶⁾)

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 Power-on Reset	VPOR	-	VSS	-	V	See section on Power-on Reset for details
D004	VDD rise rate to ensure Power-on Reset	SVDD	0.05*	-	-	V/ms	See section on Power-on Reset for details
D010	Supply Current (Note 2,5)	IDD	-	2.7	5	mA	XT, RC osc configuration (PIC16C72-04) FOSC = 4 MHz, VDD = 5.5V (Note 4)
D013				13.5	30	mA	HS osc configuration (PIC16C72-20) FOSC = 20 MHz, VDD = 5.5V
D015	Brown-out Reset Current (Note 7)	ΔIBOR	-	300*	500	μA	BOR enabled VDD = 5.0V
D020 D021 D021A D021B	Power-down Current (Note 3,5)	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 7)	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 $I_r = VDD/2R_{ext}$ (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: Automotive operating range is Advanced information for this device.

7: 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 70 71 71A 72 73 73A 74 74A

21.2 DC Characteristics: PIC16LC72-04 (Commercial, Industrial, Automotive)⁽⁶⁾

Standard Operating Conditions (unless otherwise stated)							
DC CHARACTERISTICS							
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	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 Power-on Reset	VPOR	-	VSS	-	V	See section on Power-on Reset for details
D004	VDD rise rate to ensure Power-on Reset	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	LP osc configuration FOSC = 32 kHz, VDD = 3.0V, WDT disabled
D015	Brown-out Reset Current (Note 7)	ΔIBOR	-	300*	500	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
D021B			-	0.9	10	μA	VDD = 3.0V, WDT disabled, -40°C to +125°C
D023	Brown-out Reset Current (Note 7)	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: Automotive operating range is Advanced information for this device.

7: 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.

21.3 DC Characteristics:

PIC16C72-04 (Commercial, Industrial, Automotive⁽⁴⁾)
PIC16C72-10 (Commercial, Industrial, Automotive⁽⁴⁾)
PIC16C72-20 (Commercial, Industrial, Automotive⁽⁴⁾)
PIC16LC72-04 (Commercial, Industrial, Automotive⁽⁴⁾)

DC CHARACTERISTICS 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 VDD range as described in DC spec Section 21.1 and Section 21.2.							
Param No.	Characteristic	Sym	Min	Typ †	Max	Units	Conditions
D030 D031 D032 D033	Input Low Voltage I/O ports	VIL					
	with TTL buffer		VSS	-	0.5V	V	
	with Schmitt Trigger buffer		VSS	-	0.2VDD	V	
	MCLR, RA4/T0CKI, OSC1 (in RC mode)		VSS	-	0.2VDD	V	
D033	OSC1 (in XT, HS and LP)		VSS	-	0.3VDD	V	Note1
D040 D040A D041 D042 D042A D043	Input High Voltage I/O ports	VIH					
	with TTL buffer		2.0	-	VDD	V	$4.5 \leq VDD \leq 5.5V$
			0.8VDD	-	VDD	V	For VDD > 5.5V or VDD < 4.5V
	with Schmitt Trigger buffer		0.8VDD	-	VDD	V	For entire VDD range
	MCLR, RA4/T0CKI, RC7:RC4, RB0/INT		0.8VDD	-	VDD	V	
	OSC1 (XT, HS and LP)		0.7VDD	-	VDD	V	Note1
	OSC1 (in RC mode)		0.9VDD	-	VDD	V	
D070	PORTB weak pull-up current	IPURB	50	250	†400	μA	VDD = 5V, VPIN = VSS
D060 D061 D063	Input Leakage Current (Notes 2, 3) I/O ports	IIL	-	-	±1	μA	VSS ≤ VPIN ≤ VDD, Pin at hi-impedance
	MCLR, RA4/T0CKI		-	-	±5	μA	VSS ≤ VPIN ≤ VDD
	OSC1		-	-	±5	μA	VSS ≤ VPIN ≤ VDD, XT, HS and LP osc configuration
D080 D080A D083 D083A	Output Low Voltage I/O ports	VOL	-	-	0.6	V	IOL = 8.5 mA, VDD = 4.5V, -40°C to +85°C
			-	-	0.6	V	IOL = 7.0 mA, VDD = 4.5V, -40°C to +125°C
	OSC2/CLKOUT (RC osc config)		-	-	0.6	V	IOL = 1.6 mA, VDD = 4.5V, -40°C to +85°C
			-	-	0.6	V	IOL = 1.2 mA, VDD = 4.5V, -40°C to +125°C

† 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 Advanced information for this device.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

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
D090	Output High Voltage I/O ports (Note 3)	VOH	VDD - 0.7	-	-	V	IOH = -3.0 mA, VDD = 4.5V, -40°C to +85°C
D090A			VDD - 0.7	-	-	V	IOH = -2.5 mA, VDD = 4.5V, -40°C to +125°C
D092	OSC2/CLKOUT (RC osc config)		VDD - 0.7	-	-	V	IOH = -1.3 mA, VDD = 4.5V, -40°C to +85°C
D092A			VDD - 0.7	-	-	V	IOH = -1.0 mA, VDD = 4.5V, -40°C to +125°C
D100	Capacitive Loading Specs on Output Pins 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 ² 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 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 Advanced information for this device.

Applicable Devices	70	71	71A	72	73	73A	74	74A
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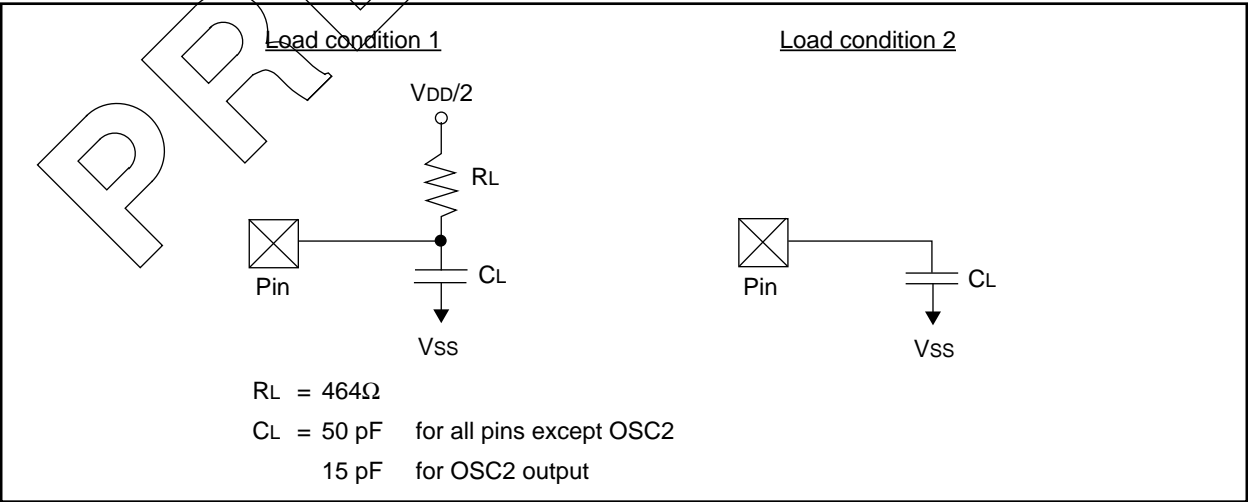
21.4 Timing Parameter Symbology

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

1. TppS2ppS
2. TppS
3. Tcc:ST (I²C specifications only)
4. Ts (I²C specifications only)

T F Frequency	T Time
Lowercase letters (pp) and their meanings:	
pp cc CCP1 ck CLKOUT cs \overline{CS} di SDI do SDO dt Data in io I/O port mc \overline{MCLR}	osc OSC1 rd \overline{RD} rw \overline{RD} or \overline{WR} sc SCK ss \overline{SS} t0 T0CKI t1 T1CKI wr \overline{WR}
Uppercase letters and their meanings:	
S F Fall H High I Invalid (Hi-impedance) L Low I²C only AA output access BUF Bus free	P Period R Rise V Valid Z Hi-impedance High High Low Low
Tcc:ST (I ² C specifications only)	
CC HD Hold ST DAT DATA input hold STA START condition	SU Setup STO STOP condition

FIGURE 21-1: LOAD CONDITIONS



PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

21.5 Timing Diagrams and Specifications

FIGURE 21-2: EXTERNAL CLOCK TIMING

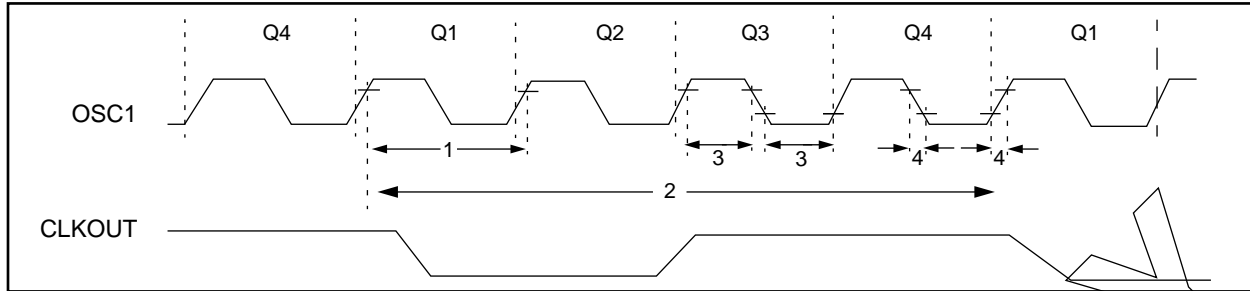


TABLE 21-2: CLOCK TIMING REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
	Fos	External CLKIN Frequency (Note 1)	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
		Oscillator Frequency (Note 1)	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	External CLKIN Period (Note 1)	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
			—	—	—	—	—
		Oscillator Period (Note 1)	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)
2	TCY	Instruction Cycle Time (Note 1)	200	—	DC	ns	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.

FIGURE 21-3: CLKOUT AND I/O TIMING

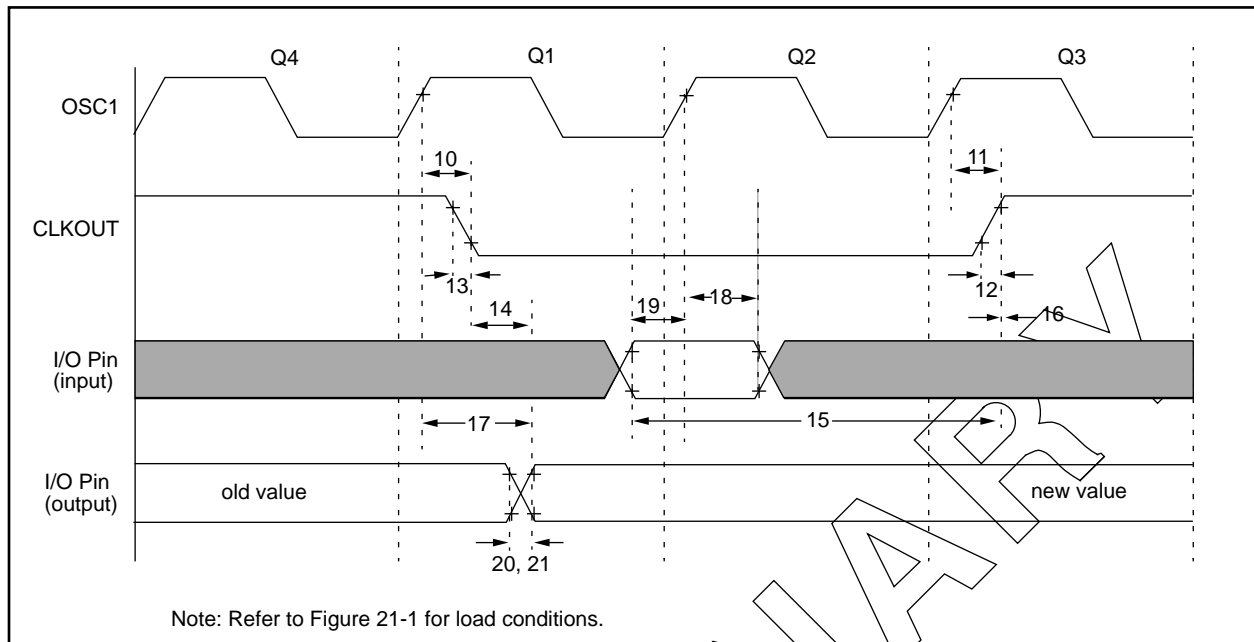


TABLE 21-3: CLKOUT AND I/O TIMING REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
10*	TosH2ckL	OSC1↑ to CLKOUT↓	—	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	—	—	0.5Tcy + 20	ns	Note 1
15*	TioV2ckH	Port in valid before CLKOUT ↑	0.25Tcy + 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	—	10	25	ns	
			—	—	60	ns	
21*	TioF	Port output fall time	—	10	25	ns	
			—	—	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 TOSC.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

FIGURE 21-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER TIMING

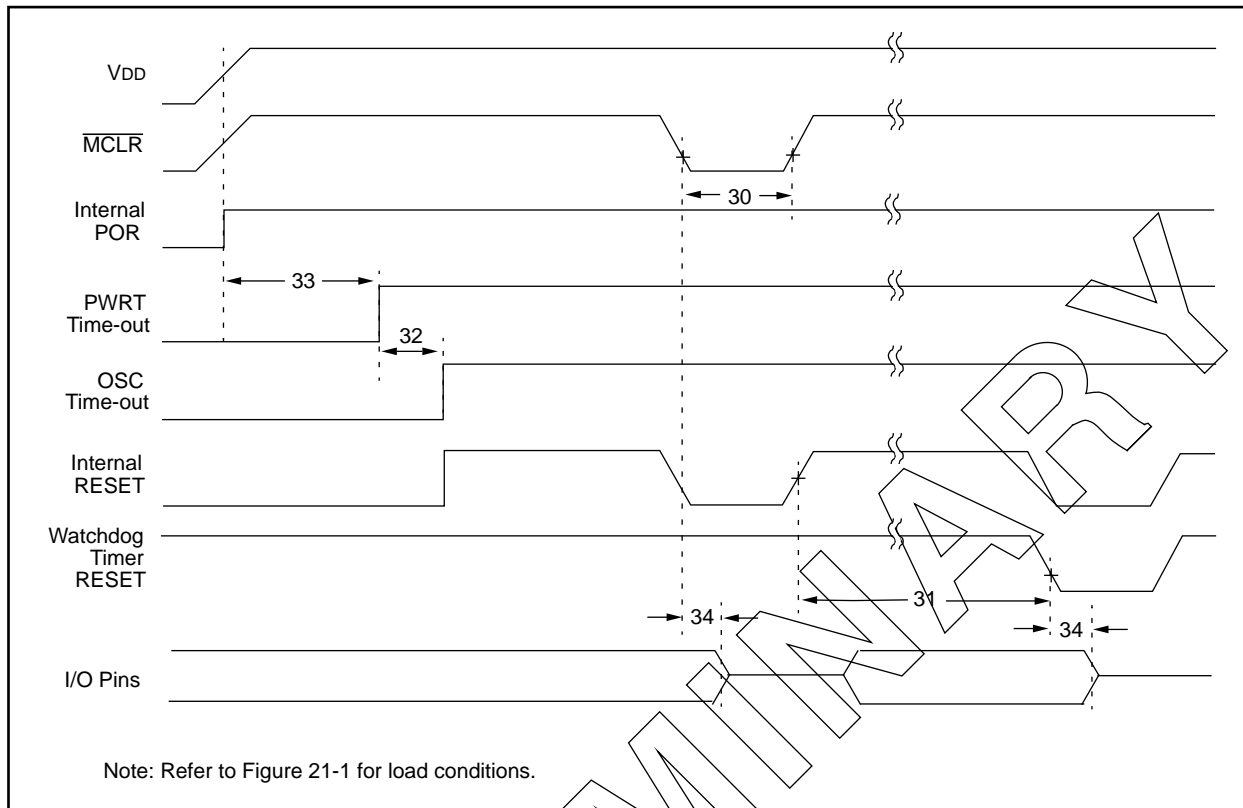


FIGURE 21-5: BROWN-OUT RESET TIMING

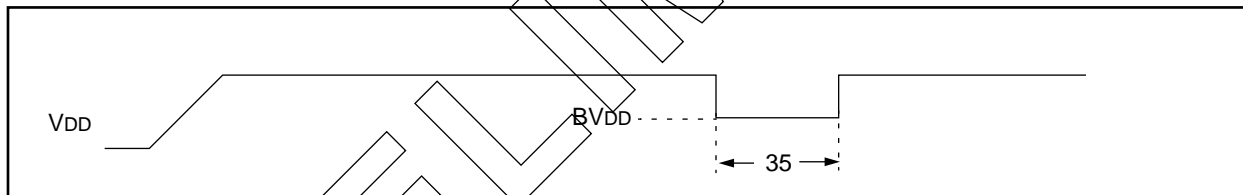


TABLE 21-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
30	Tmcl	MCLR Pulse Width (low)	1	—	—	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			1.1	μs	
35	TBOR	Brown-out Reset pulse width	100	—	—	μs	3.8V ≤ VDD ≤ 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 21-6: TIMER0 AND TIMER1 CLOCK TIMINGS

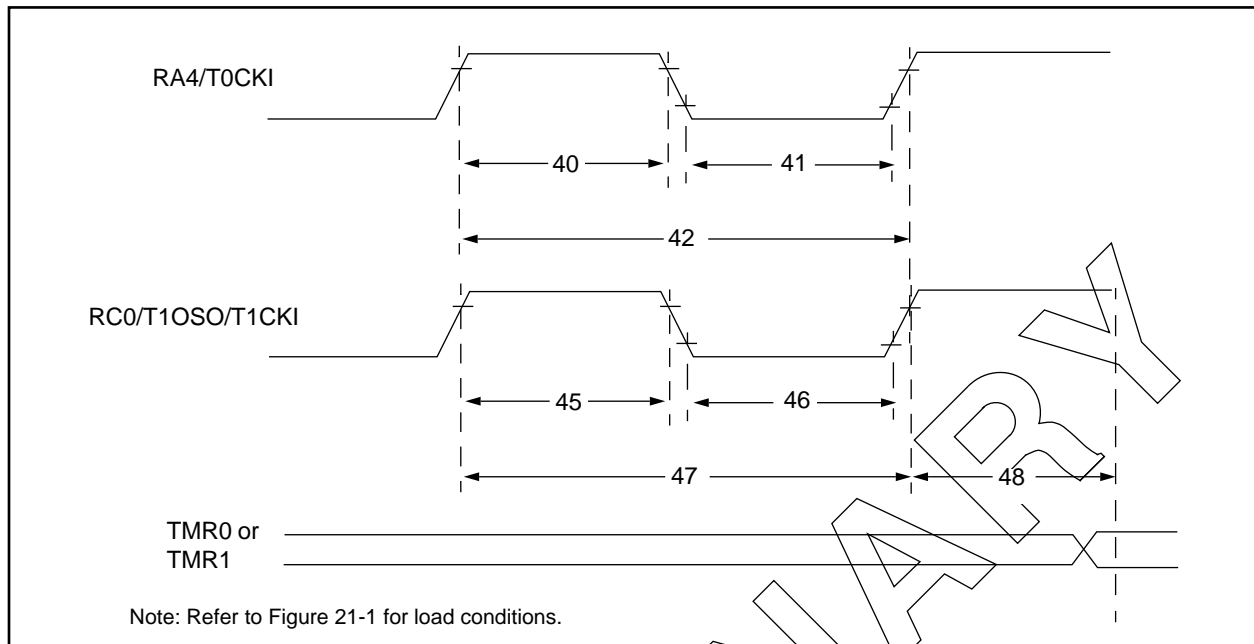


TABLE 21-5: TIMER0 AND TIMER1 CLOCK REQUIREMENTS

Param No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
40	Tt0H	T0CKI High Pulse Width	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	PIC16C72 10*	—	—	ns
				PIC16LC72 20*	—	—	
			Asynchronous	$2T_{CY}$	—	—	ns
46	Tt1L	T1CKI Low Time	Synchronous, no prescaler	$0.5T_{CY} + 20$	—	—	ns
			Synchronous, with prescaler	PIC16C72 10*	—	—	ns
				PIC16LC72 20*	—	—	
			Asynchronous	$2T_{CY}$	—	—	ns
47	Tt1P	T1CKI input period	Synchronous	Greater of: $20\mu s$ or $\frac{T_{CY} + 40^*}{N}$	—	—	ns
			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.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

FIGURE 21-7: CAPTURE/COMPARE/PWM TIMINGS (CCP1)

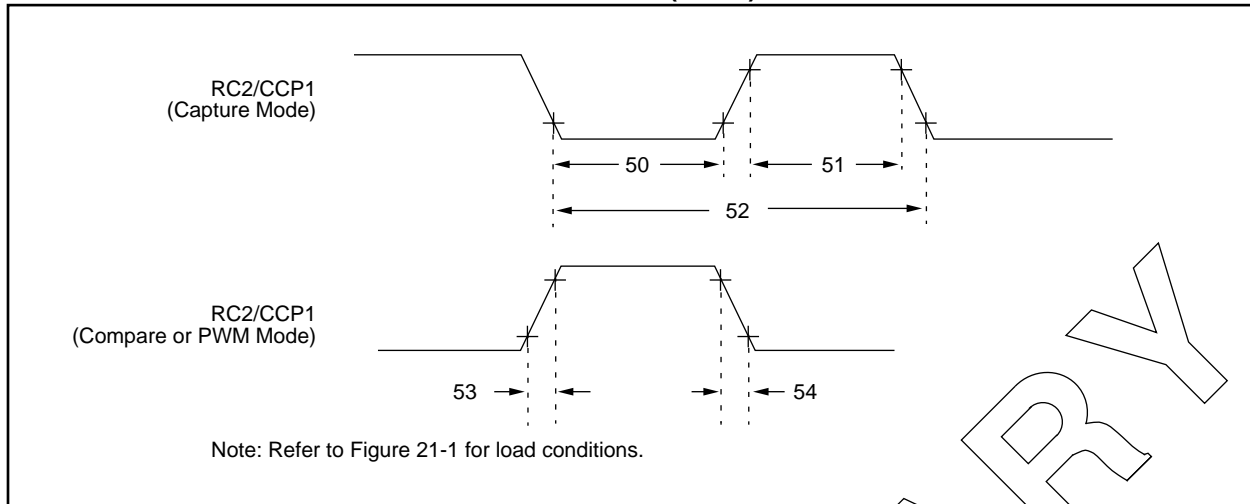


TABLE 21-6: CAPTURE/COMPARE/PWM REQUIREMENTS (CCP1)

Param No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
50	TccL	CCP1 input low time	No Prescaler	$0.5T_{CY} + 20^*$	—	ns	
			With Prescaler	10*	—	ns	
			PIC16LC72	20*	—	ns	
51	TccH	CCP1 input high time	No Prescaler	$0.5T_{CY} + 20^*$	—	ns	
			With Prescaler	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	—	10	25	ns	
54	TccF	CCP1 output fall time	—	10	25	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

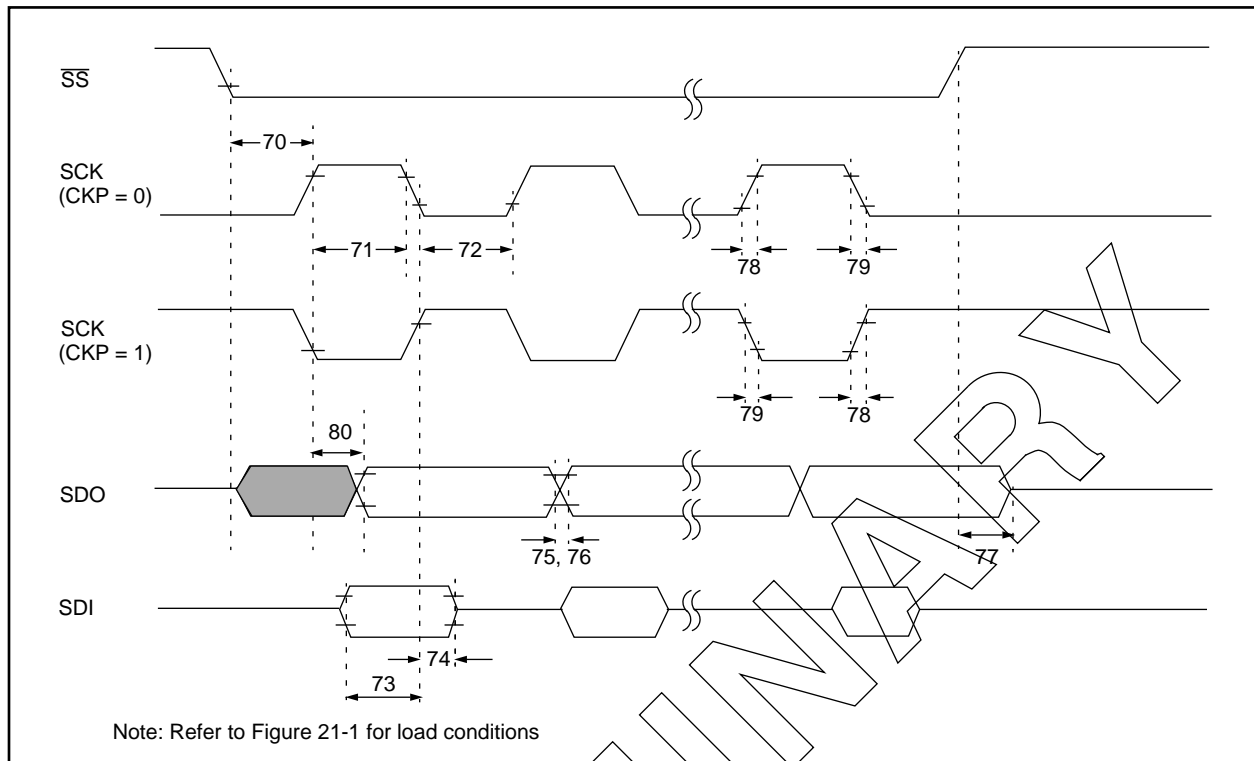


TABLE 21-7: SPI MODE REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
70	TssL2scH, TssL2scL	\overline{SS} ↓ to SCK↓ or SCK↑ input	T _{CY}	—	—	ns	
71	TscH	SCK input high time (slave mode)	T _{CY} + 20	—	—	ns	
72	TscL	SCK input low time (slave mode)	T _{CY} + 20	—	—	ns	
73	TdiV2scH, TdiV2scL	Setup time of SDI data input to SCK edge	T _{CY}	—	—	ns	
74	Tsch2diL, TscL2diL	Hold time of SDI data input to SCK edge	0.5T _{CY}	—	—	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.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

FIGURE 21-9: I²C BUS START/STOP BITS TIMING

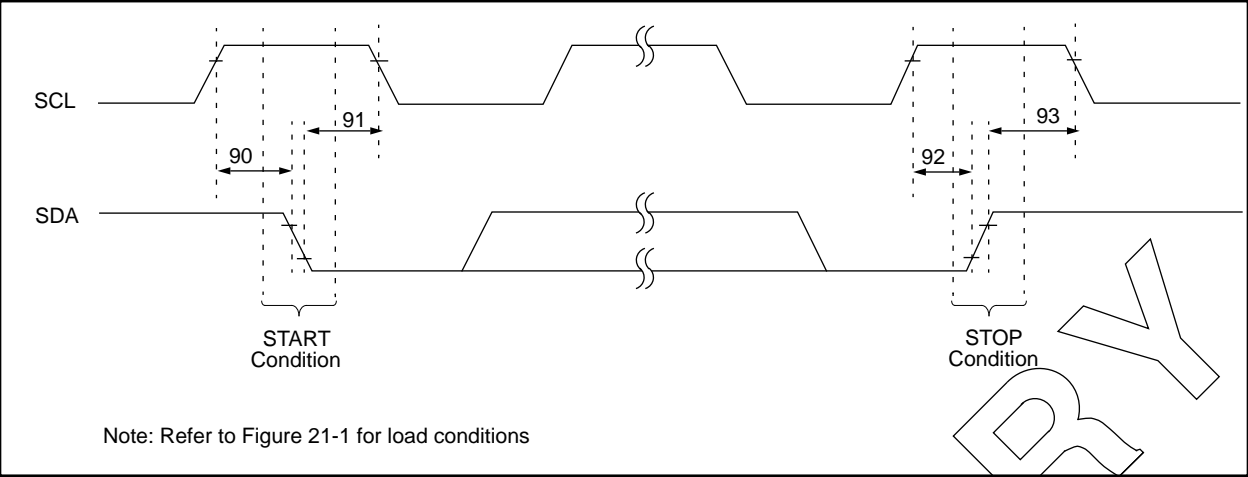


TABLE 21-8: I²C BUS START/STOP BITS REQUIREMENTS

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 21-10: I²C BUS DATA TIMING

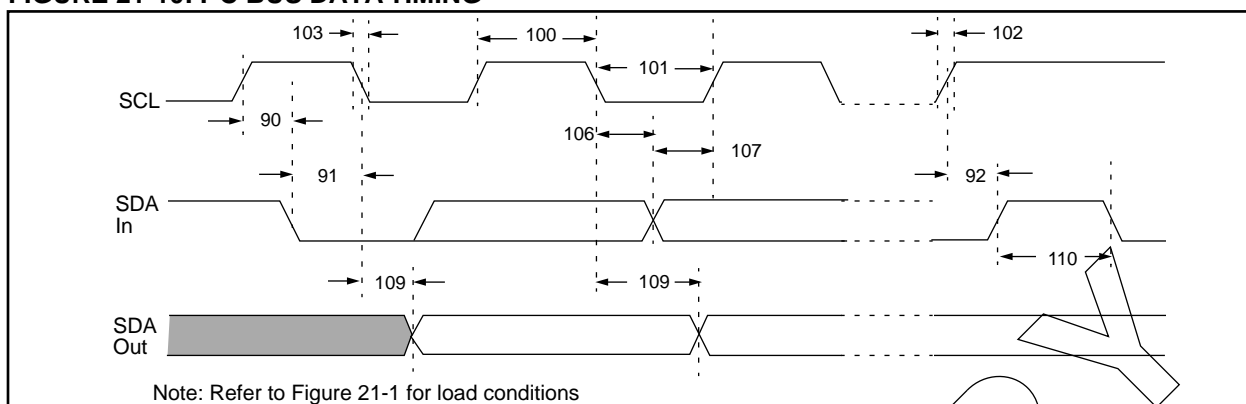


TABLE 21-9: I²C BUS DATA REQUIREMENTS

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	1.5TCY	—		
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	1.5TCY	—		
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.

Note 2: A fast-mode I²C-bus device can be used in a standard-mode I²C-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 $T_{R\max} + tsu;DAT = 1000 + 250 = 1250$ ns (according to the standard-mode I²C bus specification) before the SCL line is released.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

TABLE 21-10: SERIAL PORT SYNCHRONOUS TRANSMISSION REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
120	TckH2dtV	SYNC XMIT (MASTER & SLAVE) Clock high to data out valid	PIC16C72	—	—	50	ns
			PIC16LC72	—	—	100	ns
121	Tckrf	Clock out rise time and fall time (Master Mode)	PIC16C72	—	—	25	ns
			PIC16LC72	—	—	50	ns
122	Tdtrf	Data out rise time and fall time	PIC16C72	—	—	25	ns
			PIC16LC72	—	—	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.

TABLE 21-11: SERIAL PORT 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 21-12: A/D CONVERTER CHARACTERISTICS:
PIC16C72-04 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽³⁾)
PIC16C72-10 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽³⁾)
PIC16C72-20 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽³⁾)

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 ± 1 LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq AIN \leq V_{REF}$
	NDIF	Differential error	—	—	less than ± 1 LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq AIN \leq V_{REF}$
	NFS	Full scale error	—	—	less than ± 1 LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq AIN \leq V_{REF}$
	NOFF	Offset error	—	—	less than ± 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 Ω	
	IAD	A/D conversion current (V_{DD})	—	180	—	μA	Average current consumption when A/D is on. (Note 1)
	IREF	VREF input current (Note 2)	—	—	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: 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 Advanced information for this device.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

TABLE 21-13: A/D CONVERTER CHARACTERISTICS:
PIC16LC72-04 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽⁴⁾)

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 ≤ VIN ≤ 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.

4: Automotive operating range is Advanced information for this device.

FIGURE 21-11: A/D CONVERSION TIMING

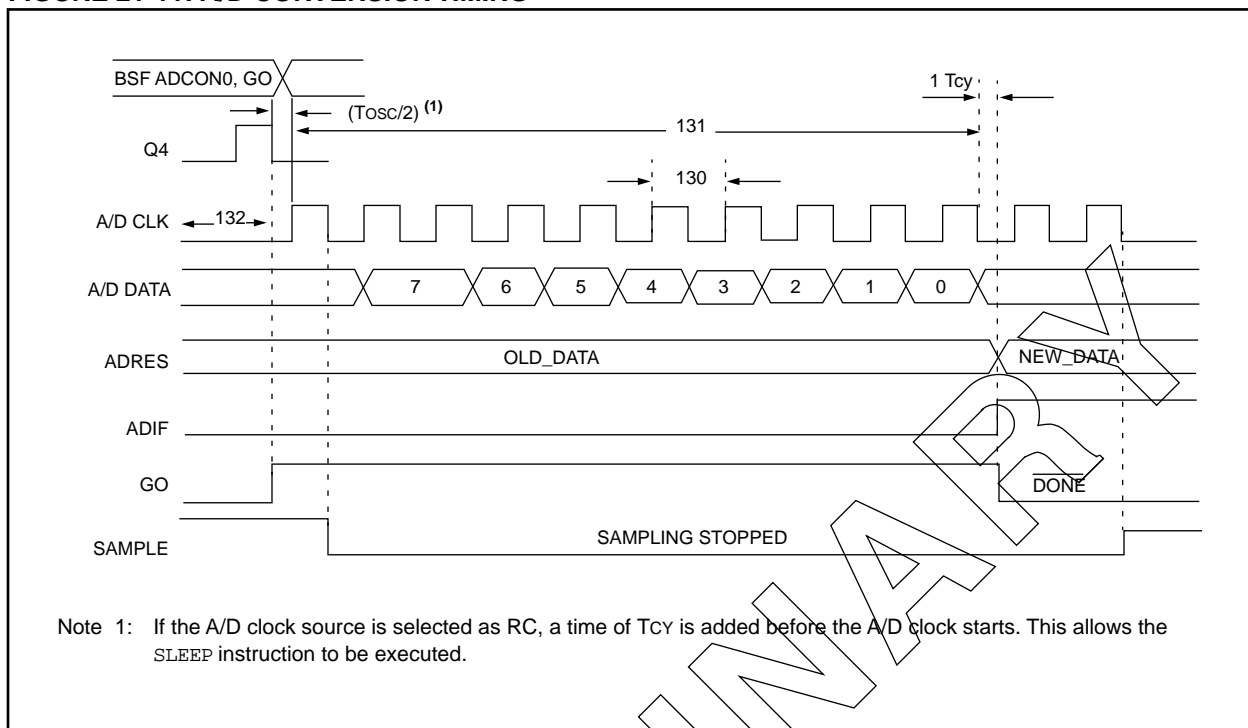


TABLE 21-14: A/D CONVERSION REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
130	TAD	A/D clock period	1.6 2.0	—	—	μs	VREF ≥ 3.0V VREF full range
130	TAD	A/D Internal RC Oscillator source	3.0 2.0	6.0 4.0	9.0 6.0	μs	ADCS1:ADCS0 = 11 (RC oscillator source) PIC16LC72, VDD = 3.0V PIC16C72
131	TCNV	Conversion time (not including S/H time) (Note 1)	—	9.5TAD	—	—	
132	TSMP	Sampling 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 T_{CY} cycle.

2: See Section 13.1 for min conditions.

PIC16C7X

Applicable Devices	70	71	71A	72	73	73A	74	74A
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NOTES:

PRELIMINARY

Applicable Devices	70	71	71A	72	73	73A	74	74A
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22.0 DC AND AC CHARACTERISTICS GRAPHS AND TABLES FOR PIC16C72

NOT AVAILABLE AT THIS TIME

PIC16C7X

Applicable Devices	70	71	71A	72	73	73A	74	74A
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NOTES:

23.0 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 MCLR)	-0.6V to (VDD + 0.6V)
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 _{IK} (V _I < 0 or V _I > VDD)	±20 mA
Output clamp current, I _{OK} (V _O < 0 or V _O > 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 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.

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.

PIC16C7X

Applicable Devices	70	71	71A	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	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 μ 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 μ 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 μ A typ. at 4V Freq: 4 MHz max.	VDD: 3.0V to 6.0V IDD: 2.0 mA typ. at 3.0V IPD: 0.9 μ A typ. at 3V Freq: 4 MHz max.	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 21 μ A max. at 4V Freq: 4 MHz max.
XT	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 21 μ 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 μ 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 μ A typ. at 4V Freq: 4 MHz max.	VDD: 3.0V to 6.0V IDD: 2.0 mA typ. at 3.0V IPD: 0.9 μ A typ. at 3V Freq: 4 MHz max.	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 21 μ 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 μ A typ. at 4.5V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 30 mA max. at 5.5V IPD: 1.5 μ 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 μ 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 μ A typ. at 4.5V Freq: 10 MHz max.
LP	VDD: 4.0V to 6.0V IDD: 52.5 μ A typ. at 32 kHz, 4.0V IPD: 0.9 μ 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 μ A max. at 32 kHz, 3.0V IPD: 13.5 μ A max. at 3.0V Freq: 200 kHz max.	VDD: 3.0V to 6.0V IDD: 48 μ A max. at 32 kHz, 3.0V IPD: 13.5 μ 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:

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 Power-on Reset	VPOR	-	VSS	-	V	See section on Power-on Reset for details
D004	VDD rise rate to ensure Power-on Reset	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 $I_r = VDD/2R_{ext}$ (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.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

23.2 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 Power-on Reset	VPOR	-	VSS	-	V	See section on Power-on Reset for details
D004	VDD rise rate to ensure Power-on Reset	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	LP osc configuration FOSC = 32 kHz, VDD = 3.0V, WDT disabled
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.

23.3 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)

DC CHARACTERISTICS Standard Operating Conditions (unless otherwise stated) 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 VDD range as described in DC spec Section 23.1 and Section 23.2.							
Param No.	Characteristic	Sym	Min	Typ †	Max	Units	Conditions
D030	Input Low Voltage I/O ports	V _{IL}	V _{SS}	-	0.5V	V	Note1
D031	with TTL buffer		V _{SS}	-	0.2V _{DD}	V	
D032	with Schmitt Trigger buffer		V _{SS}	-	0.2V _{DD}	V	
D033	MCLR, RA4/T0CKI, OSC1 (in RC mode) OSC1 (in XT, HS and LP)		V _{SS}	-	0.3V _{DD}	V	
D040	Input High Voltage I/O ports	V _{IH}	-	-	-	-	4.5V ≤ V _{DD} ≤ 5.5V For V _{DD} > 5.5V or V _{DD} < 4.5V For entire V _{DD} range Note1
D040A	with TTL buffer		2.0	-	V _{DD}	V	
D041	with Schmitt Trigger buffer		0.8V _{DD}	-	V _{DD}	V	
D042	MCLR, RA4/T0CKI, RC7:RC4, RD7:RD4, RB0/INT		0.8V _{DD}	-	V _{DD}	V	
D042A	RE2:RE0, OSC1 (XT, HS and LP)		0.7V _{DD}	-	V _{DD}	V	
D043	OSC1 (in RC mode)		0.9V _{DD}	-	V _{DD}	V	
D070	PORTB weak pull-up current	I _{PURB}	50	250	400	μA	V _{DD} = 5V, V _{PIN} = V _{SS}
D060	Input Leakage Current (Notes 2, 3) I/O ports	I _{IL}	-	-	±1	μA	V _{SS} ≤ V _{PIN} ≤ V _{DD} , Pin at hi-impedance
D061	MCLR, RA4/T0CKI		-	-	±5	μA	V _{SS} ≤ V _{PIN} ≤ V _{DD}
D063	OSC1		-	-	±5	μA	V _{SS} ≤ V _{PIN} ≤ V _{DD} , XT, HS and LP osc configuration
D080	Output Low Voltage I/O ports	V _{OL}	-	-	0.6	V	I _{OL} = 8.5 mA, V _{DD} = 4.5V, -40°C to +85°C
D083	OSC2/CLKOUT (RC osc config)		-	-	0.6	V	I _{OL} = 1.6 mA, V _{DD} = 4.5V, -40°C to +85°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

Applicable Devices 70 71 71A 72 73 73A 74 74A

Standard Operating Conditions (unless otherwise stated)							
Operating temperature -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
D090	Output High Voltage I/O ports (Note 3)	VOH	VDD - 0.7	-	-	V	IOH = -3.0 mA, VDD = 4.5V, -40°C to +85°C IOH = -1.3 mA, VDD = 4.5V, -40°C to +85°C
D092	OSC2/CLKOUT (RC osc config)		VDD - 0.7	-	-	V	
Capacitive Loading Specs on Output Pins							
D100	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 I2C 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 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.

Applicable Devices	70	71	71A	72	73	73A	74	74A
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23.4 Timing Parameter Symbology

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

1. TppS2ppS
2. TppS
3. Tcc:ST (I²C specifications only)
4. Ts (I²C specifications only)

T			
F	Frequency	T	Time

Lowercase letters (pp) and their meanings:

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

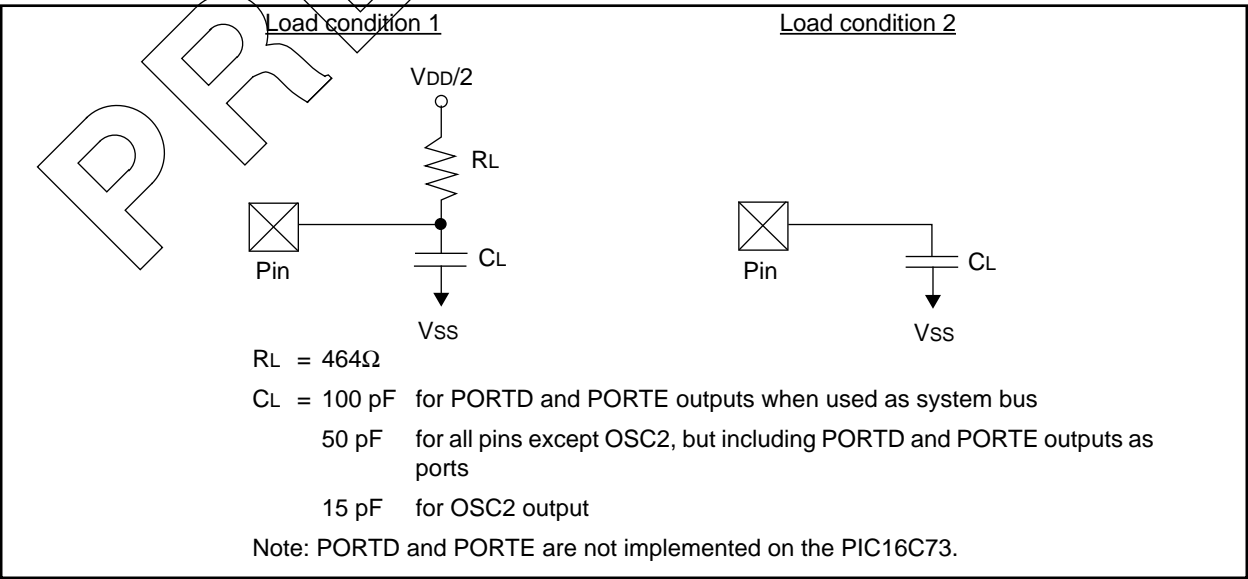
Uppercase letters and their meanings:

S			
F	Fall	P	Period
H	High	R	Rise
I	Invalid (Hi-impedance)	V	Valid
L	Low	Z	Hi-impedance
I²C only		High	High
AA	output access	Low	Low
BUF	Bus free		

Tcc:ST (I²C specifications only)

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

FIGURE 23-1: LOAD CONDITIONS



PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

23.5 Timing Diagrams and Specifications

FIGURE 23-2: EXTERNAL CLOCK TIMING

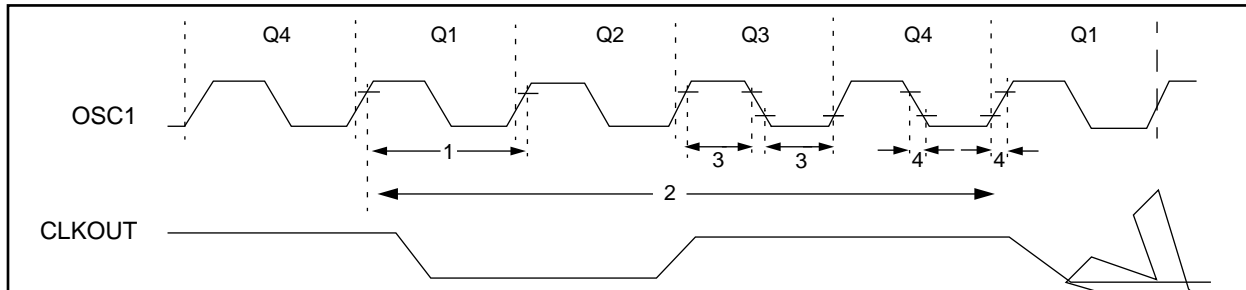


TABLE 23-2: CLOCK TIMING REQUIREMENTS

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 (PIC16C73-04, PIC16C74-04)
			DC	—	20	MHz	HS osc mode (PIC16C73-20, PIC16C74-20)
			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 (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	External CLKIN Period (Note 1)	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
			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 (PIC16C73-04, PIC16C74-04)
			100	—	250	ns	HS osc mode (PIC16C73-10, PIC16C74-10)
			50	—	250	ns	HS osc mode (PIC16C73-20, PIC16C74-20)
2	TCY	Instruction Cycle Time (Note 1)	200	—	DC	ns	TCY = 4/Fosc
			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.

Applicable Devices	70	71	71A	72	73	73A	74	74A
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TABLE 23-2: CLOCK TIMING REQUIREMENTS (Cont.'d)

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
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.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

FIGURE 23-3: CLKOUT AND I/O TIMING

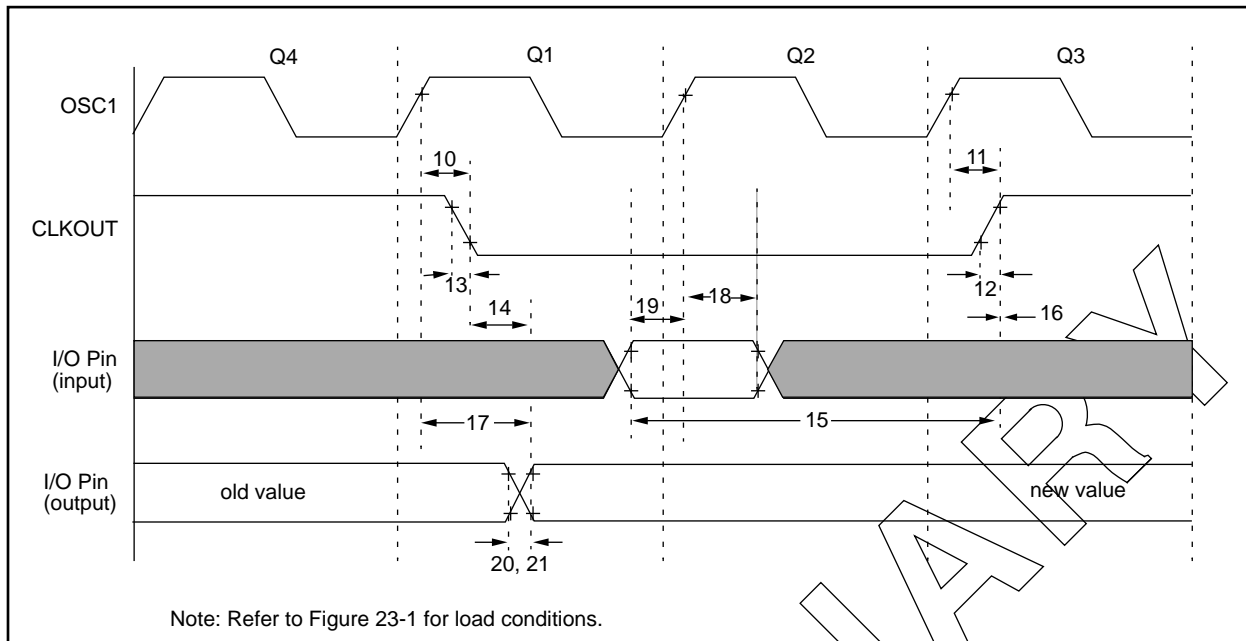


TABLE 23-3: CLKOUT AND I/O TIMING REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
10*	TosH2ckL	OSC1↑ to CLKOUT↓	—	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 _{CY} + 20	ns	Note 1
15*	TioV2ckH	Port in valid before CLKOUT ↑	0.25T _{CY} + 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	—	10	25	ns	
		PIC16LC73/74	—	—	60	ns	
21*	TioF	Port output fall time	—	10	25	ns	
		PIC16LC73/74	—	—	60	ns	
22††*	Tiop	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_{osc}.

FIGURE 23-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER TIMING

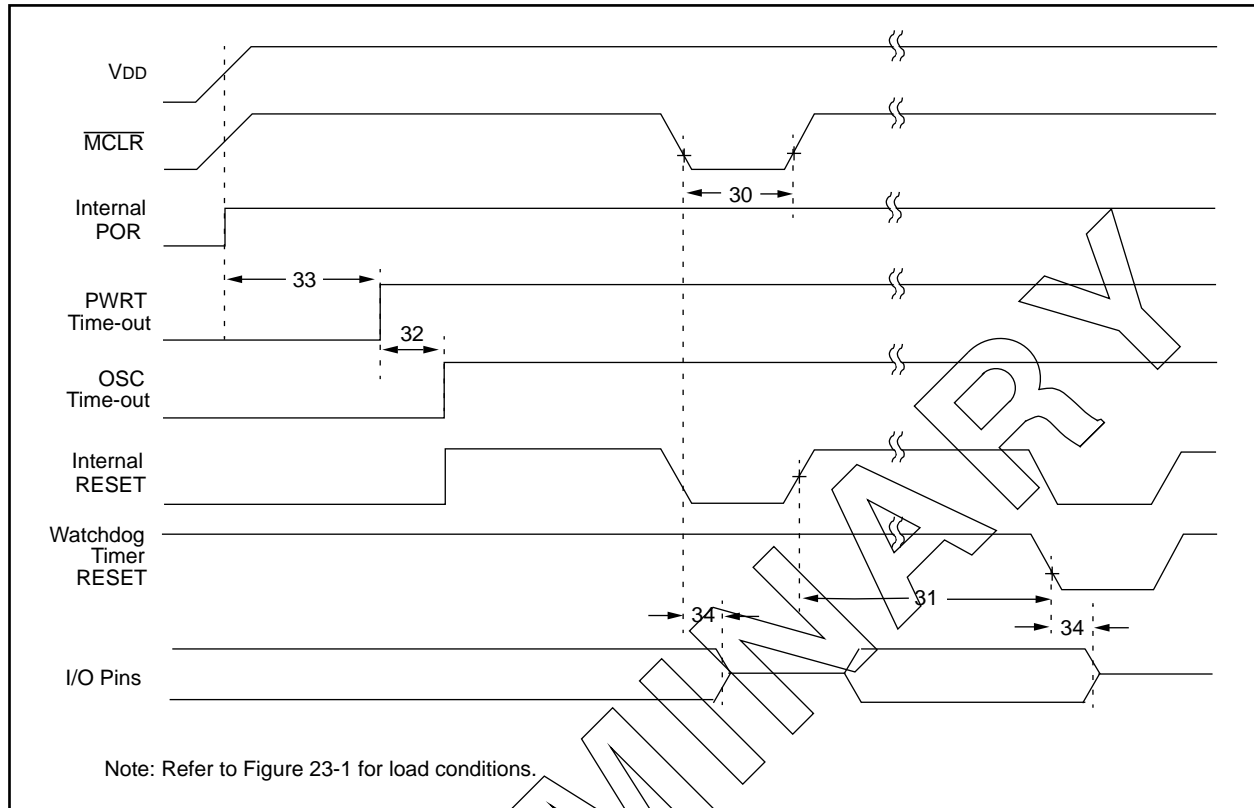


TABLE 23-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
30	Tmcl	MCLR Pulse Width (low)	100	—	—	ns	VDD = 5V, -40°C to +85°C
31	Twdt	Watchdog Timer Time-out Period (No Prescaler)	7*	18	33*	ms	VDD = 5V, -40°C to +85°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 +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.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

FIGURE 23-5: TIMER0 AND TIMER1 CLOCK TIMINGS

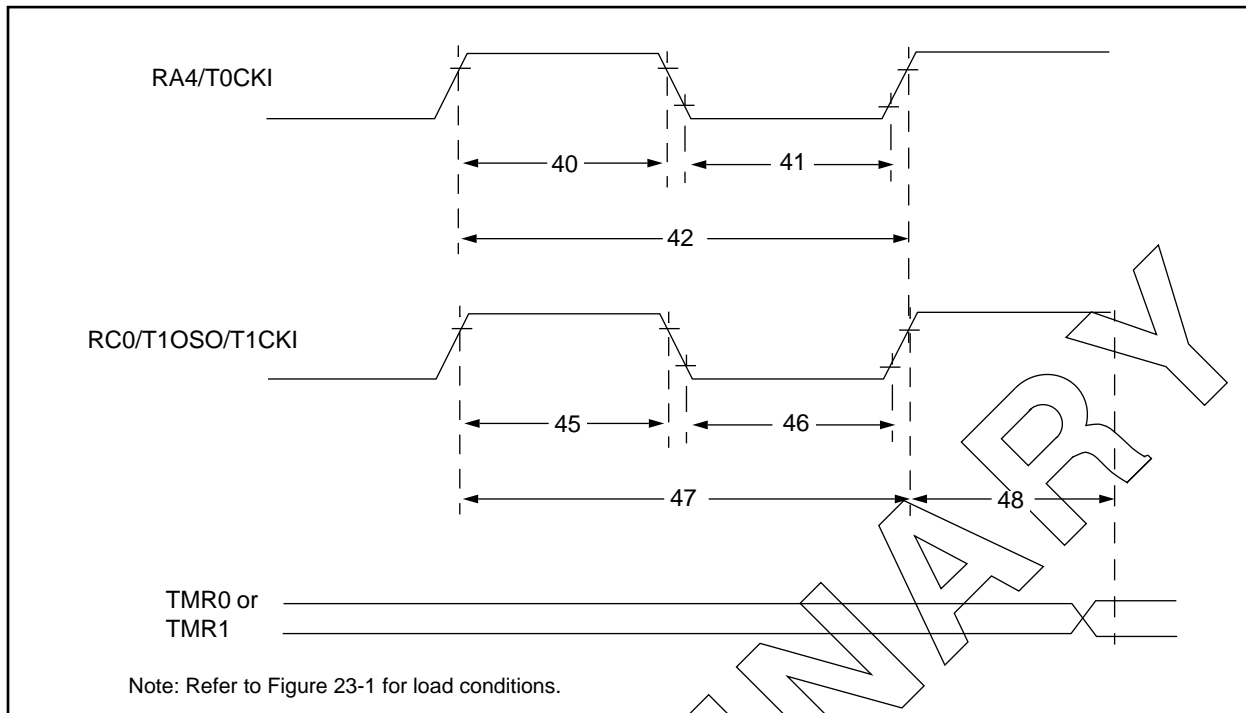


TABLE 23-5: TIMER0 AND TIMER1 CLOCK REQUIREMENTS

Param No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
40	Tt0H	T0CKI High Pulse Width	No Prescaler 0.5Tcy + 20*	—	—	ns	
			With Prescaler 10*	—	—	ns	
41	Tt0L	T0CKI Low Pulse Width	No Prescaler 0.5Tcy + 20*	—	—	ns	
			With Prescaler 10*	—	—	ns	
42	Tt0P	T0CKI Period	Greater of: 20µs or $\frac{Tcy + 40}{N}$ *	—	—	ns	N = prescale value (1, 2, 4, ..., 256)
45	Tt1H	T1CKI High Time	Synchronous, no prescaler 0.5Tcy + 20	—	—	ns	
		Synchronous, with prescaler	PIC16C73/74 10*	—	—	ns	
			PIC16LC73/74 20*	—	—	ns	
		Asynchronous	2Tcy	—	—	ns	
46	Tt1L	T1CKI Low Time	Synchronous, no prescaler 0.5Tcy + 20	—	—	ns	
		Synchronous, with prescaler	PIC16C73/74 10*	—	—	ns	
			PIC16LC73/74 20*	—	—	ns	
		Asynchronous	2Tcy	—	—	ns	
47	Tt1P	T1CKI input period	Synchronous Greater of: 20µs or $\frac{Tcy + 40}{N}$ *	—	—	ns	N = prescale value (1, 2, 4, 8)
		Asynchronous Greater of: 20µs or 4Tcy	—	—	—	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	2Tosc	—	7Tosc	—	

* 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 23-6: CAPTURE/COMPARE/PWM TIMINGS (CCP1 AND CCP2)

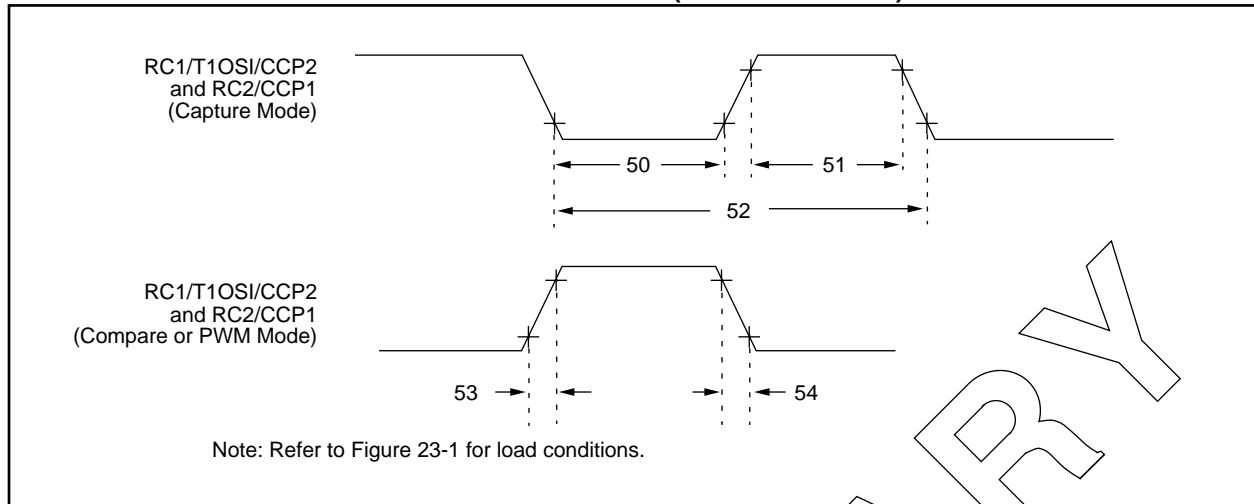


TABLE 23-6: CAPTURE/COMPARE/PWM REQUIREMENTS (CCP1 AND CCP2)

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
50	TccL	CCP1 and CCP2 input low time	No Prescaler	$0.5T_{CY} + 20^*$	—	ns	
			PIC16C73/74	10*	—	ns	
			With Prescaler	20*	—	ns	
51	TccH	CCP1 and CCP2 input high time	No Prescaler	$0.5T_{CY} + 20^*$	—	ns	
			PIC16C73/74	10*	—	ns	
			With Prescaler	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	—	10	25	ns	
54	TccF	CCP1 and CCP2 output fall time	—	10	25	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.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

FIGURE 23-7: PARALLEL SLAVE PORT TIMING FOR THE PIC16C74 ONLY

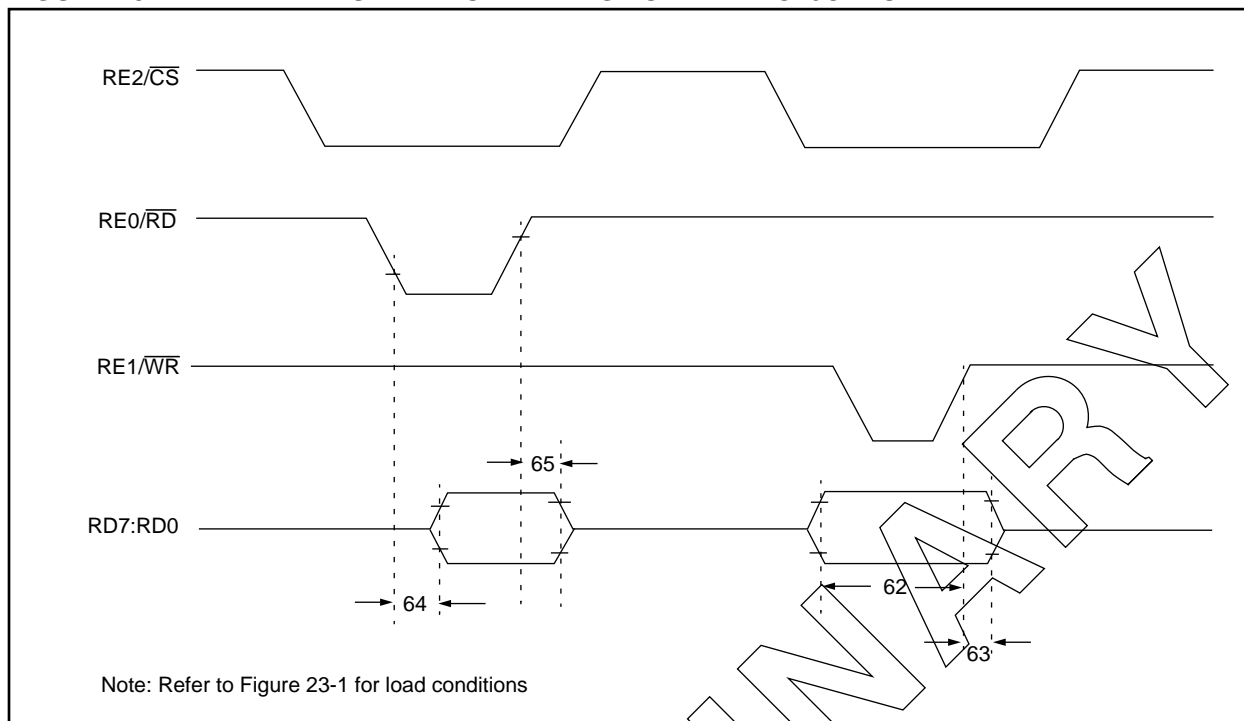


TABLE 23-7: PARALLEL SLAVE PORT REQUIREMENTS FOR THE PIC16C74 ONLY

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
62	TdtV2wrH	Data in valid before $WR\uparrow$ or $CS\uparrow$ (setup time)	20	—	—	ns	
63	TwrH2dtI	$WR\uparrow$ or $CS\uparrow$ to data-in invalid (hold time)	PIC16C74	20*	—	ns	
			PIC16LC74	35*	—	ns	
64	TrdL2dtV	$RD\downarrow$ and $CS\downarrow$ to data-out valid	—	—	60	ns	
65	TrdH2dtI	$RD\uparrow$ or $CS\downarrow$ 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 23-8: SPI MODE TIMING

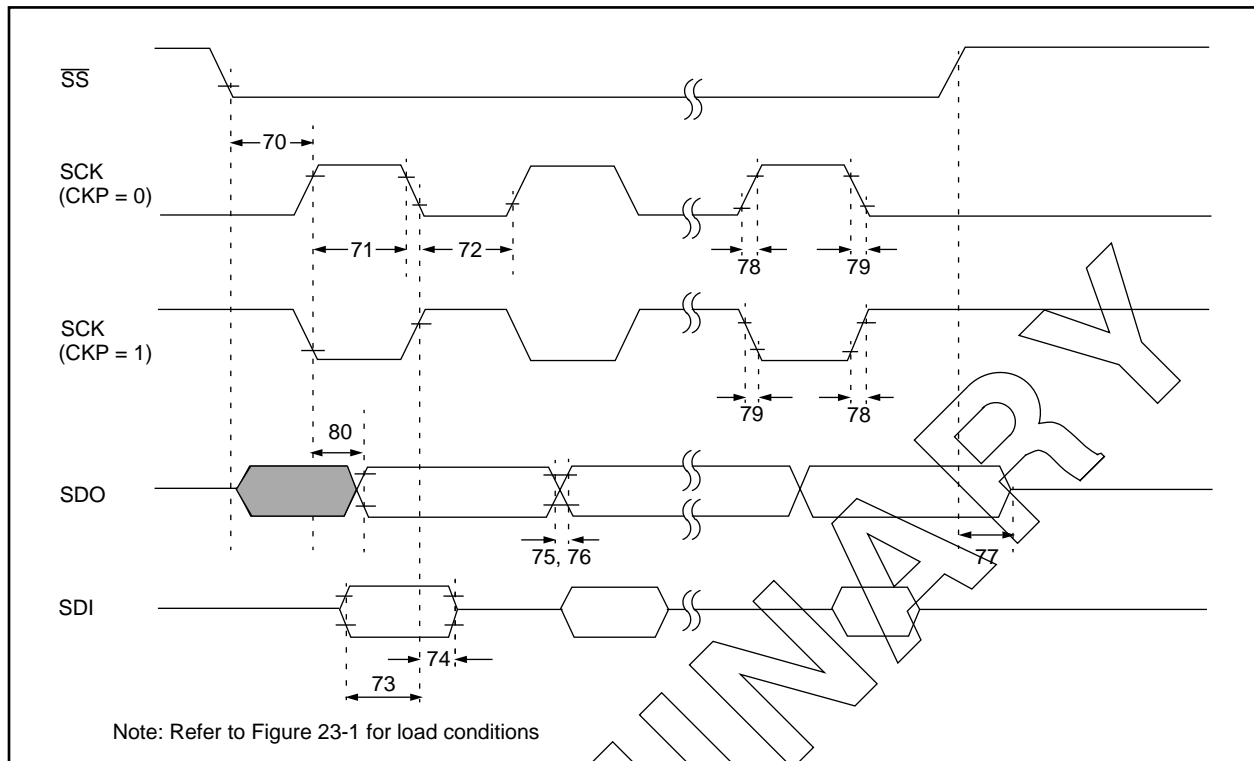


TABLE 23-8: SPI MODE REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
70	TssL2scH, TssL2scL	\overline{SS} ↓ to SCK↓ or SCK↑ input	T _{CY}	—	—	ns	
71	TscH	SCK input high time (slave mode)	T _{CY} + 20	—	—	ns	
72	TscL	SCK input low time (slave mode)	T _{CY} + 20	—	—	ns	
73	TdiV2scH, TdiV2scL	Setup time of SDI data input to SCK edge	T _{CY}	—	—	ns	
74	Tsch2diL, TscL2diL	Hold time of SDI data input to SCK edge	0.5T _{CY}	—	—	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.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

FIGURE 23-9: I²C BUS START/STOP BITS TIMING

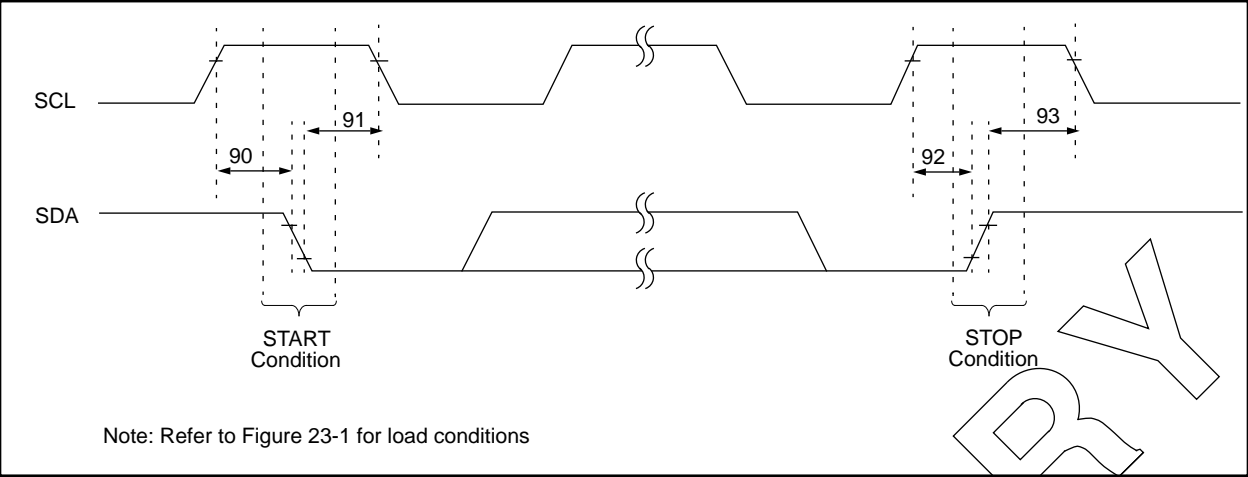


TABLE 23-9: I²C BUS START/STOP BITS REQUIREMENTS

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 23-10: I²C BUS DATA TIMING

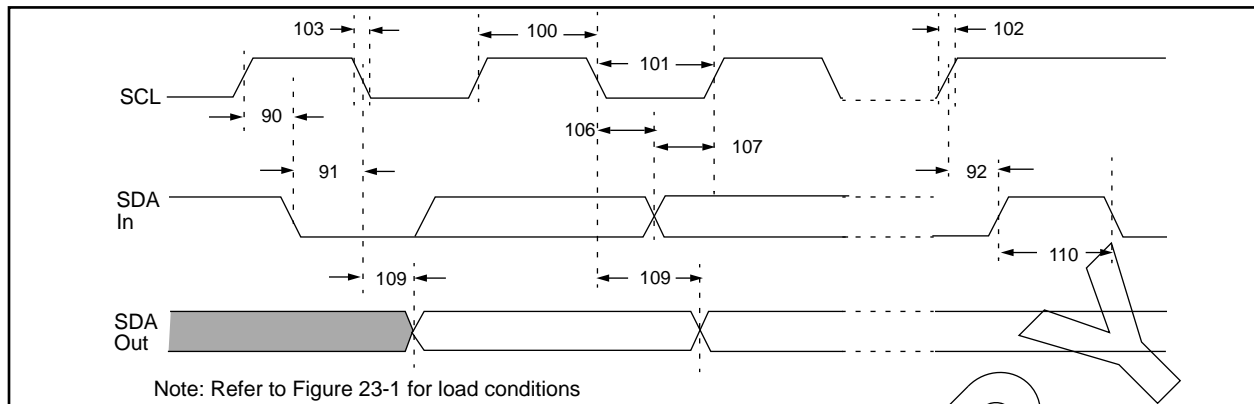


TABLE 23-10: I²C BUS DATA REQUIREMENTS

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.

Note 2: A fast-mode I²C-bus device can be used in a standard-mode I²C-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 I²C bus specification) before the SCL line is released.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

FIGURE 23-11: USART MODULE: SYNCHRONOUS TRANSMISSION (MASTER/SLAVE) TIMING

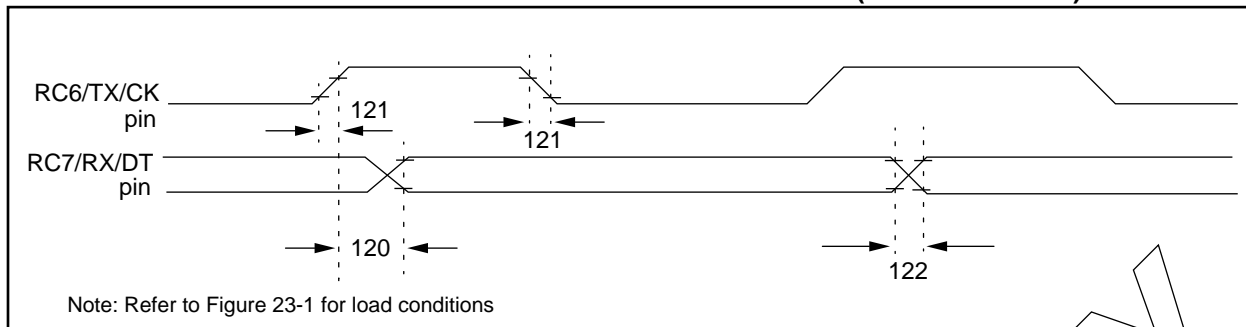


TABLE 23-11: SERIAL PORT SYNCHRONOUS TRANSMISSION REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
120	TckH2dtV	SYNC XMIT (MASTER & SLAVE) Clock high to data out valid					
					50	ns	
121	Tckrf	Clock out rise time and fall time (Master Mode)			100	ns	
					25	ns	
122	TdtV	Data out rise time and fall time			50	ns	
					25	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 23-12: USART MODULE: SYNCHRONOUS RECEIVE (MASTER/SLAVE) TIMING

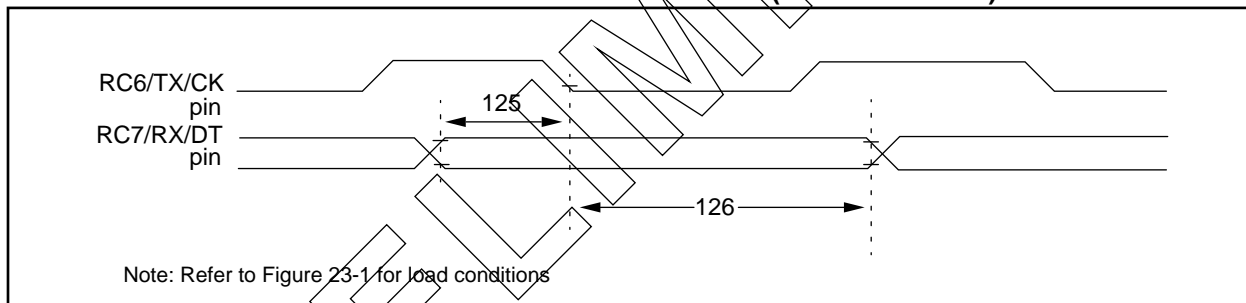


TABLE 23-12: SERIAL PORT SYNCHRONOUS RECEIVE REQUIREMENTS

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 23-13: 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 ± 1 LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NDIF	Differential error	—	—	less than ± 1 LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NFS	Full scale error	—	—	less than ± 1 LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NOFF	Offset error	—	—	less than ± 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	—	$V_{DD} \pm 0.3$	V	
	VAIN	Analog input voltage	$V_{SS} - 0.3$	—	$V_{REF} + 0.3$	V	
	ZAIN	Recommended impedance of analog voltage source	—	—	10.0	k Ω	
	IAD	A/D conversion current (V_{DD})	—	180	—	μA	Average current consumption when A/D is on. (Note 1)
	IREF	VREF input current (Note 2)	—	—	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: 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.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

**TABLE 23-14: 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 23-13: A/D CONVERSION TIMING

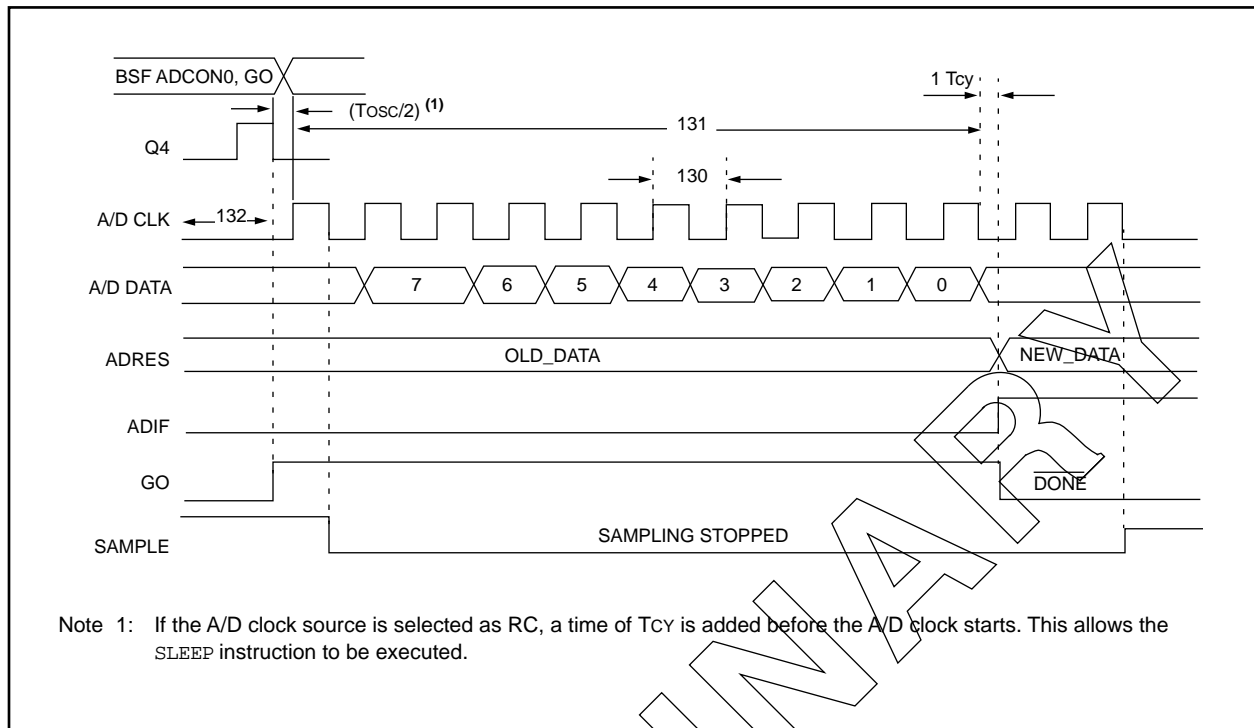


TABLE 23-15: A/D CONVERSION REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
130	TAD	A/D clock period	1.6 2.0	—	—	μs μs	VREF ≥ 3.0V VREF full range
130	TAD	A/D Internal RC Oscillator source	3.0 2.0	6.0 4.0	9.0 6.0	μs μs	ADCS1:ADCS0 = 11 (RC oscillator source) PIC16LC73, PIC16LC74, VDD = 3.0V PIC16C73, PIC16C74
131	TCNV	Conversion time (not including S/H time) (Note 1)	—	9.5TAD	—	—	
132	TSMP	Sampling 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.

PIC16C7X

Applicable Devices	70	71	71A	72	73	73A	74	74A
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NOTES:

PRELIMINARY

Applicable Devices	70	71	71A	72	73	73A	74	74A
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24.0 DC AND AC CHARACTERISTICS GRAPHS AND TABLES FOR PIC16C73/74

NOT AVAILABLE AT THIS TIME

PIC16C7X

Applicable Devices	70	71	71A	72	73	73A	74	74A
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NOTES:

25.0 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 MCLR)	-0.6V to (VDD + 0.6V)
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 _{IK} (V _I < 0 or V _I > VDD)	±20 mA
Output clamp current, I _{OK} (V _O < 0 or V _O > 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 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.

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.

PIC16C7X

Applicable Devices	70	71	71A	72	73	73A	74	74A
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TABLE 25-1: 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: 21 μ 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 μ 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 μ A typ. at 4V Freq: 4 MHz max.	VDD: 3.0V to 6.0V IDD: 2.0 mA typ. at 3.0V IPD: 0.9 μ A typ. at 3V Freq: 4 MHz max.	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 21 μ A max. at 4V Freq: 4 MHz max.
XT	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 21 μ 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 μ 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 μ A typ. at 4V Freq: 4 MHz max.	VDD: 3.0V to 6.0V IDD: 2.0 mA typ. at 3.0V IPD: 0.9 μ A typ. at 3V Freq: 4 MHz max.	VDD: 4.0V to 6.0V IDD: 5 mA max. at 5.5V IPD: 21 μ 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 μ A typ. at 4.5V Freq: 4 MHz max.	VDD: 4.5V to 5.5V IDD: 30 mA max. at 5.5V IPD: 1.5 μ 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 μ 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 μ A typ. at 4.5V Freq: 10 MHz max.
LP	VDD: 4.0V to 6.0V IDD: 52.5 μ A typ. at 32 kHz, 4.0V IPD: 0.9 μ 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 μ A max. at 32 kHz, 3.0V IPD: 5.0 μ A max. at 3.0V Freq: 200 kHz max.	VDD: 3.0V to 6.0V IDD: 48 μ A max. at 32 kHz, 3.0V IPD: 5.0 μ 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.

25.1 DC Characteristics:

PIC16C73A-04 (Commercial, Industrial, Automotive⁽⁶⁾)
PIC16C74A-04 (Commercial, Industrial, Automotive⁽⁶⁾)
PIC16C73A-10 (Commercial, Industrial, Automotive⁽⁶⁾)
PIC16C74A-10 (Commercial, Industrial, Automotive⁽⁶⁾)
PIC16C73A-20 (Commercial, Industrial, Automotive⁽⁶⁾)
PIC16C74A-20 (Commercial, Industrial, Automotive⁽⁶⁾)

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 Power-on Reset	VPOR	-	VSS	-	V	See section on Power-on Reset for details
D004	VDD rise rate to ensure Power-on Reset	SVDD	0.05*	-	-	V/ms	See section on Power-on Reset for details
D010	Supply Current (Note 2,5)	IDD	-	2.7	5	mA	XT, RC osc configuration (PIC16C74A-04) FOSC = 4 MHz, VDD = 5.5V (Note 4)
D013				13.5	30	mA	HS osc configuration (PIC16C74A-20) FOSC = 20 MHz, VDD = 5.5V
D015	Brown-out Reset Current (Note 7)	ΔIBOR	-	300*	500	μA	BOR enabled VDD = 5.0V
D020 D021 D021A D021B	Power-down Current (Note 3,5)	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 7)	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 $I_r = VDD/2R_{ext}$ (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: Automotive operating range is Advanced information for this device.

7: 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 70 71 71A 72 73 73A 74 74A

25.2 DC Characteristics:

PIC16LC73A-04 (Commercial, Industrial, Automotive⁽⁶⁾)
PIC16LC74A-04 (Commercial, Industrial, Automotive⁽⁶⁾)

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	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 Power-on Reset	VPOR	-	VSS	-	V	See section on Power-on Reset for details
D004	VDD rise rate to ensure Power-on Reset	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	LP osc configuration FOSC = 32 kHz, VDD = 3.0V, WDT disabled
D015	Brown-out Reset Current (Note 7)	ΔIBOR	-	300*	500	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
D021B			-	0.9	10	μA	VDD = 3.0V, WDT disabled, -40°C to +125°C
D023	Brown-out Reset Current (Note 7)	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 $I_r = VDD/2R_{ext}$ (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: Automotive operating range is Advanced information for this device.

7: 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.

25.3 DC Characteristics:

PIC16C73A-04 (Commercial, Industrial, Automotive)⁽⁴⁾
PIC16C74A-04 (Commercial, Industrial, Automotive)⁽⁴⁾
PIC16C73A-10 (Commercial, Industrial, Automotive)⁽⁴⁾
PIC16C74A-10 (Commercial, Industrial, Automotive)⁽⁴⁾
PIC16C73A-20 (Commercial, Industrial, Automotive)⁽⁴⁾
PIC16C74A-20 (Commercial, Industrial, Automotive)⁽⁴⁾
PIC16LC73A-04 (Commercial, Industrial, Automotive)⁽⁴⁾
PIC16LC74A-04 (Commercial, Industrial, Automotive)⁽⁴⁾

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 25.1 and Section 25.2.							
Param No.	Characteristic	Sym	Min	Typ †	Max	Units	Conditions
D030	Input Low Voltage I/O ports	VIL	VSS	-	0.5V	V	
D031	with TTL buffer		VSS	-	0.2VDD	V	
D032	with Schmitt Trigger buffer		VSS	-	0.2VDD	V	
D033	MCLR, RA4/T0CKI, OSC1 (in RC mode) OSC1 (in XT, HS and LP)		VSS	-	0.3VDD	V	
D040	Input High Voltage I/O ports	VIH	2.0	-	VDD	V	4.5V ≤ VDD ≤ 5.5V For VDD > 5.5V or VDD < 4.5V For entire VDD range
D040A	with TTL buffer		0.8VDD	-	VDD	V	
D041	with Schmitt Trigger buffer		0.8VDD	-	VDD	V	
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	Input Leakage Current (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.

4: Automotive operating range is Advanced information for this device.

PIC16C7X

Applicable Devices 70 71 71A 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 25.1 and Section 25.2.							
Param No.	Characteristic	Sym	Min	Typ †	Max	Units	Conditions
D080	Output Low Voltage 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
D090	Output High Voltage I/O ports (Note 3)	VOH	VDD - 0.7	-	-	V	IOH = -3.0 mA, VDD = 4.5V, -40°C to +85°C
D090A			VDD - 0.7	-	-	V	IOH = -2.5 mA, VDD = 4.5V, -40°C to +125°C
D092	OSC2/CLKOUT (RC osc config)		VDD - 0.7	-	-	V	IOH = -1.3 mA, VDD = 4.5V, -40°C to +85°C
D092A			VDD - 0.7	-	-	V	IOH = -1.0 mA, VDD = 4.5V, -40°C to +125°C
D100	Capacitive Loading Specs on Output Pins 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 ² 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 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 Advanced information for this device.

25.4 Timing Parameter Symbolology

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

- | | |
|-------------|--|
| 1. TppS2ppS | 3. TCC:ST (I ² C specifications only) |
| 2. TppS | 4. Ts (I ² C specifications only) |

T		T	
F	Frequency	T	Time

Lowercase letters (pp) and their meanings:

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

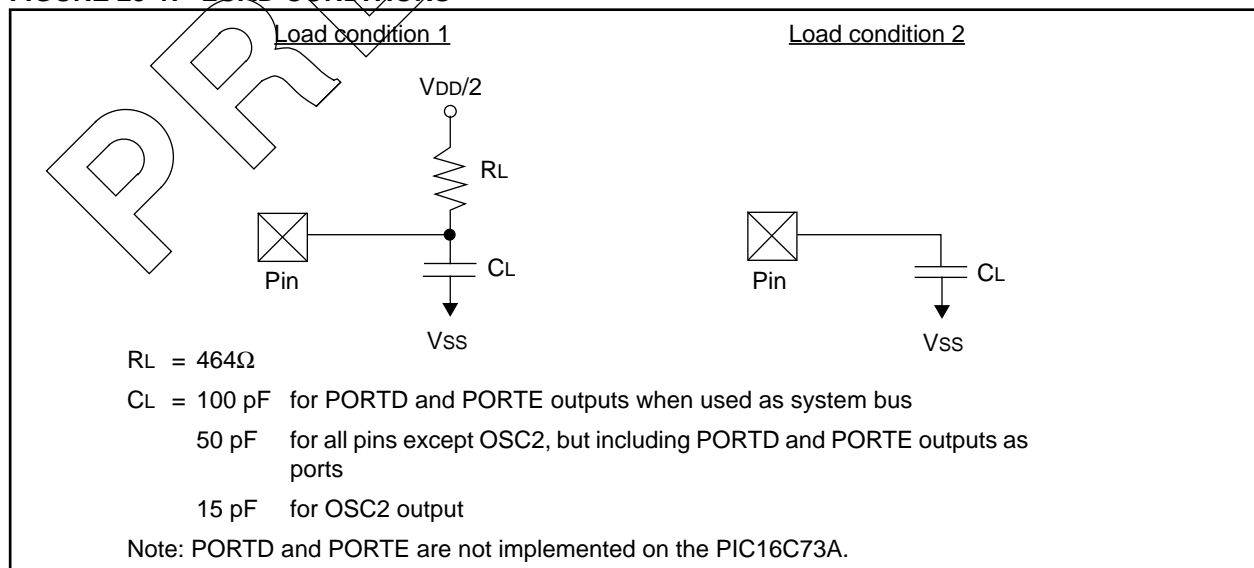
Uppercase letters and their meanings:

S		P	Period
F	Fall	R	Rise
H	High	V	Valid
I	Invalid (Hi-impedance)	Z	Hi-impedance
L	Low		
I²C only		High	High
AA	output access	Low	Low
BUF	Bus free		

TCC:ST (I²C specifications only)

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

FIGURE 25-1: LOAD CONDITIONS



PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

25.5 Timing Diagrams and Specifications

FIGURE 25-2: EXTERNAL CLOCK TIMING

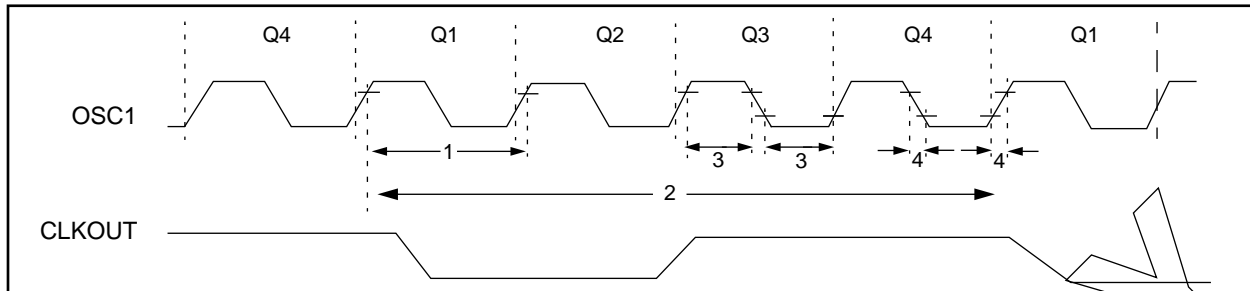


TABLE 25-2: CLOCK TIMING REQUIREMENTS

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)
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.

Applicable Devices	70	71	71A	72	73	73A	74	74A
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TABLE 25-2: CLOCK TIMING REQUIREMENTS (Cont.'d)

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
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.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

FIGURE 25-3: CLKOUT AND I/O TIMING

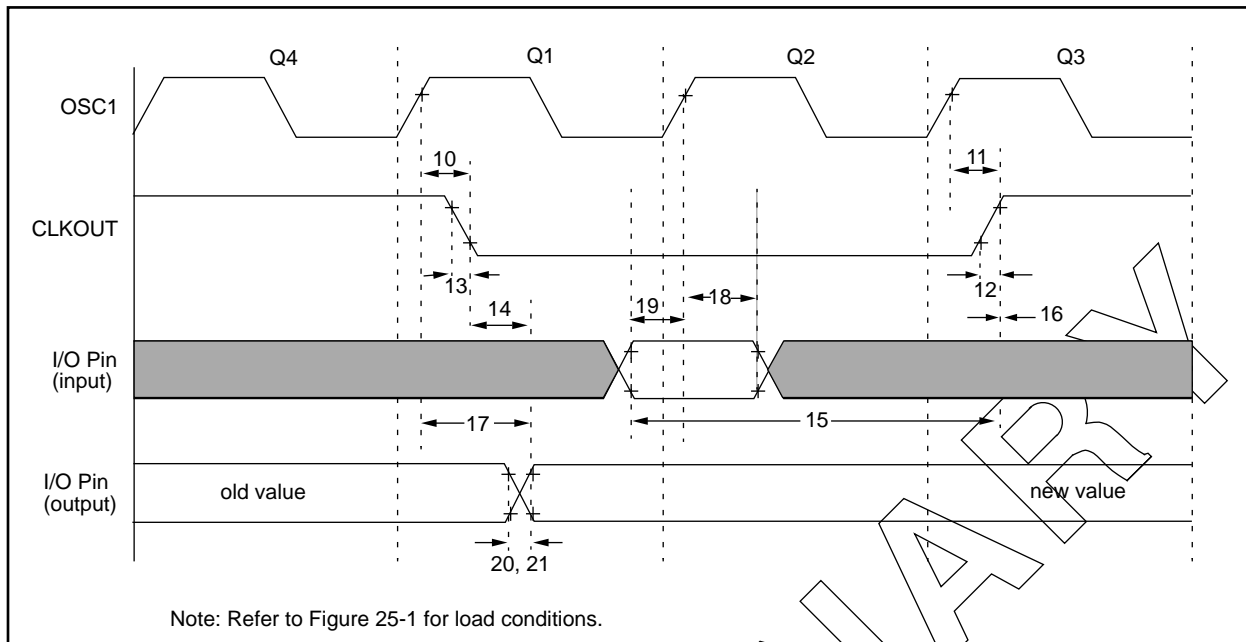


TABLE 25-3: CLKOUT AND I/O TIMING REQUIREMENTS

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	—	—	0.5Tcy + 20	ns	Note 1
15*	TioV2ckH	Port in valid before CLKOUT ↑	0.25Tcy + 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	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††*	Tiop	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 TOSC.

FIGURE 25-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER TIMING

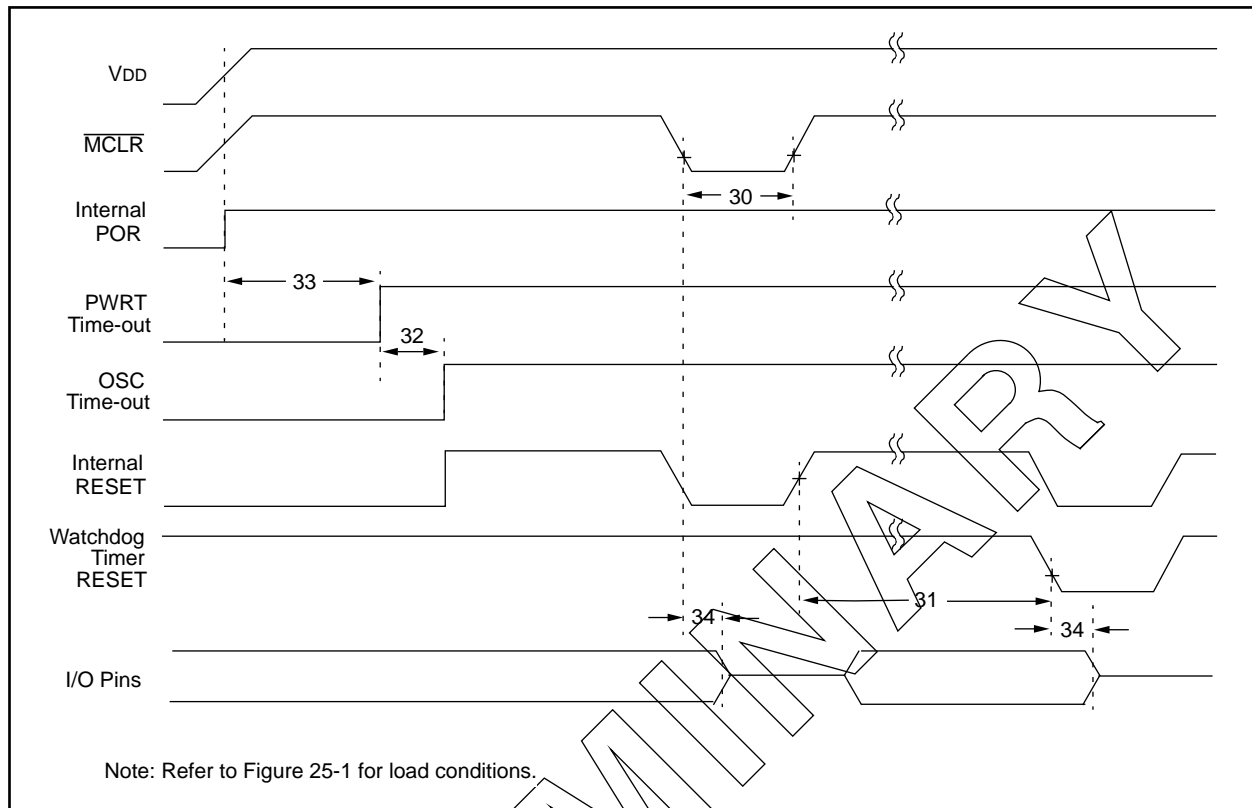


FIGURE 25-5: BROWN-OUT RESET TIMING

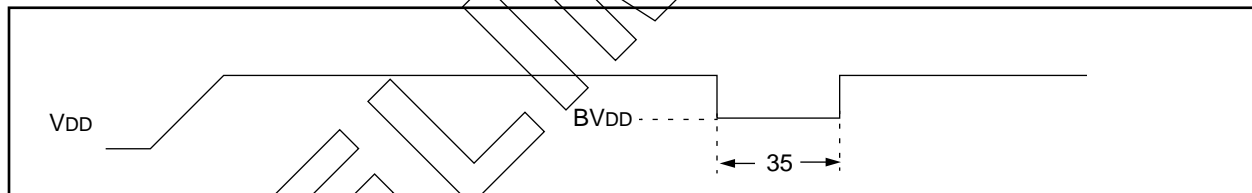


TABLE 25-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
30	Tmcl	MCLR Pulse Width (low)	1	—	—	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	—	—	1.1	μs	
35	TBOR	Brown-out Reset pulse width	100	—	—	μs	3.8V ≤ VDD ≤ 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.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

FIGURE 25-6: TIMER0 AND TIMER1 CLOCK TIMINGS

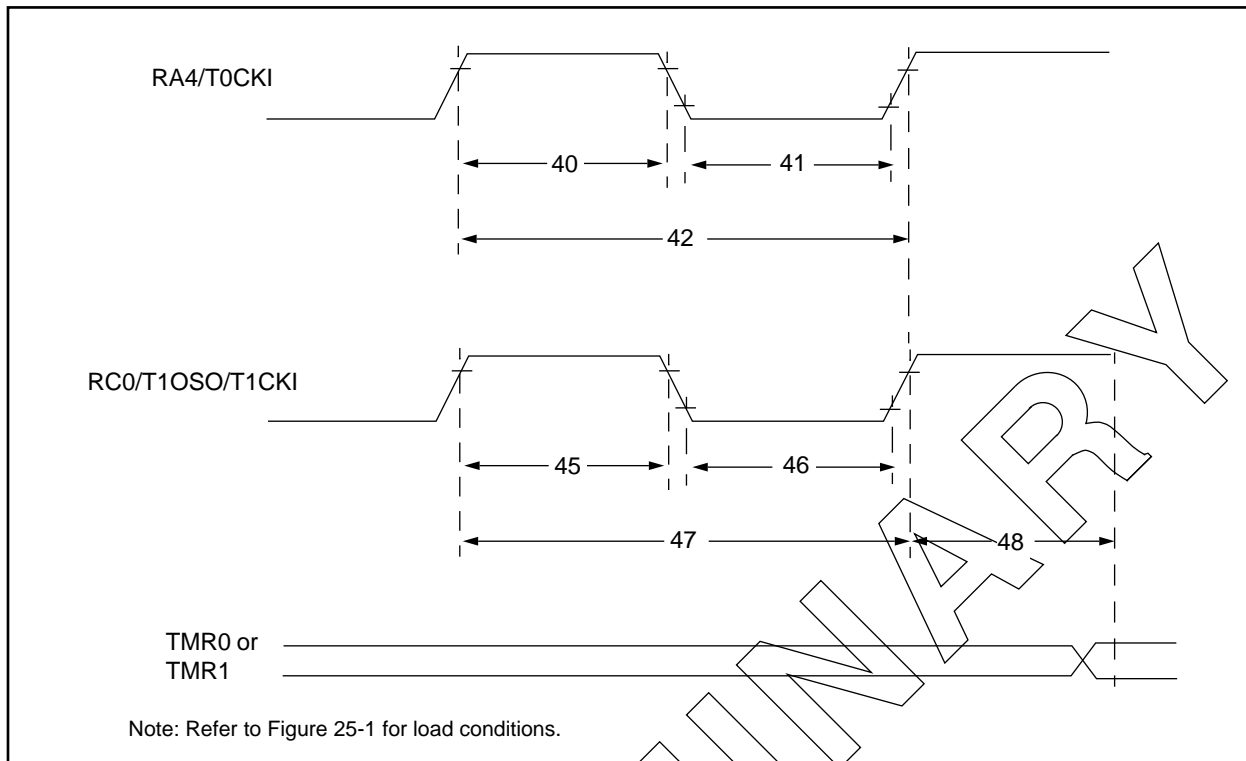


TABLE 25-5: TIMER0 AND TIMER1 CLOCK REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
40	Tt0H	T0CKI High Pulse Width	No Prescaler	0.5Tcy + 20*	—	—	ns
			With Prescaler	10*	—	—	
41	Tt0L	T0CKI Low Pulse Width	No Prescaler	0.5Tcy + 20*	—	—	ns
			With Prescaler	10*	—	—	
42	Tt0P	T0CKI Period	$\frac{Tcy + 40^*}{N}$	—	—	ns	N = prescale value (1, 2, 4, ..., 256)
45	Tt1H	T1CKI High Time	Synchronous, no prescaler	0.5Tcy + 20	—	—	ns
			Synchronous, with prescaler	PIC16C73A/74A 10*	—	—	
			PIC16LC73A/74A	20*	—	—	
			Asynchronous	2Tcy	—	—	
46	Tt1L	T1CKI Low Time	Synchronous, no prescaler	0.5Tcy + 20	—	—	ns
			Synchronous, with prescaler	PIC16C73A/74A 10*	—	—	
			PIC16LC73A/74A	20*	—	—	
			Asynchronous	2Tcy	—	—	
47	Tt1P	T1CKI input period	Synchronous	$\frac{Tcy + 40^*}{N}$	—	—	ns
			Asynchronous	4Tcy	—	—	
	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	2Tosc	—	7Tosc	—	

* 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 25-7: CAPTURE/COMPARE/PWM TIMINGS (CCP1 AND CCP2)

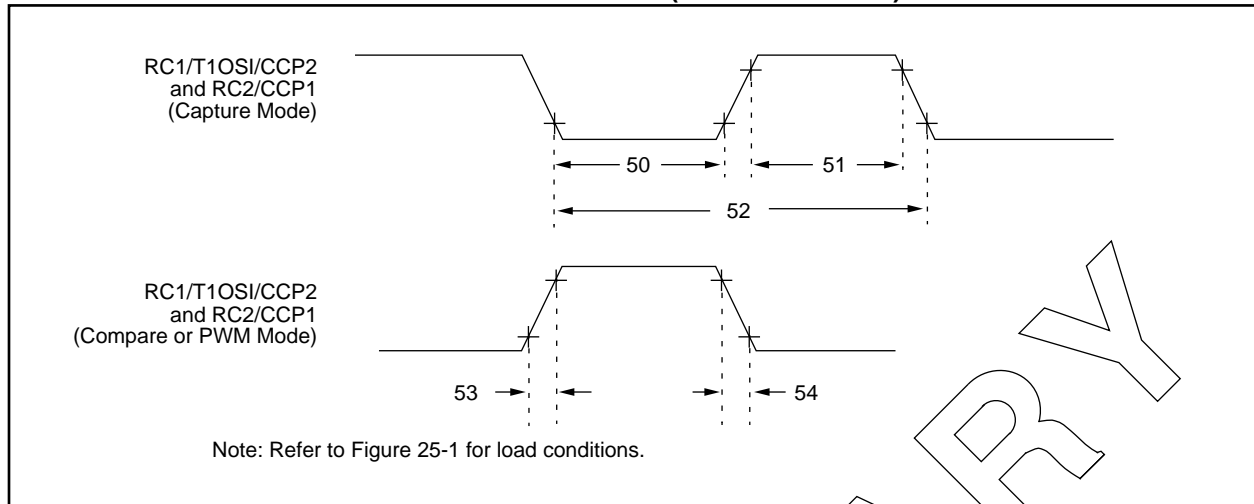


TABLE 25-6: CAPTURE/COMPARE/PWM REQUIREMENTS (CCP1 AND CCP2)

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	10*	—	ns	
			PIC16C73A/74A	20*	—	ns	
51	TccH	CCP1 and CCP2 input high time	No Prescaler	$0.5T_{CY} + 20^*$	—	ns	
			With Prescaler	10*	—	ns	
			PIC16C73A/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	—	10	25	ns	
54	TccF	CCP1 and CCP2 output fall time	—	10	25	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.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

FIGURE 25-8: PARALLEL SLAVE PORT TIMING FOR THE PIC16C74A ONLY

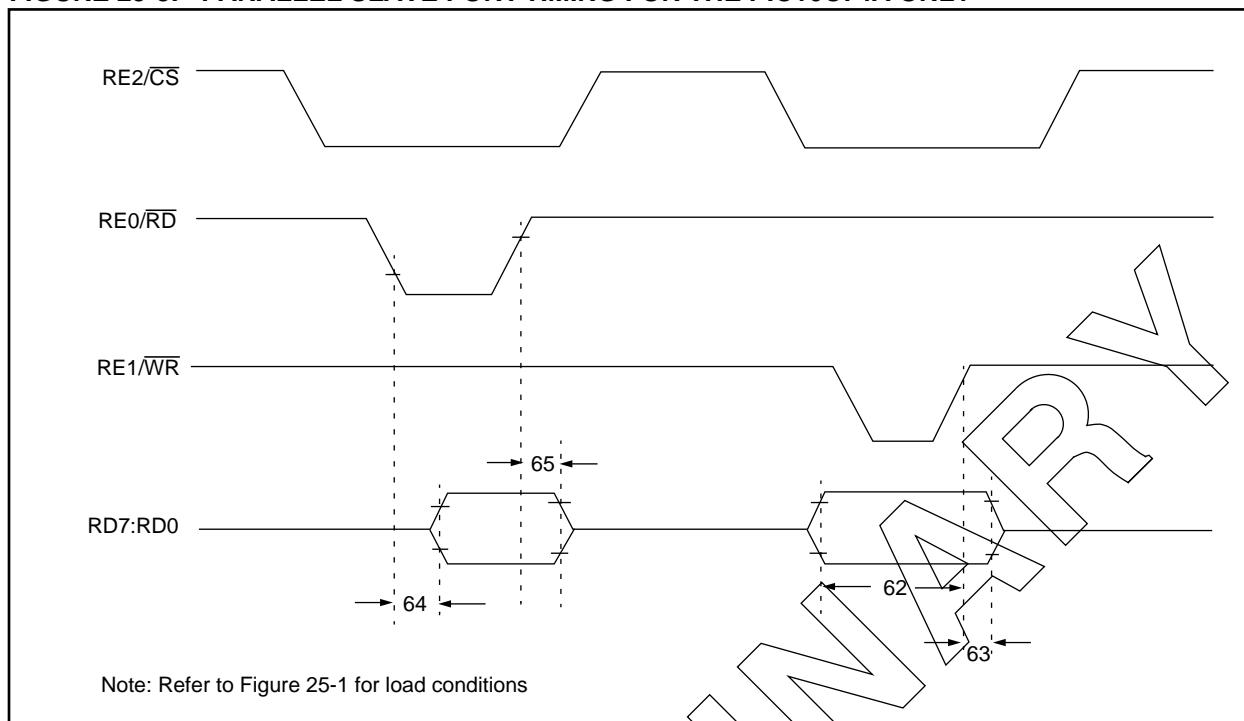


TABLE 25-7: PARALLEL SLAVE PORT REQUIREMENTS FOR THE PIC16C74A ONLY

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
62	TdtV2wrH	Data in valid before WR↑ or CS↑ (setup time)	20	—	—	ns	
63	TwrH2dtI	WR↑ or CS↑ to data-in invalid (hold time)					
		PIC16C74A	20*	—	—	ns	
		PIC16LC74A	35*	—	—	ns	
64	TrdL2dtV	RD↓ and CS↓ to data-out valid	—	—	60	ns	
65	TrdH2dtI	RD↑ or CS↓ 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 25-9: SPI MODE TIMING

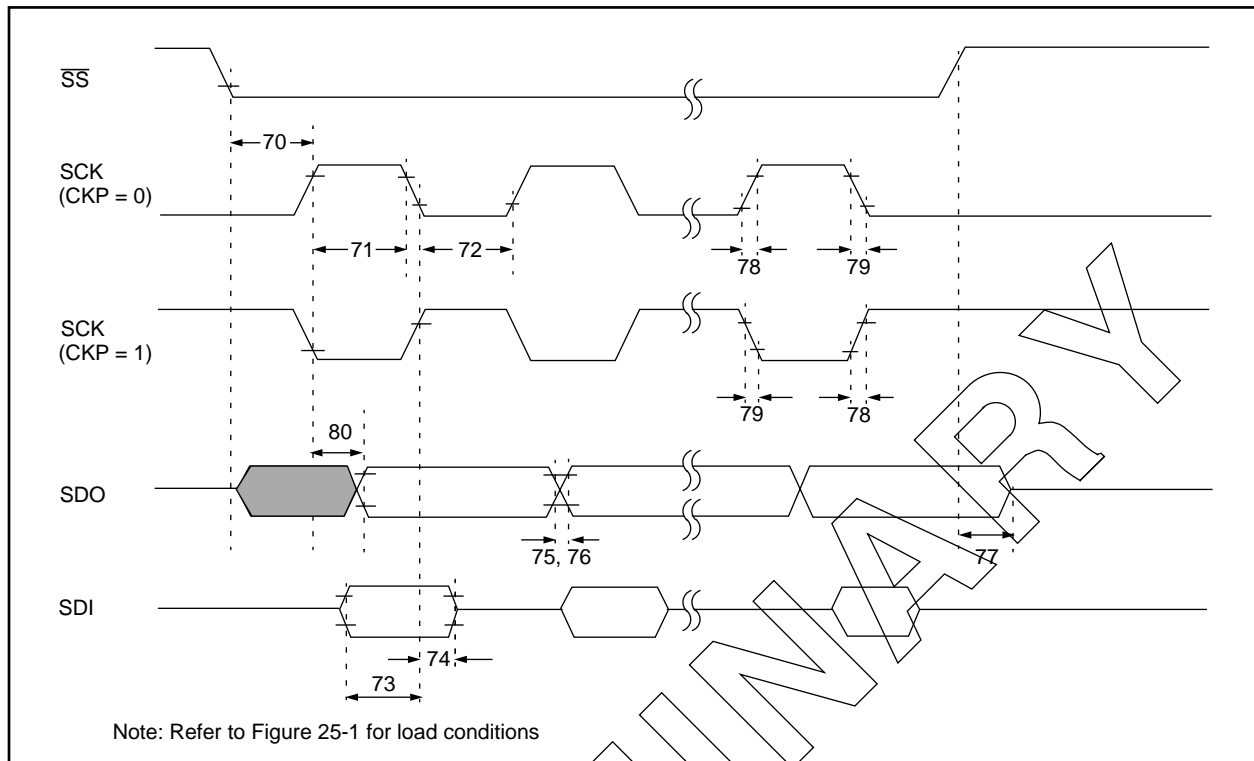


TABLE 25-8: SPI MODE REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
70	TssL2scH, TssL2scL	\overline{SS} ↓ to SCK↓ or SCK↑ input	T _{CY}	—	—	ns	
71	TscH	SCK input high time (slave mode)	T _{CY} + 20	—	—	ns	
72	TscL	SCK input low time (slave mode)	T _{CY} + 20	—	—	ns	
73	TdiV2scH, TdiV2scL	Setup time of SDI data input to SCK edge	T _{CY}	—	—	ns	
74	Tsch2diL, TscL2diL	Hold time of SDI data input to SCK edge	0.5T _{CY}	—	—	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.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

FIGURE 25-10: I²C BUS START/STOP BITS TIMING

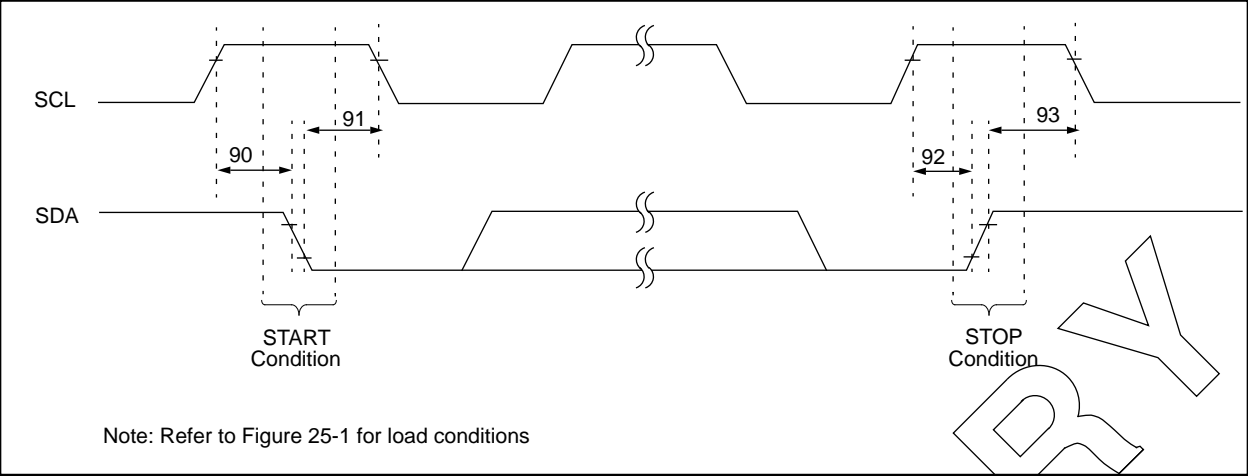


TABLE 25-9: I²C BUS START/STOP BITS REQUIREMENTS

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 25-11: I²C BUS DATA TIMING

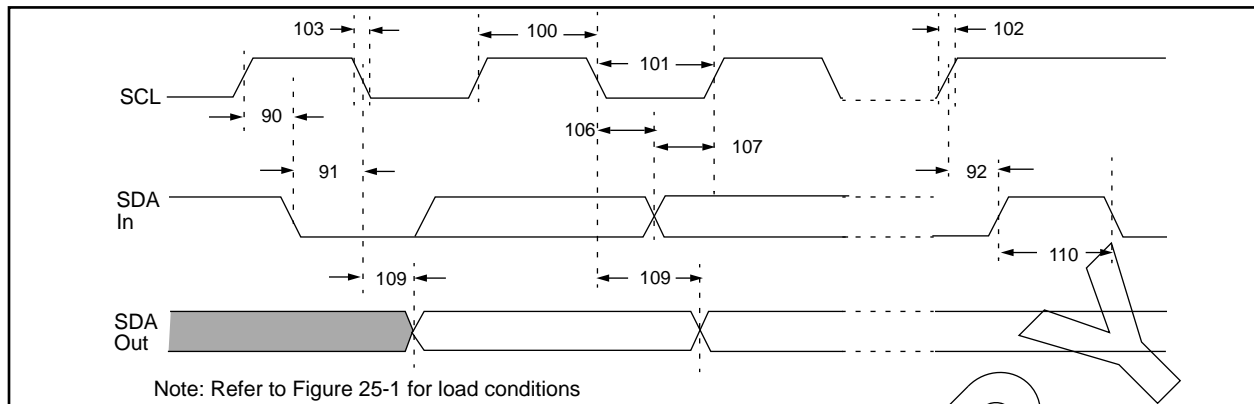


TABLE 25-10: I²C BUS DATA REQUIREMENTS

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	1.5TCY	—		
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	1.5TCY	—		
102	Tr	SDA and SCL rise time	100 kHz mode	—	1000	ns	
			400 kHz mode	20 + 0.1Cb	300	ns	Cb 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 + 0.1Cb	300	ns	Cb 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	
	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 I²C-bus device can be used in a standard-mode I²C-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 I²C bus specification) before the SCL line is released.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

FIGURE 25-12: USART MODULE: SYNCHRONOUS TRANSMISSION (MASTER/SLAVE) TIMING

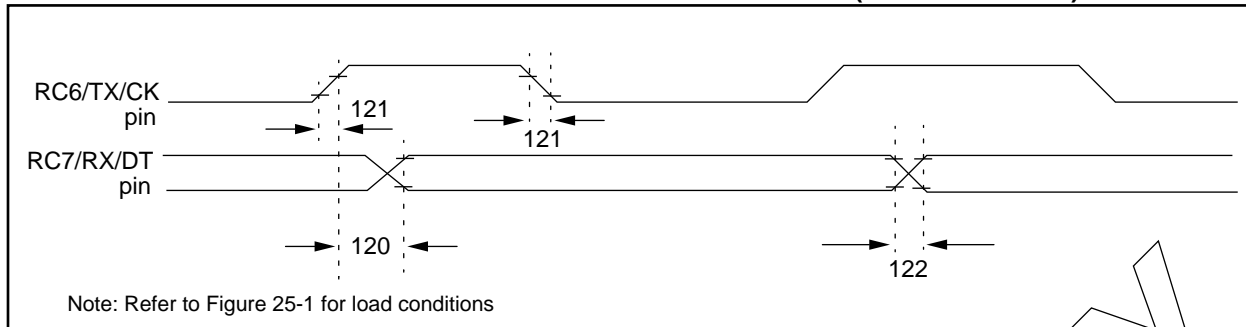


TABLE 25-11: SERIAL PORT SYNCHRONOUS TRANSMISSION REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
120	TckH2dtV	SYNC XMIT (MASTER & SLAVE) Clock high to data out valid					
		PIC16C73A/74A	—	—	50	ns	
		PIC16LC73A/74A	—	—	100	ns	
121	Tckrf	Clock out rise time and fall time (Master Mode)					
			PIC16C73A/74A	—	25	ns	
			PIC16LC73A/74A	—	50	ns	
122	TdtV	Data out rise time and fall time					
			PIC16C73A/74A	—	25	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 25-13: USART MODULE: SYNCHRONOUS RECEIVE (MASTER/SLAVE) TIMING

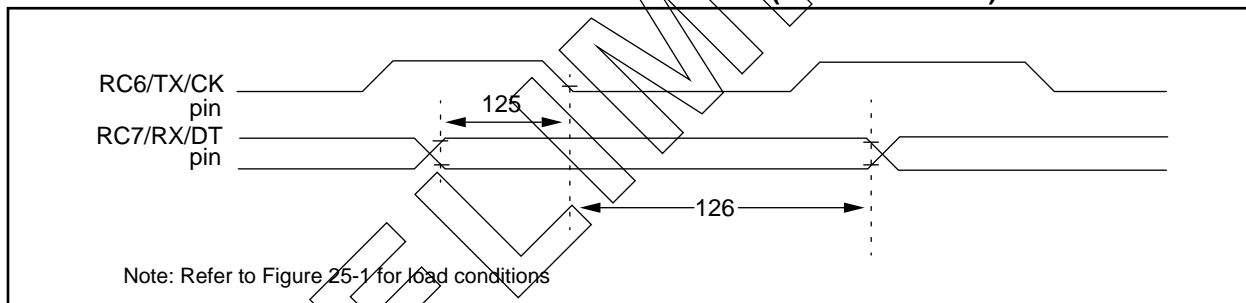


TABLE 25-12: SERIAL PORT SYNCHRONOUS RECEIVE REQUIREMENTS

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 25-13: A/D CONVERTER CHARACTERISTICS:

PIC16C73A-04 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽³⁾)

PIC16C74A-04 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽³⁾)

PIC16C73A-10 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽³⁾)

PIC16C74A-10 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽³⁾)

PIC16C73A-20 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽³⁾)

PIC16C74A-20 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽³⁾)

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 ± 1 LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NDIF	Differential error	—	—	less than ± 1 LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NFS	Full scale error	—	—	less than ± 1 LSb	—	$V_{REF} = V_{DD} = 5.12V, V_{SS} \leq A_{IN} \leq V_{REF}$
	NOFF	Offset error	—	—	less than ± 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	—	$V_{DD} \pm 0.3$	V	
	VAIN	Analog input voltage	$V_{SS} - 0.3$	—	$V_{REF} + 0.3$	V	
	ZAIN	Recommended impedance of analog voltage source	—	—	10.0	k Ω	
	IAD	A/D conversion current (V_{DD})	—	180	—	μA	Average current consumption when A/D is on. (Note 1)
	IREF	VREF input current (Note 2)	—	—	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: 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 Advanced information for this device.

PIC16C7X

Applicable Devices 70 71 71A 72 73 73A 74 74A

TABLE 25-14: A/D CONVERTER CHARACTERISTICS:
PIC16LC73A-04 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽⁴⁾)
PIC16LC74A-04 (COMMERCIAL, INDUSTRIAL, AUTOMOTIVE⁽⁴⁾)

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.

4: Automotive operating range is Advanced information for this device.

FIGURE 25-14: A/D CONVERSION TIMING

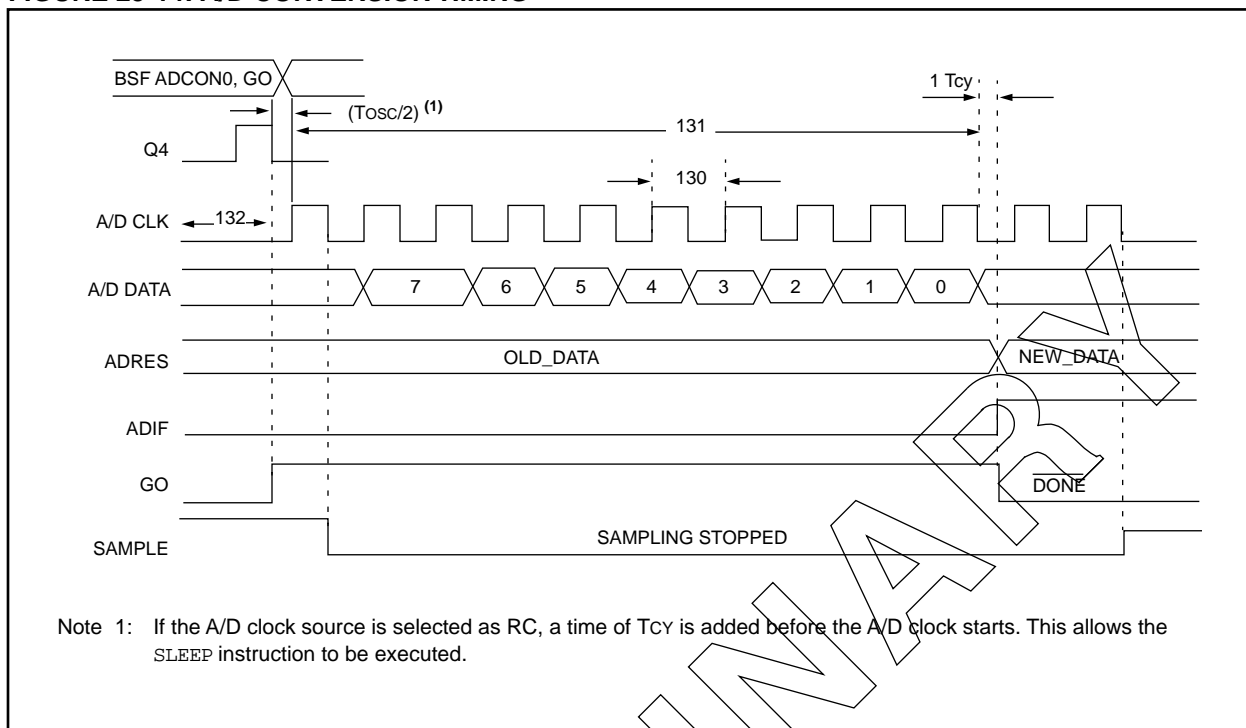


TABLE 25-15: A/D CONVERSION REQUIREMENTS

Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
130	TAD	A/D clock period	1.6 2.0	—	—	μs	VREF ≥ 3.0V VREF full range
130	TAD	A/D Internal RC Oscillator source	3.0 2.0	6.0 4.0	9.0 6.0	μs	ADCS1:ADCS0 = 11 (RC oscillator source) PIC16LC73A, PIC16LC74A, VDD = 3.0V PIC16C73A, PIC16C74A
131	TCNV	Conversion time (not including S/H time) (Note 1)	—	9.5TAD	—	—	
132	TSMP	Sampling 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.

Note 2: See Section 13.1 for min conditions.

PIC16C7X

Applicable Devices	70	71	71A	72	73	73A	74	74A
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NOTES:

PRELIMINARY

Applicable Devices	70	71	71A	72	73	73A	74	74A
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26.0 DC AND AC CHARACTERISTICS GRAPHS AND TABLES FOR PIC16C73A/
74A

NOT AVAILABLE AT THIS TIME

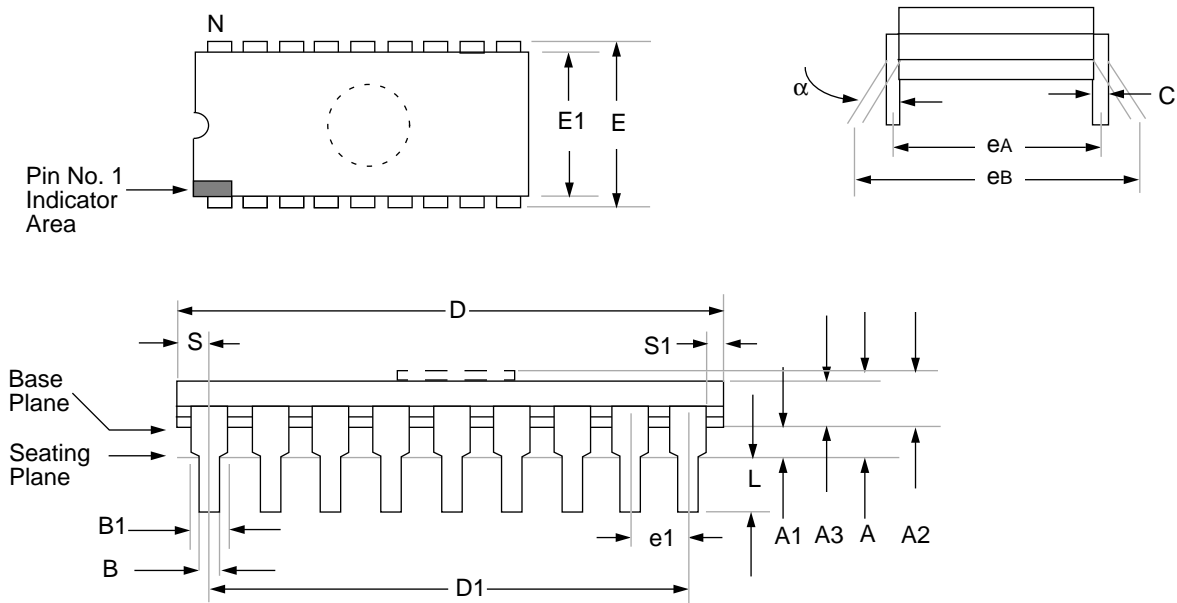
PIC16C7X

Applicable Devices	70	71	71A	72	73	73A	74	74A
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NOTES:

27.0 PACKAGING INFORMATION

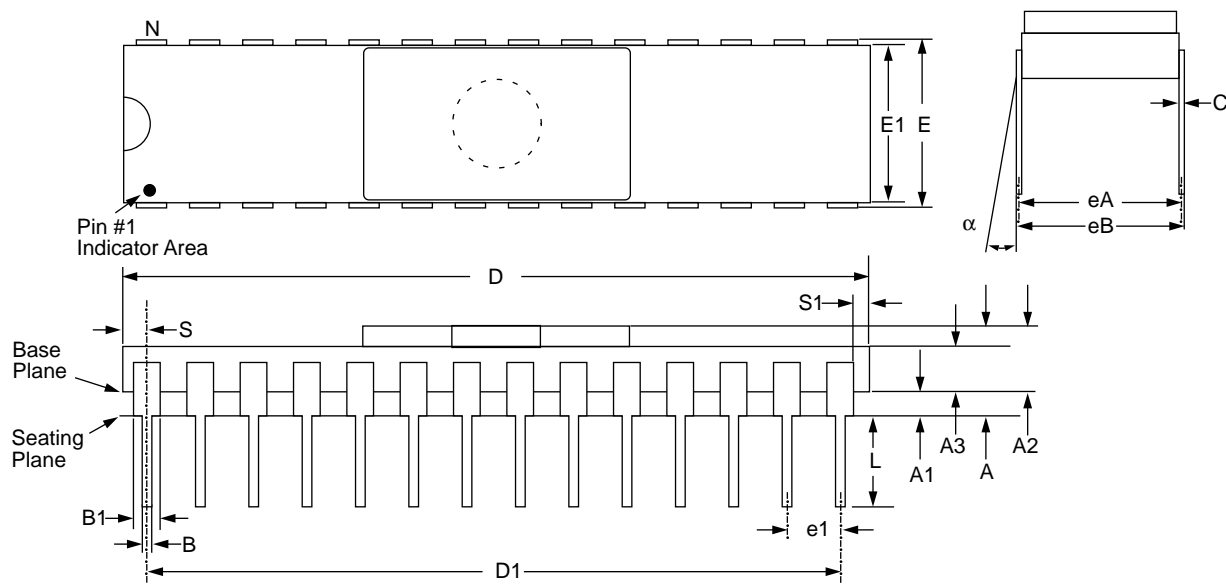
27.1 18-Lead Ceramic Cerdip Dual In-line with Window (300 mil)



Package Group: Ceramic Cerdip Dual In-Line (CDP)						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
α	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	

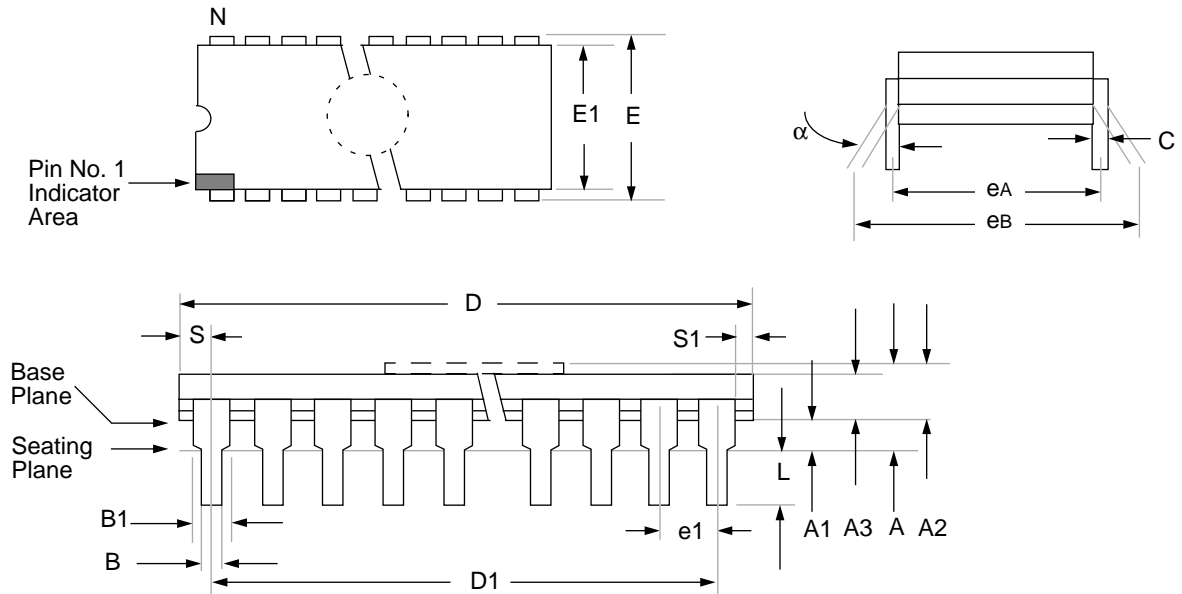
PIC16C7X

27.2 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
α	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	

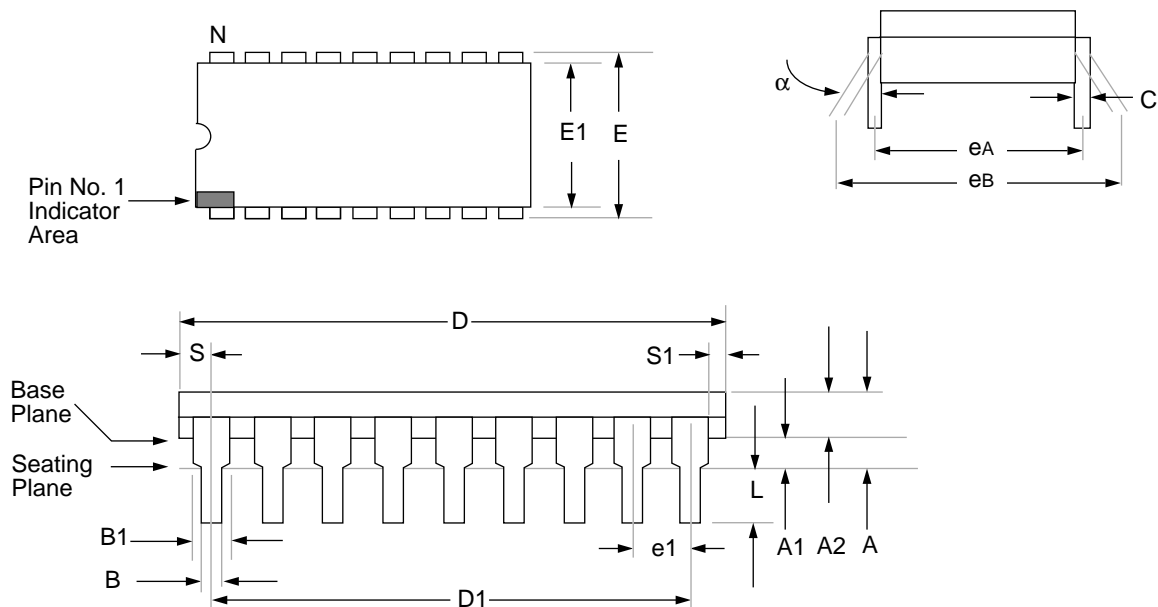
27.3 40-Lead Ceramic Cerdip Dual In-line with Window (600 mil)



Package Group: Ceramic Cerdip Dual In-Line (CDP)						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
α	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	

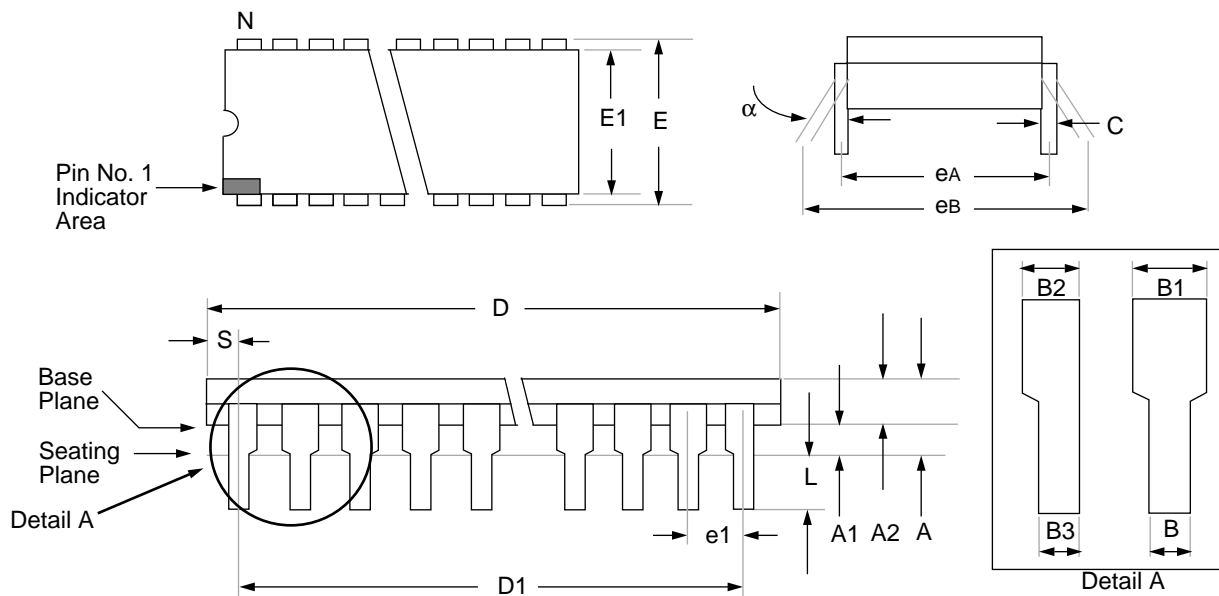
PIC16C7X

27.4 18-Lead Plastic Dual In-line (300 mil)



Package Group: Plastic Dual In-Line (PLA)						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
α	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	—	

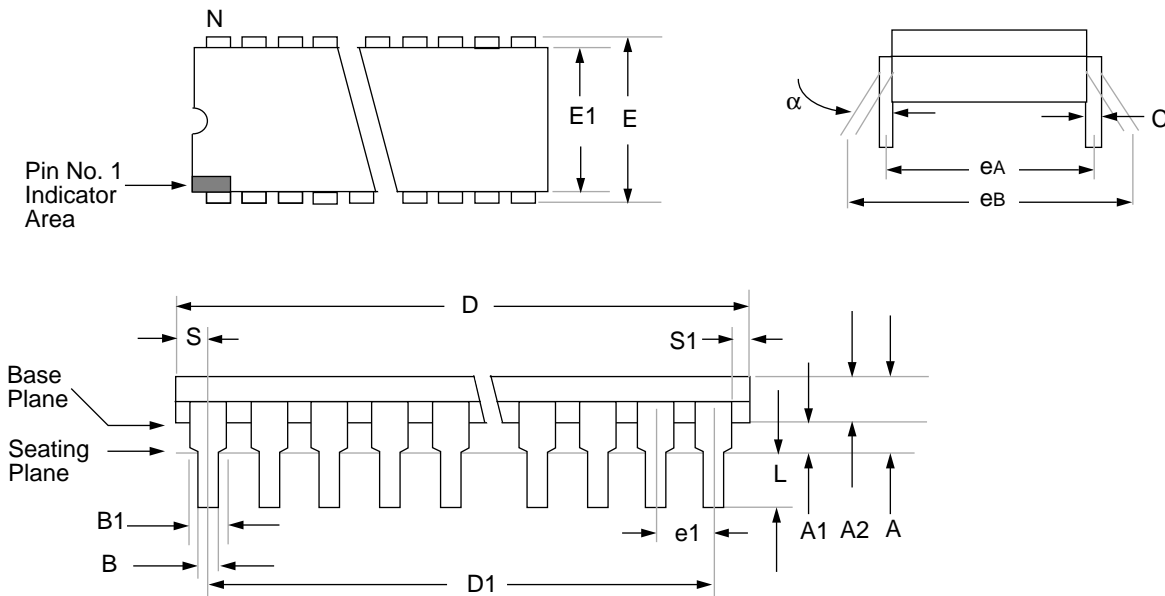
27.5 28-Lead Plastic Dual In-line (300 mil)



Package Group: Plastic Dual In-Line (PLA)						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
α	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	Typical	0.040	0.065	Typical
B2	0.762	1.016	4 places	0.030	0.040	4 places
B3	0.203	0.508	4 places	0.008	0.020	4 places
C	0.203	0.331	Typical	0.008	0.013	Typical
D	34.163	35.179		1.385	1.395	
D1	33.020	33.020	Reference	1.300	1.300	Reference
E	7.874	8.382		0.310	0.330	
E1	7.112	7.493		0.280	0.295	
e1	2.540	2.540	Typical	0.100	0.100	Typical
eA	7.874	7.874	Reference	0.310	0.310	Reference
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	

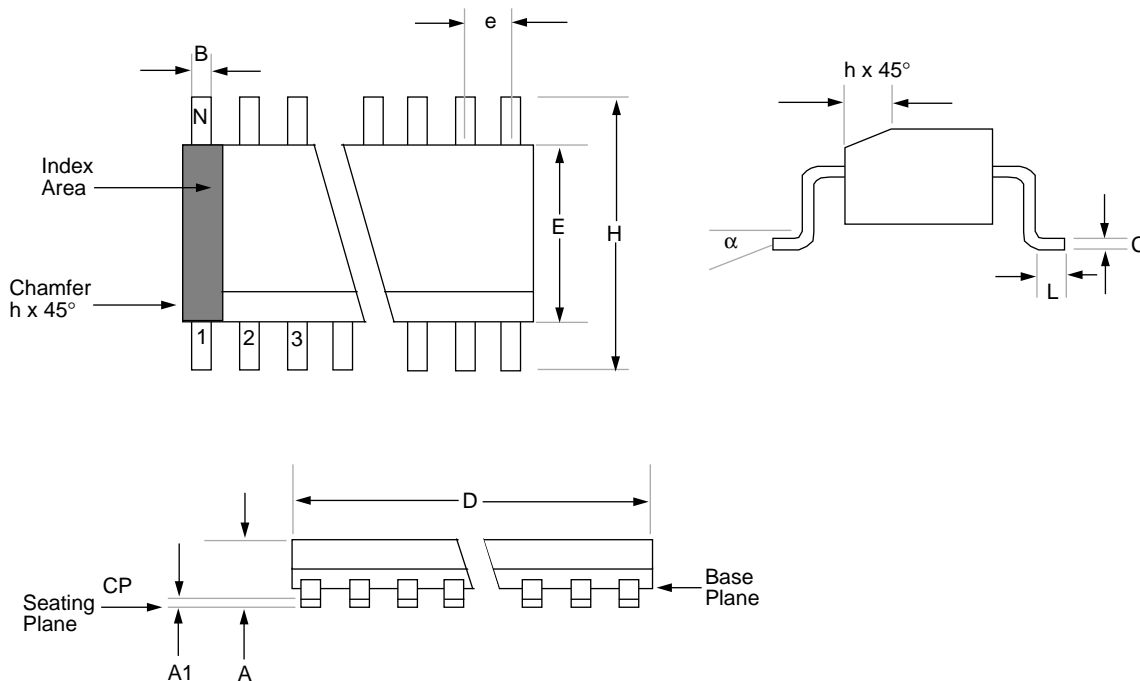
PIC16C7X

27.6 40-Lead Plastic Dual In-line (600 mil)



Package Group: Plastic Dual In-Line (PLA)						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
α	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	—	

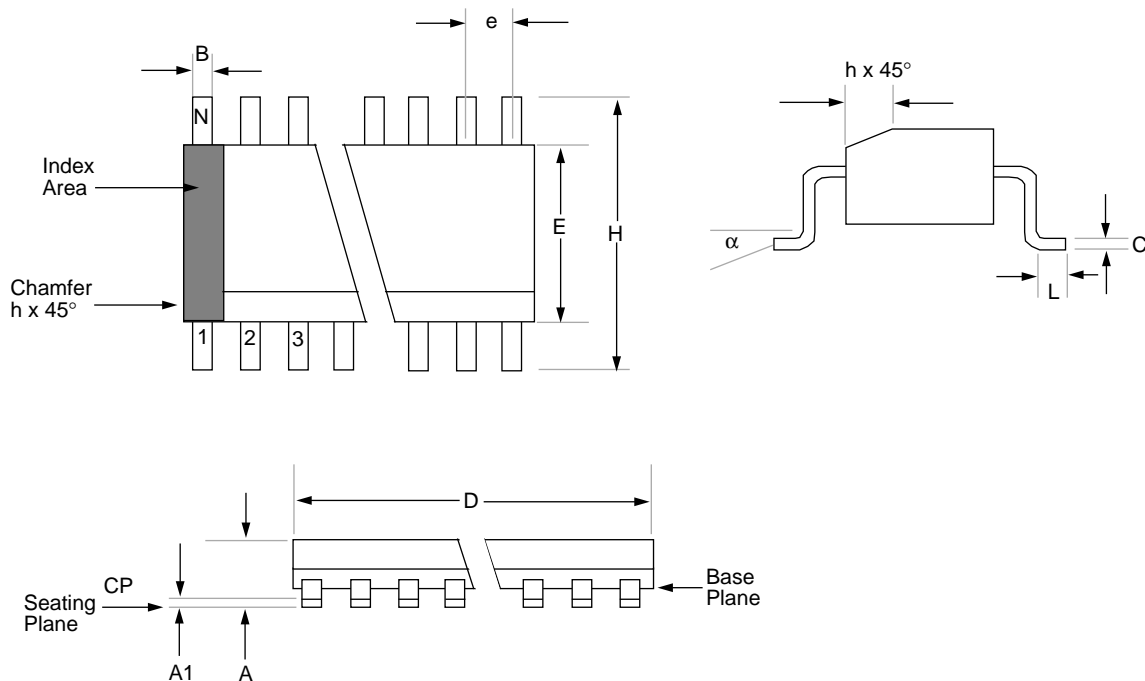
27.7 18-Lead Plastic Surface Mount (SOIC - Wide, 300 mil Body)



Package Group: Plastic SOIC (SO)						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
α	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	

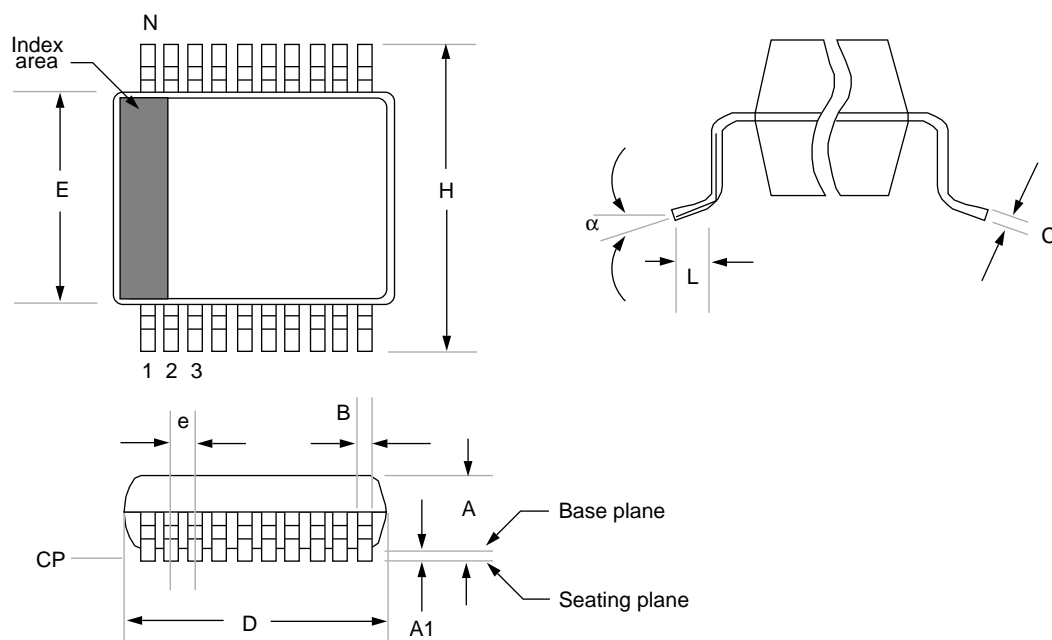
PIC16C7X

27.8 28-Lead Plastic Surface Mount (SOIC - Wide, 300 mil Body)



Package Group: Plastic SOIC (SO)						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
α	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	Typical	0.050	0.050	Typical
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	

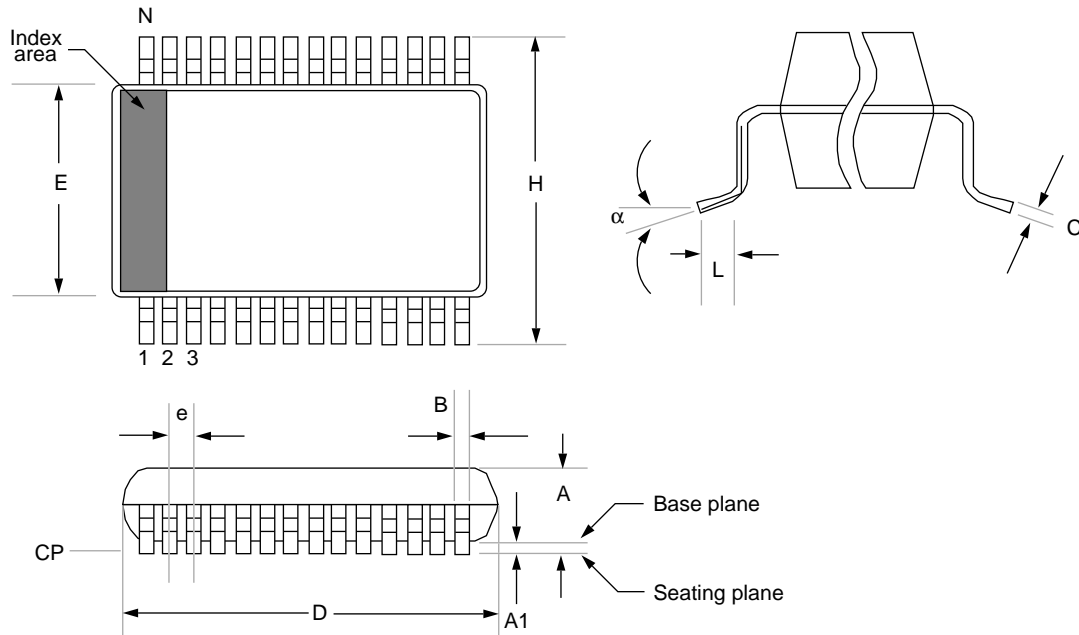
27.9 20-Lead Plastic Surface Mount (SSOP - 209 mil Body 5.30 mm)



Package Group: Plastic SSOP						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
α	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	

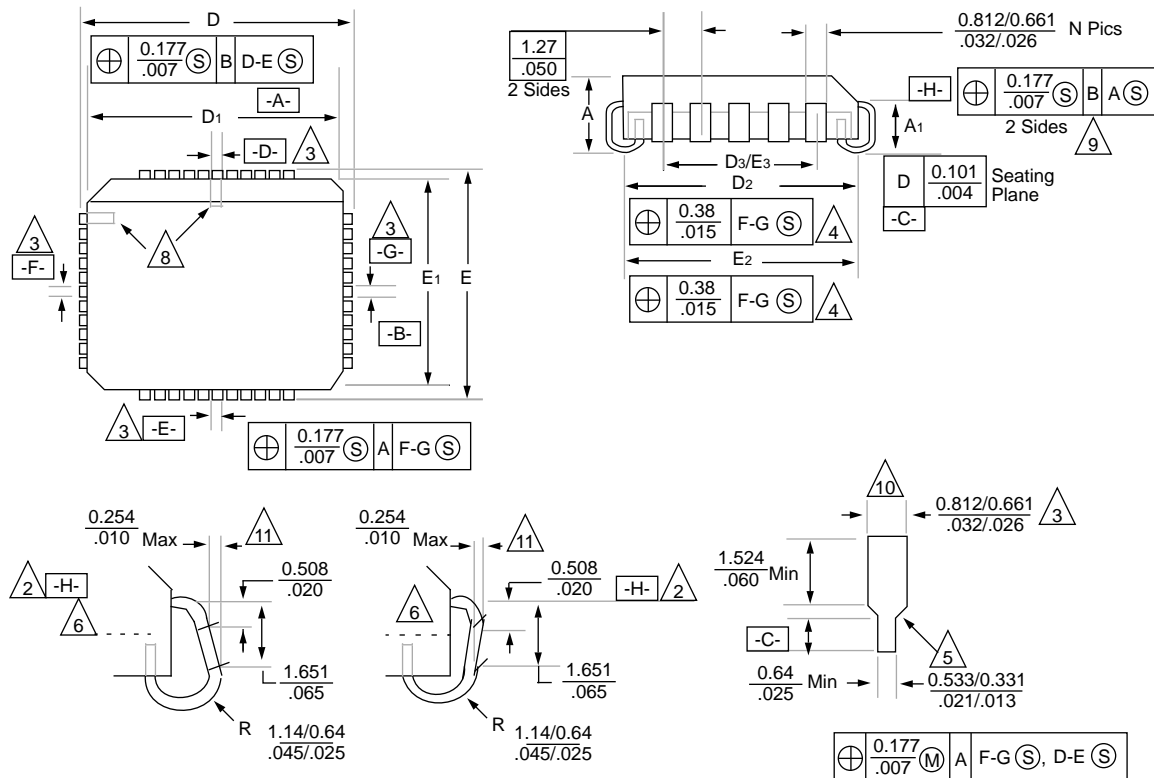
PIC16C7X

27.10 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
α	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	

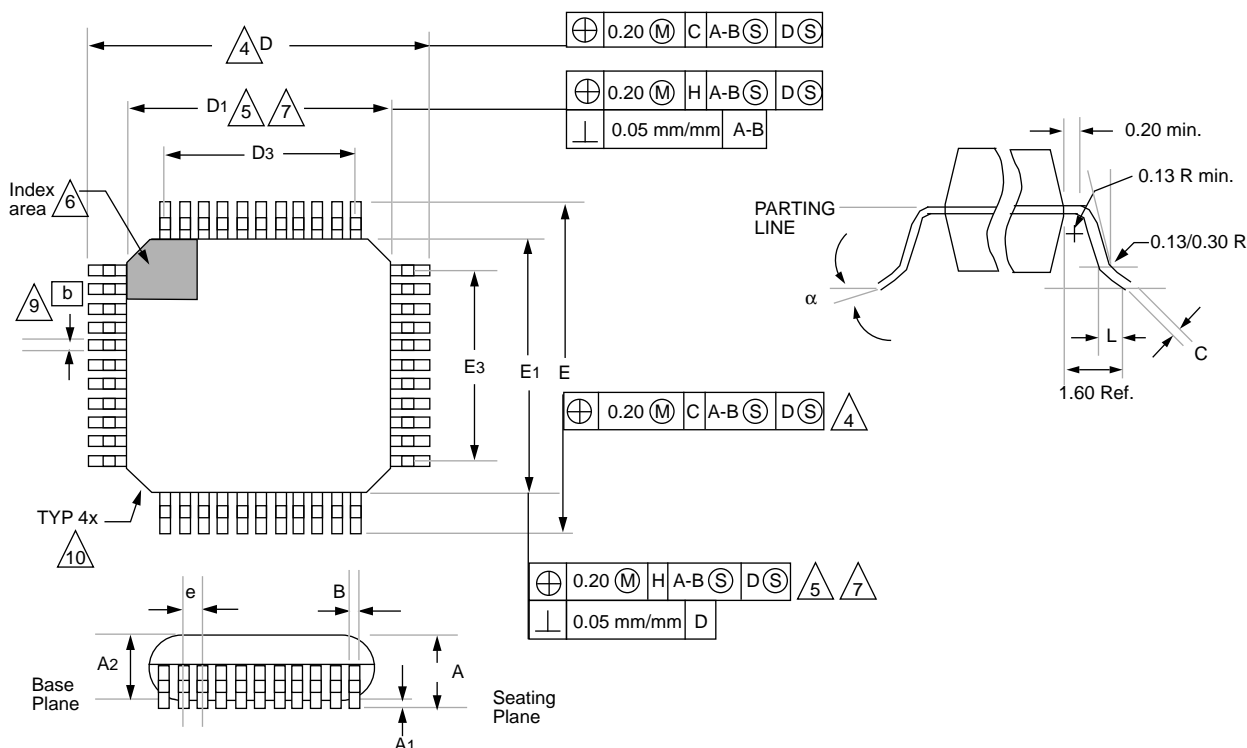
27.11 44-Lead Plastic Leaded Chip Carrier (Square)



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	

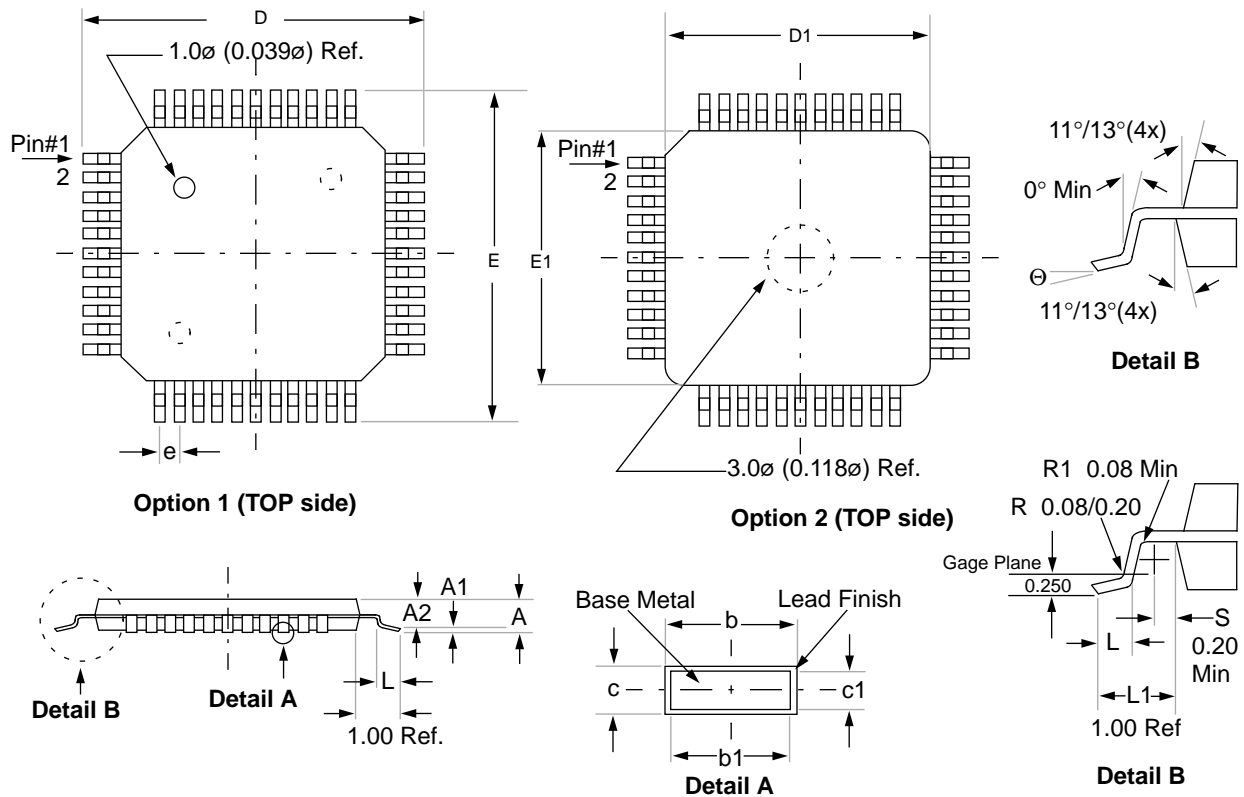
PIC16C7X

27.12 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
α	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	—	

27.13 44-Lead Plastic Surface Mount (TQFP 10x10 mm Body 1.0/0.10 mm Lead Form)



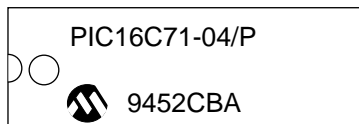
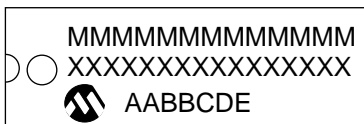
Package Group: Plastic TQFP						
Symbol	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
A	1.00	1.20		0.039	0.047	
A1	0.05	0.15		0.002	0.006	
A2	0.95	1.05		0.037	0.041	
D	11.75	12.25		0.463	0.482	
D1	9.90	10.10		0.390	0.398	
E	11.75	12.25		0.463	0.482	
E1	9.90	10.10		0.390	0.398	
L	0.45	0.75		0.018	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.

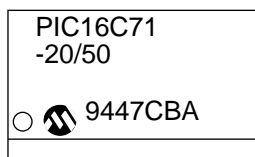
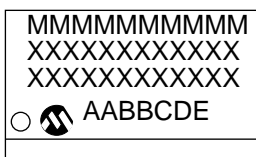
2: Dimension "b" does not include Dambar protrusion, allowable Dambar protrusion shall be 0.08mm (0.003") max.

3: This outline conforms to JEDEC MS-026.

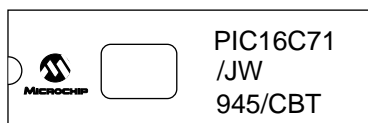
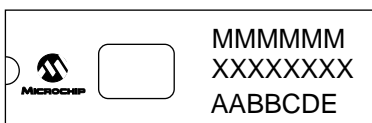
Example



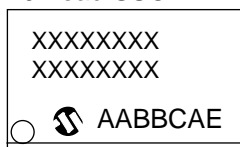
Example



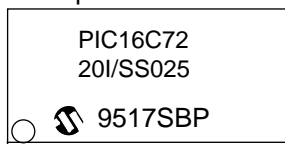
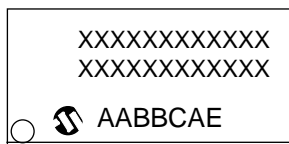
Example



Example



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 ₁	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.

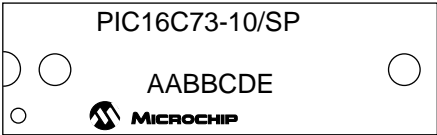
* Standard OTP marking consists of Microchip part number, year code, week code, facility code, mask revision number, and assembly code. For OTP marking beyond this, certain price adders apply. Please check with your Microchip Sales Office. For QTP devices, any special marking adders are included in QTP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

Package Marking Information (Cont'd)

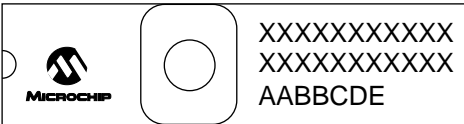
28-Lead PDIP (Skinny DIP)



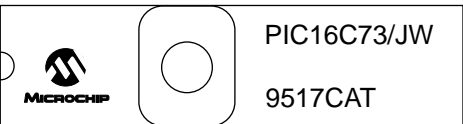
Example



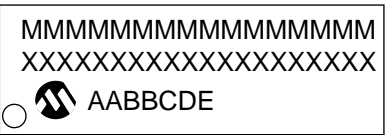
28-Lead Side Brazed Skinny Windowed



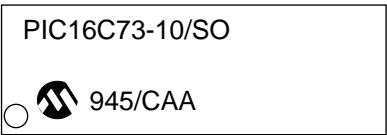
Example



28-Lead SOIC



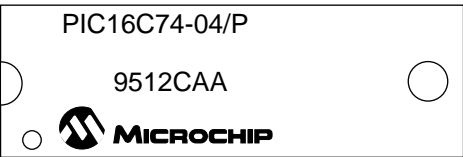
Example



40-Lead PDIP



Example



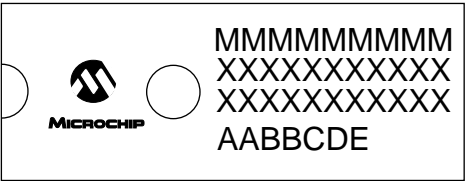
Legend:	MM...M	Microchip part number information
	XX...X	Customer specific information*
	AA	Year code (last 2 digits of calendar year)
	BB	Week code (week of January 1 is week '01')
	C	Facility code of the plant at which wafer is manufactured. C = Chandler, Arizona, U.S.A. S = Tempe, Arizona, U.S.A.
	D ₁	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.

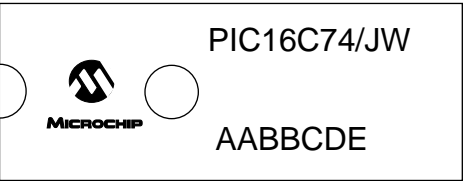
PIC16C7X

Package Marking Information (Cont'd)

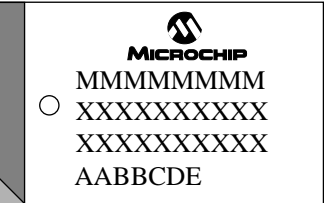
40-Lead CERDIP Windowed



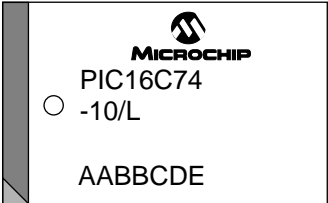
Example



44-Lead PLCC



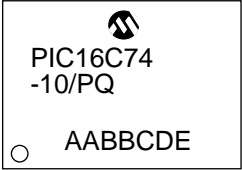
Example



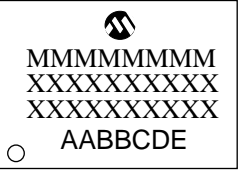
44-Lead MQFP



Example



44-Lead TQFP



Example



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 ₁	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, 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.

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

APPENDIX C: WHAT'S NEW

The format of this data sheet has been changed to be consistent with other product families. This ensures that important topics are covered across all PIC16/17 microcontroller families. Here is an overview list of new features:

Added the following devices:

PIC16C70

PIC16C71A

PIC16C72

PIC16C73A

PIC16C74A

The above devices have an on-chip Brown-out Detect circuit added.

A Brown-out Detect Enable Bit (BODEN) has been added to the Configuration Word register.

A Brown-out Reset detect bit ($\overline{\text{BOR}}$) has been added to the PCON register (for the devices with brown-out detect circuitry).

A $\overline{\text{MCLR}}$ filter circuit has been added to minimize the influence of pin state changes to the $\overline{\text{MCLR}}$ line.

APPENDIX D: WHAT'S CHANGED

All product and device family tables have been updated for the latest devices and specifications.

TX8/9 (TXSTA<6>) has been changed to TX9 - 9-bit Transmit Enable bit.

RC8/9 (RCSTA<6>) has been changed to RX9 - 9-bit Receive Enable bit.

RCD8 (RCSTA<0>) has been changed to RX9D.

TXD8 (TXSTA<0>) has been changed to TX9D.

APPENDIX E: PIC16/17 MICROCONTROLLERS

TABLE E-1: PIC16C5X FAMILY OF DEVICES

	Clock		Memory		Peripherals		Features		
	Maximum Frequency of Operation (MHz)	Program Memory (words)	Timer Module(s)		I/O Pins	Voltage Range (Volts)	Number of Instructions	Packages	
			RAM Data Memory (bytes)	EPROM					
									ROM
PIC16C54	20	512	—	25	TMR0	12	2.5-6.25	33	18-pin DIP, SOIC; 20-pin SSOP
PIC16C54A	20	512	—	25	TMR0	12	2.5-6.25	33	18-pin DIP, SOIC; 20-pin SSOP
PIC16CR54(2)	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
PIC16CR54B(1)	20	—	512	25	TMR0	12	2.5-6.25	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
PIC16CR56(1)	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
PIC16CR57A(2)	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	2.5-6.25	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
PIC16CR58B(1)	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.

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

2: Not recommended for new designs.

PIC16C7X

TABLE E-2: PIC16C62X FAMILY OF DEVICES

Clock			Memory			Peripherals			Features			
Maximum Frequency of Operation (MHz)			Data Memory (bytes)			Timer Module(s)			Comparator(s)			
Program Memory			Internal Reference Voltage			I/O Pins			Voltage Range (Volts)			
In-Circuit Serial Programming			Brown-out Reset			Packages						
PIC16C620	20	512	80	TMR0	2	Yes	4	13	3.0-6.0	Yes	Yes	18-pin DIP, SOIC; 20-pin SSOP
PIC16C621	20	1K	80	TMR0	2	Yes	4	13	3.0-6.0	Yes	Yes	18-pin DIP, SOIC; 20-pin SSOP
PIC16C622	20	2K	128	TMR0	2	Yes	4	13	3.0-6.0	Yes	Yes	18-pin DIP, SOIC; 20-pin SSOP

All PIC16C16/17 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.

TABLE E-3: PIC16C6X FAMILY OF DEVICES

	Clock			Memory			Peripherals					Features		
	Maximum Frequency of Operation (MHz)			Program Memory			Timer Module(s)					Serial Ports (SPI/I ² C, USART)		
	20	1K	—	36	TMR0	—	—	—	3	13	3.0-6.0	Yes	—	18-pin DIP, SOIC
PIC16C61	20	2K	—	128	TMR0, TMR1, TMR2	1	SPI/I ² C	—	7	22	3.0-6.0	Yes	—	28-pin SDIP, SOIC, SSOP
PIC16C62	20	2K	—	128	TMR0, TMR1, TMR2	1	SPI/I ² C	—	7	22	3.0-6.0	Yes	Yes	28-pin SDIP, SOIC, SSOP
PIC16C62A ⁽¹⁾	20	—	2K	128	TMR0, TMR1, TMR2	1	SPI/I ² C	—	7	22	3.0-6.0	Yes	Yes	28-pin SDIP, SOIC, SSOP
PIC16C62A ⁽¹⁾	20	—	2K	128	TMR0, TMR1, TMR2	1	SPI/I ² C	—	7	22	3.0-6.0	Yes	Yes	28-pin SDIP, SOIC, SSOP
PIC16C63 ⁽¹⁾	20	4K	—	192	TMR0, TMR1, TMR2	2	SPI/I ² C, USART	—	10	22	3.0-6.0	Yes	Yes	28-pin SDIP, SOIC
PIC16C64	20	2K	—	128	TMR0, TMR1, TMR2	1	SPI/I ² C	Yes	8	33	3.0-6.0	Yes	—	40-pin DIP; 44-pin PLCC, MQFP
PIC16C64A ⁽¹⁾	20	2K	—	128	TMR0, TMR1, TMR2	1	SPI/I ² C	Yes	8	33	3.0-6.0	Yes	Yes	40-pin DIP; 44-pin PLCC, MQFP, TQFP
PIC16C64A ⁽¹⁾	20	—	2K	128	TMR0, TMR1, TMR2	1	SPI/I ² C	Yes	8	33	3.0-6.0	Yes	Yes	40-pin DIP; 44-pin PLCC, MQFP
PIC16C65	20	4K	—	192	TMR0, TMR1, TMR2	2	SPI/I ² C, USART	Yes	11	33	3.0-6.0	Yes	—	40-pin DIP; 44-pin PLCC, MQFP
PIC16C65A ⁽¹⁾	20	4K	—	192	TMR0, TMR1, TMR2	2	SPI/I ² C, USART	Yes	11	33	3.0-6.0	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 PIC16CXX 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

TABLE E-4: PIC16C7X FAMILY OF DEVICES

	Clock			Memory			Peripherals					Features		
	Maximum Frequency of Operation (MHz)	Program Memory (Kbytes)	Data Memory (bytes)	EEPROM	Timer Modules	Capable/Compare/PWM Modules	Serial Ports (SPI/I ² C, USART)	Parallel Slave Port	AD Converter (8-bit) Channels	Interrupt Sources	I/O Pins	Voltage Range (Volts)	In-Circuit Serial Programming	Brown-out Reset
PIC16C70 ⁽¹⁾	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
PIC16C71A ⁽¹⁾	20	1K	68	TMR0	—	—	—	4	4	13	3.0-6.0	Yes	Yes	18-pin DIP, SOIC; 20-pin SSOP
PIC16C72 ⁽¹⁾	20	2K	128	TMR0, TMR1, TMR2	1 SPI/I ² C	—	—	5	8	22	3.0-6.0	Yes	Yes	28-pin SDIP, SOIC, SSOP
PIC16C73	20	4K	192	TMR0, TMR1, TMR2	2 SPI/I ² C, USART	—	—	5	11	22	3.0-6.0	Yes	—	28-pin SDIP, SOIC
PIC16C73A ⁽¹⁾	20	4K	192	TMR0, TMR1, TMR2	2 SPI/I ² C, USART	—	—	5	11	22	3.0-6.0	Yes	Yes	28-pin SDIP, SOIC
PIC16C74	20	4K	192	TMR0, TMR1, TMR2	2 SPI/I ² C, USART	Yes	Yes	8	12	33	3.0-6.0	Yes	—	40-pin DIP; 44-pin PLCC, MQFP
PIC16C74A ⁽¹⁾	20	4K	192	TMR0, TMR1, TMR2	2 SPI/I ² C, USART	Yes	Yes	8	12	33	3.0-6.0	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 PIC16CXX 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.

TABLE E-5: PIC16C8X FAMILY OF DEVICES

	Clock			Memory			Peripherals		Features	
	Maximum Frequency of Operation (MHz)			Program Memory			Timer Module(s)		Interrupt Sources	
	EEPROM	ROM	Data Memory (bytes)	Data EEPROM (bytes)	Timer Module(s)	I/O Pins	In-Circuit Serial Programming	Voltage Range (Volts)	Packages	
PIC16C83 ⁽¹⁾	10	512	—	36	64	TMR0	4	13	Yes	2.0-6.0 18-pin DIP, SOIC
PIC16CR83 ⁽¹⁾	10	—	512	36	64	TMR0	4	13	Yes	2.0-6.0 18-pin DIP, SOIC
PIC16C84	10	1K	—	36	64	TMR0	4	13	Yes	2.0-6.0 18-pin DIP, SOIC
PIC16C84A ⁽¹⁾	10	1K	—	68	64	TMR0	4	13	Yes	2.0-6.0 18-pin DIP, SOIC
PIC16CR84 ⁽¹⁾	10	—	1K	68	64	TMR0	4	13	Yes	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 PIC16CXX 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

TABLE E-6: PIC17CXX FAMILY OF DEVICES

	Clock			Memory			Peripherals				Features			
	Maximum Frequency of Operation (MHz)	EPROM	RAM Data Memory (bytes)	Program Memory	Timer Modules	Captures	PTMs	Serial Port(s) (USART)	External Interrupts	I/O Pins	Voltage Range (Volts)	Hardware Multiply	In-Circuit Serial Programming	Number of Instructions
PIC17C42	25	2K	232	TMR0, TMR1, TMR2, TMR3	2	2	Yes	Yes	11	33	4.5-5.5	—	Yes	55
PIC17C43	25	4K	454	TMR0, TMR1, TMR2, TMR3	2	2	Yes	Yes	11	33	2.5-6.0	Yes	Yes	58
PIC17C44	25	8K	454	TMR0, TMR1, TMR2, TMR3	2	2	Yes	Yes	11	33	2.5-6.0	Yes	Yes	58

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

E.1 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 requires 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-7: PIN COMPATIBLE DEVICES

Pin Compatible Devices	Package
PIC16C54, PIC16C54A, PIC16CR54, PIC16CR54A, PIC16CR54B, PIC16C56, PIC16CR56, PIC16C58A, PIC16CR58A, PIC16CR58B, PIC16C61, PIC16C620, PIC16C621, PIC16C622, PIC16C70, PIC16C71, PIC16C71A PIC16C83, PIC16CR83, PIC16C84, PIC16C84A, PIC16CR84	18 pin (20 pin)
PIC16C55, PIC16CR55, PIC16C57, PIC16CR57A, PIC16CR57B	28 pin
PIC16C62, PIC16CR62, PIC16C62A, PIC16C63, PIC16C72, PIC16C73, PIC16C73A	28 pin
PIC16C64, PIC16CR64, PIC16C64A, PIC16C65, PIC16C65A, PIC16C74, PIC16C74A	40 pin
PIC17C42, PIC17C43, PIC17C44	40 pin

PIC16C7X

NOTES:

INDEX

A

A/D

Accuracy/Error	118
ADCON0 Register	109
ADCON1 Register	111
ADIF bit	112
Analog Input Model Block Diagram	114
Analog-to-Digital Converter	109
Block Diagram	113
Configuring Analog Port Pins	115
Configuring the Interrupt	112
Configuring the Module	112
Connection Considerations	119
Conversion Clock	115
Conversion Time	117
Conversions	116
Converter Characteristics	170, 185, 213, 237, 261
Delays	114
Effects of a Reset	118
Equations	114
Faster Conversion - Lower Resolution Tradeoff	117
Flowchart of A/D Operation	119
GO/DONE bit	112
Internal Sampling Switch (Rss) Impedance	114
Operation During Sleep	118
Sampling Requirements	114
Sampling Time	114
Source Impedance	114
Time Delays	114
Transfer Function	119
Using the CCP Trigger	118
Absolute Maximum Ratings	159, 175, 197, 219, 243
ACK	84, 88, 89
ADCS0 bit	109
ADCS1 bit	109
ADDLW Instruction	143
ADDWF Instruction	143
ADIE bit	32, 34
ADIF bit	36, 109
ADON bit	109
ADRES Register	26, 28, 109, 112
ALU	9
ANDLW Instruction	143
ANDWF Instruction	143
Application Notes	
AN546	109
AN552	45
AN556	41
AN578	77
AN594	71
Architecture	
Harvard	9
Overview	9
von Neumann	9
Assembler	156
B	
Baud Rate Error	95
Baud Rate Formula	95
Baud Rates	96, 97
BCF Instruction	144
BF bit	77, 88, 89

Block Diagrams

A/D	113
Analog Input Model	114
Capture	73
Compare	73
Interrupt Logic	134
On-Chip Reset Circuit	126
PIC16C70	10
PIC16C71	10
PIC16C71A	10
PIC16C72	11
PIC16C73	12
PIC16C73A	12
PIC16C74	13
PIC16C74A	13
PORTC	47
PORTD (In I/O Port Mode)	49
PORTD and PORTE as a Parallel Slave Port	54
PORTE (In I/O Port Mode)	52
PWM	74
RA3:RA0 and RA5 Port Pins	43
RA4/T0CKI Pin	44
RB3:RB0 Port Pins	45
RB7:RB4 Port Pins	45
SPI Master/Slave Connection	80
SSP (I ² C Mode)	87
SSP (SPI Mode)	79
Timer0	59
Timer0/WDT Prescaler	62
Timer1	66
Timer2	69
USART Receive	101
USART Transmit	99
Watchdog Timer	137
BODEN bit	122
BOR bit	40, 128
BRGH bit	93, 95
BSF Instruction	144
BTFSC Instruction	144
BTFSS Instruction	145

C

C bit	30
C Compiler (MP-C)	153, 157
CALL Instruction	145
Capture/Compare/PWM	
Capture	
Block Diagram	73
CCP1CON Register	72
CCP1IF	72
CCPR1	72
CCPR1H:CCPR1L	72
Mode	72
Prescaler	73
CCP Timer Resources	71
Compare	
Block Diagram	73
Mode	73
Software Interrupt Mode	73
Special Event Trigger	73
Special Trigger Output of CCP1	73
Special Trigger Output of CCP2	73
Interaction of Two CCP Modules	71

PIC16C7X

PWM	
Block Diagram	74
CCP1CON	74
Duty Cycle	74
Example Frequencies and Resolutions	74
Mode	74
Period	74
Section	71
Special Event Trigger and A/D Conversions	73
Carry bit	9
CCP1IE bit	34
CCP1IF bit	36, 37
CCP2IE bit	38
CCP2IF bit	39
CCPR1H Register	28, 71
CCPR1L Register	71
CCPR2H Register	28, 71
CCPR2L Register	28, 71
CCPxM0 bit	72
CCPxM1 bit	72
CCPxM2 bit	72
CCPxM3 bit	72
CCPxX bit	72
CCPxY bit	72
CHS0 bit	109
CHS1 bit	109
CKP bit	78
Clocking Scheme	20
CLRF Instruction	145
CLRW Instruction	145
CLRWDI Instruction	146
Code Examples	
Call of a Subroutine in Page 1 from Page 0	42
Changing Between Capture Prescalers	73
Changing Prescaler (Timer0 to WDT)	63
Changing Prescaler (WDT to Timer0)	63
Doing an A/D Conversion	116
I/O Programming	53
Indirect Addressing	42
Initializing PORTA	43
Initializing PORTB	45
Initializing PORTC	47
Loading the SSPBUF Register	79
Saving W register and STATUS in RAM	136
Code Protection	121, 139
COMF Instruction	146
Computed GOTO	41
Configuration Bits	121
Configuration Word	122
CP0 bit	122
CP1 bit	122
CREN bit	94
\overline{CS} pin	54
CSRC bit	93
D	
D/ \overline{A} bit	77
DC bit	30
DC Characteristics	
PIC16C70	161
PIC16C71	176
PIC16C71A	161
PIC16C72	199
PIC16C73	221
PIC16C73A	245
PIC16C74	221
PIC16C74A	245

DECF Instruction	146
DECFSZ Instruction	146
Development Support	5, 153
Development Systems	157
Development Tools	153
Diagrams - See Block Diagrams	
Digit Carry bit	9
Direct Addressing	42
Dynamic Data Exchange (DDE)	153

E

Electrical Characteristics	
PIC16C70	159
PIC16C71	175
PIC16C71A	159
PIC16C72	197
PIC16C73	219
PIC16C73A	243
PIC16C74	219
PIC16C74A	243
External Brown-out Protection Circuit	132
External Power-on Reset Circuit	132

F

Family of Devices	
PIC16C5X	285
PIC16C62X	286
PIC16C6X	287
PIC16C7X	6, 288
PIC16C8X	289
PIC17CXX	290
FERR bit	94
FOSC0 bit	122
FOSC1 bit	122
FSR Register	26, 27, 28, 29, 42
Fuzzy Logic Dev. System (<i>fuzzyTECH</i> ®-MP)	153, 157

G

General Description	5
GIE bit	32, 133
GO/DONE bit	109
GOTO Instruction	147
Graphs and Charts, PIC16C71	189

I

I/O Ports	
PORTA	43
PORTB	45
PORTC	47
PORTD	49, 54
PORTE	51
Section	43
I/O Programming Considerations	53
I ² C, See Synchronous Serial Port	
IBF bit	54
IDLE_MODE	92
INCF Instruction	147
INCFSZ Instruction	147
In-Circuit Serial Programming	121, 139
INDF Register	25-??, 25, 27, 28, 29, 42
Indirect Addressing	42
Initialization Condition for all Register	129
Instruction Cycle	20
Instruction Flow/Pipelining	20
Instruction Format	141

Instruction Set

ADDLW	143
ADDWF	143
ANDLW	143
ANDWF	143
BCF	144
BSF	144
BTFSC	144
BTFSS	145
CALL	145
CLRF	145
CLRW	145
CLRWDT	146
COMF	146
DECF	146
DECFSZ	146
GOTO	147
INCF	147
INCFSZ	147
IORLW	147
IORWF	148
MOVF	148
MOVLW	148
MOVWF	148
NOP	149
OPTION	149
RETFIE	149
RETLW	149
RETURN	150
RLF	150
RRF	150
SLEEP	150
SUBLW	151
SUBWF	151
SWAPF	152
TRIS	152
XORLW	152
XORWF	152
Section	141
Summary Table	142
INT Interrupt	136
INTCON Register	32
INTE bit	32
INTEDG bit	31, 136
Inter-Integrated Circuit (I ² C)	77
Internal Sampling Switch (Rss) Impedance	114
Interrupts	121
A/D	133
CCP1	133
CCP2	133
PortB Change	136
PSP	133
RB7:RB4 Port Change	45
Section	133
SSP	133
TMR0	136
TMR1 Overflow	133
TMR2 Matches PR2	133
USART RX	133
USART TX	133
INTF bit	32
IORLW Instruction	147
IORWF Instruction	148
IRP bit	30

L

Loading of PC	41
---------------------	----

M

MCLR	126, 129
Memory	
Data Memory	22
Program Memory	21
Program Memory Maps	
PIC16C70	21
PIC16C71	21
PIC16C71A	21
PIC16C72	22
PIC16C73	22
PIC16C73A	22
PIC16C74	22
PIC16C74A	22
Register File Maps	
PIC16C70	23
PIC16C71	23
PIC16C71A	23
PIC16C72	24
PIC16C73	24
PIC16C73A	24
PIC16C74	24
PIC16C74A	24
MOVF Instruction	148
MOVLW Instruction	148
MOVWF Instruction	148
MPASM Assembler	153, 156
MP-C C Compiler	157
MPSIM Software Simulator	153, 157

N

NOP Instruction	149
-----------------------	-----

O

OBF bit	54
OERR bit	94
Opcode	141
OPTION Instruction	149
OPTION Register	31
Orthogonal	9
OSC selection	121
Oscillator	
HS	123, 128
LP	123, 128
RC	123
XT	123, 128
Oscillator Configurations	123
Output of TMR2	69

P

P bit	77
Packaging	
18-Lead CERDIP w/Window	267
18-Lead PDIP	270
18-Lead SOIC	273
20-Lead SSOP	275
28-Lead Ceramic w/Window	268
28-Lead PDIP	271
28-Lead SOIC	274
28-Lead SSOP	276
40-Lead CERDIP w/Window	269
40-Lead PDIP	272
44-Lead MQFP	278
44-Lead PLCC	277
44-Lead TQFP	279
Paging, Program Memory	41

PIC16C7X

Parallel Slave Port	49, 54	PIC16C73A	17
PCFG0 bit	111	PIC16C74	18
PCFG1 bit	111	PIC16C74A	18
PCFG2 bit	111	PIR1 Register	36
PCL Register	25, 26, 27, 28, 29, 41	PIR2 Register	39
PCLATH	129	POP	41
PCLATH Register	25, 26, 27, 28, 29, 41	POR	127, 128
PCON Register	40, 128	Oscillator Start-up Timer (OST)	121, 127
PD bit	30, 126, 128	Power Control Register (PCON)	128
PICDEM-1 Low-Cost PIC16/17 Demo Board	153, 155	Power-on Reset (POR)	121, 127, 129
PICDEM-2 Low-Cost PIC16CXX Demo Board	153, 155	Power-up Timer (PWRT)	121, 127
PICMASTER Probes	154	Power-Up-Timer (PWRT)	127
PICMASTER System Configuration	153	Time-out Sequence	128
PICMASTER™ RT In-Circuit Emulator	153	Time-out Sequence on Power-up	131
PICSTART™ Low-Cost Development System	153, 155	TO	126, 128
PIE1 Register	34	POR bit	40, 128
PIE2 Register	38	Port RB Interrupt	136
Pin Compatible Devices	291	PORTA	129
Pin Functions		PORTA Register	25, 26, 28, 43
MCLR/VPP	14, 15, 16, 17, 18	PORTB	129
OSC1/CLKIN	14, 15, 16, 17, 18	PORTB Register	25, 26, 28, 45
OSC2/CLKOUT	14, 15, 16, 17, 18	PORTC	129
RA0/AN0	14, 15, 16, 17, 18	PORTC Register	26, 28, 47
RA1/AN1	14, 15, 16, 17, 18	PORTD	129
RA2/AN2	14, 15, 16, 17, 18	PORTD Register	28, 49
RA3/AN3/VREF	14, 15, 16, 17, 18	PORTE	129
RA4/T0CKI	14, 15, 16, 17, 18	PORTE Register	28, 51
RA5/AN4/SS	16, 17, 18	Power-down Mode (SLEEP)	138
RB0/INT	14, 15, 16, 17, 18	PR2 Register	29, 69
RB1	14, 15, 16, 17, 18	Prescaler, Switching Between Timer0 and WDT	63
RB2	14, 15, 16, 17, 18	PRO MATE™ Universal Programmer	153, 155
RB3	14, 15, 16, 17, 18	Probes	154
RB4	14, 15, 16, 17, 18	Program Branches	9
RB5	14, 15, 16, 17, 18	Program Memory	
RB6	14, 15, 16, 17, 18	Paging	41
RB7	14, 15, 16, 17, 18	Program Memory Maps	
RC0/T1OSO/T1CKI	16, 17, 19	PIC16C70	21
RC1/T1OSI	16	PIC16C71	21
RC1/T1OSI/CCP2	17, 19	PIC16C71A	21
RC2/CCP1	16, 17, 19	PIC16C72	22
RC3/SCK/SCL	16, 17, 19	PIC16C73	22
RC4/SDI/SDA	16, 17, 19	PIC16C73A	22
RC5/SDO	16, 17, 19	PIC16C74	22
RC6	16	PIC16C74A	22
RC6/TX/CK	17, 19, 93–107	Program Verification	139
RC7	16	PS0 bit	31
RC7/RX/DT	17, 19, 93–107	PS1 bit	31
RD0/PSP0	19	PS2 bit	31
RD1/PSP1	19	PSA bit	31
RD2/PSP2	19	PSPIE bit	35, 54
RD3/PSP3	19	PSPIF bit	37, 54
RD4/PSP4	19	PSPMODE bit	49, 51, 54
RD5/PSP5	19	PUSH	41
RD6/PSP6	19	PWRT bit	122
RD7/PSP7	19		
RE0/RD/AN5	19	R	
RE1/WR/AN6	19	R/W bit	84, 88, 89, 90
RE2/CS/AN7	19	R/W bit	77
VDD	14, 15, 16, 17, 19	RBIE bit	32
VSS	14, 15, 16, 17, 19	RBIF bit	32, 45, 136
Pinout Descriptions		RBPU bit	31
PIC16C70	14, 15	RC Oscillator	125, 128
PIC16C71	14, 15	RCIE bit	35
PIC16C71A	14, 15	RCIF bit	37
PIC16C72	16	RCSTA Register	94
PIC16C73	17	RCV_MODE	92

\overline{RD} pin	54
Read-Modify-Write	53
Register File	22
Registers	
Initialization Conditions	129
Maps	
PIC16C70	23
PIC16C71	23
PIC16C71A	23
PIC16C72	24
PIC16C73	24
PIC16C73A	24
PIC16C74	24
PIC16C74A	24
Reset Conditions	129
Summary	25–28
Reset	121, 126
Reset Conditions for Special Registers	129
RETFIE Instruction	149
RETLW Instruction	149
RETURN Instruction	150
RLF Instruction	150
RP0 bit	22, 30
RP1 bit	30
RRF Instruction	150
RX9 bit	94
RX9D bit	94
S	
S bit	77
SCL	88, 91
SDA	90, 91
Serial Communication Interface (SCI) Module, See USART	
Serial Peripheral Interface (SPI)	77
Services	
One-Time-Programmable (OTP)	7
Quick-Turnaround-Production (QTP)	7
Serialized Quick-Turnaround Production (SQTP)	7
SLEEP	121, 126
SLEEP Instruction	150
Software Simulator (MPSIM)	157
SPBRG Register	29
Special Event Trigger	118
Special Features of the CPU	121
Special Function Registers	
PIC16C70	25
PIC16C71	25
PIC16C71A	25
PIC16C72	26
PIC16C73	28
PIC16C73A	28
PIC16C74	28
PIC16C74A	28
Special Function Registers, Section	25
SPEN bit	94
SPI, See Synchronous Serial Port	
SREN bit	94
\overline{SS} bit	81
SSPADD Register	27, 29, 88
SSPBUF Register	28, 88
SSPCON Register	28, 78, 89
SSPEN bit	78
SSPIE bit	34
SSPIF bit	36, 37, 88, 89
SSPM0 bit	78
SSPM1 bit	78

SSPM2 bit	78
SSPM3 bit	78
SSPOV bit	78, 88
SSPSR Register	88
SSPSTAT Register	27, 29, 77, 89
Stack	41
Overflows	41
Underflow	41
STATUS Register	30
SUBLW Instruction	151
SUBWF Instruction	151
SWAPF Instruction	152
SYNC bit	93
Synchronous Serial Port	
I ² C	
Addressing	88
Addressing I ² C Devices	84
Arbitration	86
Block Diagram	87
Clock Synchronization	86
Combined Format	85
I ² C Operation	87
I ² C Overview	83
Initiating and Terminating Data Transfer	83
Master-Receiver Sequence	85
Master-Transmitter Sequence	85
Multi-master	86
Multi-master Mode	91
Reception	89
Slave Mode	88
START	83, 90
START (S)	91
STOP	83, 84
STOP (P)	91
Transfer Acknowledge	84
Transmission	90
SPI	
Block Diagram	79
Block Diagram of Master/Slave Connection	80
Master Mode	80
Serial Clock	79
Serial Data In	79
Serial Data Out	79
Slave Select	79
SPI Clock	80
SPI Mode	79
SSPBUF Register	80
SSPSR Register	80
Synchronous Serial Port Module	77
T	
T0CS bit	31
T0IE bit	32
T0IF bit	32
T1CKPS0 bit	65
T1CKPS1 bit	65
T1CON Register	65
T1OSCEN bit	65
T1SYNC bit	65
T2CKPS0 bit	70
T2CKPS1 bit	70
T2CON Register	70
TAD	115
Timer Modules, Overview	57
Timer0	
RTCC	129

PIC16C7X

Timers

Timer0

Block Diagram	59
External Clock	61
External Clock Timing	61
Increment Delay	61
Interrupt	59
Interrupt Timing	60
Overview	57
Prescaler	62
Prescaler Block Diagram	62
Section	59
Switching Prescaler Assignment	63
Synchronization	61
T0CKI	61
T0IF	136
Timing	59
TMR0 Interrupt	136

Timer1

Asynchronous Counter Mode	67
Block Diagram	66
Capacitor Selection	67
External Clock Input	66
External Clock Input Timing	67
Operation in Timer Mode	66
Oscillator	67
Overview	57
Prescaler	66, 68
Resetting of Timer1 Registers	68
Resetting Timer1 using a CCP Trigger Output ..	68
Synchronized Counter Mode	66
T1CON	65
TMR1H	67
TMR1L	67

Timer2

Block Diagram	69
Module	69
Overview	57
Postscaler	69
Prescaler	69
T2CON	70

Timing Diagrams

A/D Conversion	172, 187, 215, 239, 263
Brown-out Reset	127, 168, 206, 253
Capture/Compare/PWM	208, 231, 255
CLKOUT and I/O	167, 182, 205, 228, 252
External Clock Timing	166, 181, 204, 226, 250
I ² C Bus Data	211, 235, 259
I ² C Bus Start/Stop bits	210, 234, 258
I ² C Clock Synchronization	86
I ² C Data Transfer Wait State	84
I ² C Multi-Master Arbitration	86
I ² C Reception	89
I ² C Transmission	90
Parallel Slave Port	232, 256
Power-up Timer	168, 183, 206, 229, 253
Reset	168, 183, 206, 229, 253
SPI Mode	209, 233, 257
SPI Mode Timing (No \overline{SS} Control)	81
SPI Mode Timing (\overline{SS} Control)	81
Start-up Timer	168, 183, 206, 229, 253
Time-out Sequence	131
Timer0	59, 169, 184, 207, 230, 254
Timer0 Interrupt Timing	60
Timer0 with External Clock	61
Timer1	207, 230, 254

USART Asynchronous Master Transmission	100
USART Asynchronous Reception	101
USART RX Pin Sampling	98
USART Synchronous Receive	236, 260
USART Synchronous Reception	106
USART Synchronous Transmission	104, 236, 260
Wake-up from Sleep via Interrupt	138
Watchdog Timer	168, 183, 206, 229, 253
TMR0 Register	28
TMR1CS bit	65
TMR1H Register	26, 28
TMR1IE bit	34
TMR1IF bit	36, 37
TMR1L Register	26, 28
TMR1ON bit	65
TMR2 Register	26, 28
TMR2IE bit	34
TMR2IF bit	36, 37
TMR2ON bit	70
\overline{TO} bit	30
TOUTPS0 bit	70
TOUTPS1 bit	70
TOUTPS2 bit	70
TOUTPS3 bit	70
TRIS Instruction	152
TRISA Register	25, 27, 29, 43
TRISB Register	25, 27, 29, 45
TRISC Register	27, 29, 47
TRISD Register	25, 29, 49
TRISE Register	29, 51
TRMT bit	93
Two's Complement	9
TX9 bit	93
TX9D bit	93
TXEN bit	93
TXIE bit	35
TXIF bit	37
TXSTA Register	93

U

UA bit	77
Universal Synchronous Asynchronous Receiver Transmitter (USART)	93
USART	

Asynchronous Mode	99
Asynchronous Receiver	101
Asynchronous Reception	102
Asynchronous Transmission	100
Asynchronous Transmitter	99
Baud Rate Generator (BRG)	95
Receive Block Diagram	101
Sampling	98
Synchronous Master Mode	103
Synchronous Master Reception	105
Synchronous Master Transmission	103
Synchronous Slave Mode	107
Synchronous Slave Reception	107
Synchronous Slave Transmit	107
Transmit Block Diagram	99

UV Erasable Devices	7
---------------------------	---

W

W Register	
ALU	9
Wake-up from SLEEP	138
Watchdog Timer (WDT)	121, 126, 129, 137
WCOL bit	78

WDT	129
Block Diagram	137
Period	137
Programming Considerations	137
Timeout	129
WDTE bit	122
Word	122
WR pin	54

X

XMIT_MODE	92
XORLW Instruction	152
XORWF Instruction	152

Z

Z bit	30
Zero bit	9

LIST OF EXAMPLES

Example 3-1: Instruction Pipeline Flow.....	20
Example 4-1: Call of a Subroutine in Page 1 from Page 0	42
Example 4-2: Indirect Addressing.....	42
Example 5-1: Initializing PORTA	43
Example 5-2: Initializing PORTB	45
Example 5-3: Initializing PORTC	47
Example 5-4: Read-Modify-Write Instructions on an I/O Port	53
Example 7-1: Changing Prescaler (Timer0→WDT).....	63
Example 7-2: Changing Prescaler (WDT→Timer0).....	63
Example 8-1: Reading a 16-bit Free-Running Timer.....	67
Example 10-1: Changing Between Capture Prescalers ...	73
Example 11-1: Loading the SSPBUF (SSPSR) Register	79
Example 12-1: Calculating Baud Rate Error.....	95
Equation 13-1: A/D Minimum Charging Time	114
Example 13-1: Calculating the Minimum Required Sample Time	114
Example 13-2: Doing an A/D Conversion (PIC16C70/71/71A)	116
Example 13-3: Doing an A/D Conversion (PIC16C72/73/73A/74/74A).....	116
Example 13-4: 4-bit vs. 8-bit Conversion Times	117
Example 14-1: Saving STATUS and W Registers in RAM (PIC16C70/71/71A)	136
Example 14-2: Saving STATUS and W Registers in RAM (PIC16C72/73/73A/74/74A).....	136

LIST OF FIGURES

Figure 3-1: PIC16C70/71/71A Block Diagram.....	10
Figure 3-2: PIC16C72 Block Diagram	11
Figure 3-3: PIC16C73/73A Block Diagram.....	12
Figure 3-4: PIC16C74/74A Block Diagram.....	13
Figure 3-5: Clock/Instruction Cycle.....	20
Figure 4-1: PIC16C70 Program Memory Map and Stack	21
Figure 4-2: PIC16C71/71A Program Memory Map and Stack	21
Figure 4-3: PIC16C72 Program Memory Map and Stack	22
Figure 4-4: PIC16C73/73A/74/74A Program Memory Map and Stack	22
Figure 4-5: PIC16C70/71 Register File Map	23
Figure 4-6: PIC16C71A Register File Map	23
Figure 4-7: PIC16C72 Register File Map	24
Figure 4-8: PIC16C73/73A/74/74A Register File Map	24

Figure 4-9: Status Register (Address 03h, 83h).....	30
Figure 4-10: OPTION Register (Address 81h)	31
Figure 4-11: INTCON Register for PIC16C70/71/71A (Address 0Bh, 8Bh)	32
Figure 4-12: INTCON Register for PIC16C72/73/ 73A/74/74A (Address 0Bh, 8Bh).....	33
Figure 4-13: PIE1 Register PIC16C72 (Address 8Ch)...	34
Figure 4-14: PIE1 Register PIC16C73/73A/74/74A (Address 8Ch).....	35
Figure 4-15: PIR1 Register PIC16C72 (Address 0Ch)...	36
Figure 4-16: PIR1 Register PIC16C73/73A/74/74A (Address 0Ch).....	37
Figure 4-17: PIE2 Register (Address 8Dh)	38
Figure 4-18: PIR2 Register (Address 0Dh)	39
Figure 4-19: PCON Register (Address 8Eh)	40
Figure 4-20: Loading of PC In Different Situations.....	41
Figure 4-21: Direct/Indirect Addressing.....	42
Figure 5-1: Block Diagram of RA3:RA0 and RA5 Pins	43
Figure 5-2: Block Diagram of RA4/T0CKI Pin	44
Figure 5-3: Block Diagram of RB3:RB0 Pins	45
Figure 5-4: Block Diagram of RB7:RB4 Pins	45
Figure 5-5: PORTC Block Diagram (Peripheral Output Override).....	47
Figure 5-6: PORTD Block Diagram (in I/O Port Mode)	49
Figure 5-7: TRISE Register (Address 89h)	51
Figure 5-8: PORTE Block Diagram (in I/O Port Mode)	52
Figure 5-9: Successive I/O Operation	53
Figure 5-10: PORTD and PORTE Block Diagram (Parallel Slave Port).....	54
Figure 7-1: Timer0 Block Diagram	59
Figure 7-2: Timer0 Timing: Internal Clock/No Prescale.....	59
Figure 7-3: Timer0 Timing: Internal Clock/ Prescale 1:2.....	60
Figure 7-4: Timer0 Interrupt Timing	60
Figure 7-5: Timer0 Timing with External Clock	61
Figure 7-6: Block Diagram of the Timer0/WDT Prescaler.....	62
Figure 8-1: T1CON: Timer1 Control Register (Address 10h)	65
Figure 8-2: Timer1 Block Diagram	66
Figure 9-1: Timer2 Block Diagram	69
Figure 9-2: T2CON: Timer2 Control Register (Address 12h)	70
Figure 10-1: CCP1CON Register (Address 17h)/ CCP2CON Register (Address 1Dh).....	72
Figure 10-2: Capture Mode Operation Block Diagram...	73
Figure 10-3: Compare Mode Operation Block Diagram.	73
Figure 10-4: Simplified PWM Block Diagram	74
Figure 11-1: SSPSTAT: Sync Serial Port Status Register (Address 94h)	77
Figure 11-2: SSPCON: Sync Serial Port Control Register (Address 14h)	78
Figure 11-3: SSP Block Diagram (SPI Mode).....	79
Figure 11-4: SPI Master/Slave Connection.....	80
Figure 11-5: SPI Mode Timing (Master Mode or Slave Mode w/o \overline{SS} Control).....	81
Figure 11-6: SPI Mode Timing (Slave Mode with \overline{SS} Control)	81
Figure 11-7: Start and Stop Conditions.....	83
Figure 11-8: 7-bit Address Format	84
Figure 11-9: I ² C 10-bit Address Format.....	84
Figure 11-10: Slave-Receiver Acknowledge	84
Figure 11-11: Data Transfer Wait State	84
Figure 11-12: Master-transmitter Sequence	85
Figure 11-13: Master-receiver Sequence.....	85

PIC16C7X

Figure 11-14:	Combined Format	85	Figure 14-16:	External Brown-out Protection Circuit 1..	132
Figure 11-15:	Multi-master Arbitration (Two Masters)	86	Figure 14-17:	External Brown-out Protection Circuit 2..	132
Figure 11-16:	Clock Synchronization.....	86	Figure 14-18:	Interrupt Logic for PIC16C70/71/71A.....	134
Figure 11-17:	SSP Block Diagram (I ² C Mode)	87	Figure 14-19:	Interrupt Logic for PIC16C72	134
Figure 11-18:	I ² C Waveforms for Reception (7-bit Address).....	89	Figure 14-20:	Interrupt Logic for PIC16C73/73A.....	134
Figure 11-19:	I ² C Waveforms for Transmission (7-bit Address).....	90	Figure 14-21:	Interrupt Logic for PIC16C74/74A.....	135
Figure 11-20:	Operation of the I2C Module in IDLE_MODE, RCV_MODE or XMIT_MODE	92	Figure 14-22:	INT Pin Interrupt Timing.....	135
Figure 12-1:	TXSTA: Transmit Status and Control Register (Address 98h)	93	Figure 14-23:	Watchdog Timer Block Diagram	137
Figure 12-2:	RCSTA: Receive Status and Control Register (Address 18h).....	94	Figure 14-24:	Summary of Watchdog Timer Registers ..	137
Figure 12-3:	RX Pin Sampling Scheme (BRGH = 0)	98	Figure 14-25:	Wake-up from Sleep Through Interrupt ..	138
Figure 12-4:	RX Pin Sampling Scheme (BRGH = 1)	98	Figure 14-26:	Typical In-Circuit Serial Programming Connection.....	139
Figure 12-5:	RX Pin Sampling Scheme (BRGH = 1)	98	Figure 15-1:	General Format for Instructions	141
Figure 12-6:	USART Transmit Block Diagram.....	99	Figure 16-1:	PICMASTER System Configuration	153
Figure 12-7:	Asynchronous Master Transmission	100	Figure 17-1:	Load Conditions.....	165
Figure 12-8:	Asynchronous Master Transmission (Back to Back)	100	Figure 17-2:	External Clock Timing	166
Figure 12-9:	USART Receive Block Diagram.....	101	Figure 17-3:	CLKOUT and I/O Timing.....	167
Figure 12-10:	Asynchronous Reception	101	Figure 17-4:	Reset, Watchdog Timer, Oscillator Start-up Timer and Power-up Timer Timing	168
Figure 12-11:	Synchronous Transmission	104	Figure 17-5:	Brown-out Reset Timing	168
Figure 12-12:	Synchronous Transmission (Through TXEN)	104	Figure 17-6:	Timer0 Clock Timings	169
Figure 12-13:	Synchronous Reception (Master Mode, SREN)	106	Figure 17-7:	A/D Conversion Timing	172
Figure 13-1:	ADCON0 Register, PIC16C70/71/71A (Address 08h).....	109	Figure 19-1:	Load Conditions.....	180
Figure 13-2:	ADCON0 Register, PIC16C72/73/73A/74/ 74A (Address 1Fh)	110	Figure 19-2:	External Clock Timing	181
Figure 13-3:	ADCON1 Register for PIC16C70/71/71A (Address 88h).....	110	Figure 19-3:	CLKOUT and I/O Timing.....	182
Figure 13-4:	ADCON1 Register, PIC16C72/73/73A/74/ 74A (Address 9Fh)	111	Figure 19-4:	Reset, Watchdog Timer, Oscillator Start-up Timer and Power-up Timer Timing	183
Figure 13-5:	A/D Block Diagram, PIC16C70/71/71A ...	112	Figure 19-5:	Timer0 Clock Timings	184
Figure 13-6:	A/D Block Diagram, PIC16C72/73/73A/74/ 74A	113	Figure 19-6:	A/D Conversion Timing	187
Figure 13-7:	Analog Input Model	114	Figure 20-1:	Typical RC Oscillator Frequency vs. Temperature	189
Figure 13-8:	A/D Transfer Function	119	Figure 20-2:	Typical RC Oscillator Frequency vs. VDD	189
Figure 13-9:	Flowchart of A/D Operation.....	119	Figure 20-3:	Typical RC Oscillator Frequency vs. VDD	189
Figure 14-1:	Configuration Word for PIC16C71	121	Figure 20-4:	Typical RC Oscillator Frequency vs. VDD	190
Figure 14-2:	Configuration Word for PIC16C70/71A ...	122	Figure 20-5:	Typical Ipd vs. VDD Watchdog Timer Disabled 25°C.....	190
Figure 14-3:	Configuration Word for PIC16C73/74 ...	122	Figure 20-6:	Typical Ipd vs. VDD Watchdog Timer Enabled 25°C.....	190
Figure 14-4:	Configuration Word for PIC16C72/73A/ 74A	123	Figure 20-7:	Maximum Ipd vs. VDD Watchdog Disabled.....	191
Figure 14-5:	Crystal/Ceramic Resonator Operation (HS, XT or LP OSC Configuration)	123	Figure 20-8:	Maximum Ipd vs. VDD Watchdog Enabled.....	191
Figure 14-6:	External Clock Input Operation (HS, XT or LP OSC Configuration)	123	Figure 20-9:	Vth (Input Threshold Voltage) of I/O Pins vs. VDD	191
Figure 14-7:	External Parallel Resonant Crystal Oscillator Circuit	125	Figure 20-10:	VIH, VIL of MCLR, T0CKI and OSC1 (in RC Mode) vs. VDD	192
Figure 14-8:	External Series Resonant Crystal Oscillator Circuit	125	Figure 20-11:	VTH (Input Threshold Voltage) of OSC1 Input (in XT, HS, and LP Modes) vs. VDD.....	192
Figure 14-9:	RC Oscillator Mode	125	Figure 20-12:	Typical IDD vs. Freq (Ext Clock, 25°C)....	193
Figure 14-10:	Simplified Block Diagram of On-chip Reset Circuit	126	Figure 20-13:	Maximum, IDD vs. Freq (Ext Clock, -40° to +85°C)	193
Figure 14-11:	Brown-out Situations	127	Figure 20-14:	Maximum Idd vs. Freq with A/D Off (Ext Clock, -55° to +125°C)	194
Figure 14-12:	Time-out Sequence on Power-up (MCLR not Tied to VDD): Case 1.....	131	Figure 20-15:	WDT Timer Time-out Period vs. VDD.....	194
Figure 14-13:	Time-out Sequence on Power-up (MCLR Not Tied To VDD): Case 2	131	Figure 20-16:	Transconductance (gm) of HS Oscillator vs. VDD	194
Figure 14-14:	Time-out Sequence on Power-up (MCLR Tied to VDD)	131	Figure 20-17:	Transconductance (gm) of LP Oscillator vs. VDD	195
Figure 14-15:	External Power-on Reset Circuit (for Slow VDD Power-up)	132	Figure 20-18:	Transconductance (gm) of XT Oscillator vs. VDD	195
			Figure 20-19:	IOH vs. VOH, VDD = 3V	195
			Figure 20-20:	IOH vs. VOH, VDD = 5V	195
			Figure 20-21:	IOL vs. VOL, VDD = 3V	196
			Figure 20-22:	IOL vs. VOL, VDD = 5V	196

Figure 21-1:	Load Conditions	203
Figure 21-2:	External Clock Timing	204
Figure 21-3:	CLKOUT and I/O Timing	205
Figure 21-4:	Reset, Watchdog Timer, Oscillator Start-up Timer and Power-up Timer Timing.....	206
Figure 21-5:	Brown-out Reset Timing.....	206
Figure 21-6:	Timer0 and Timer1 Clock Timings	207
Figure 21-7:	Capture/Compare/PWM Timings (CCP1)	208
Figure 21-8:	SPI Mode Timing.....	209
Figure 21-9:	I ² C Bus Start/Stop Bits Timing	210
Figure 21-10:	I ² C Bus Data Timing	211
Figure 21-11:	A/D Conversion Timing	215
Figure 23-1:	Load Conditions	225
Figure 23-2:	External Clock Timing	226
Figure 23-3:	CLKOUT and I/O Timing	228
Figure 23-4:	Reset, Watchdog Timer, Oscillator Start-up Timer and Power-up Timer Timing.....	229
Figure 23-5:	Timer0 and Timer1 Clock Timings	230
Figure 23-6:	Capture/Compare/PWM Timings (CCP1 and CCP2)	231
Figure 23-7:	Parallel Slave Port Timing for the PIC16C74 Only	232
Figure 23-8:	SPI Mode Timing.....	233
Figure 23-9:	I ² C Bus Start/Stop Bits Timing	234
Figure 23-10:	I ² C Bus Data Timing	235
Figure 23-11:	USART Module: Synchronous Transmission (Master/Slave) Timing	236
Figure 23-12:	USART Module: Synchronous Receive (Master/Slave) Timing	236
Figure 23-13:	A/D Conversion Timing	239
Figure 25-1:	Load Conditions	249
Figure 25-2:	External Clock Timing	250
Figure 25-3:	CLKOUT and I/O Timing	252
Figure 25-4:	Reset, Watchdog Timer, Oscillator Start-up Timer and Power-up Timer Timing.....	253
Figure 25-5:	Brown-out Reset Timing.....	253
Figure 25-6:	Timer0 and Timer1 Clock Timings	254
Figure 25-7:	Capture/Compare/PWM Timings (CCP1 and CCP2)	255
Figure 25-8:	Parallel Slave Port Timing for the PIC16C74A Only	256
Figure 25-9:	SPI Mode Timing.....	257
Figure 25-10:	I ² C Bus Start/Stop Bits Timing	258
Figure 25-11:	I ² C Bus Data Timing	259
Figure 25-12:	USART Module: Synchronous Transmission (Master/Slave) Timing	260
Figure 25-13:	USART Module: Synchronous Receive (Master/Slave) Timing	260
Figure 25-14:	A/D Conversion Timing	263

LIST OF TABLES

Table 1-1:	PIC16C7X Family of Devices.....	6
Table 3-1:	PIC16C70/71A Pinout Description	14
Table 3-2:	PIC16C71 Pinout Description	15
Table 3-3:	PIC16C72 Pinout Description	16
Table 3-4:	PIC16C73/73A Pinout Description	17
Table 3-5:	PIC16C74/74A Pinout Description	18
Table 4-1:	PIC16C70/71/71A Special Function Register Summary.....	25
Table 4-2:	PIC16C72 Special Function Register Summary.....	26
Table 4-3:	PIC16C73/73A/74/74A Special Function Register Summary	28
Table 5-1:	PORTA Functions	44

Table 5-2:	Summary of Registers Associated with PORTA	44
Table 5-3:	PORTB Functions.....	46
Table 5-4:	Summary of Registers Associated with PORTB	46
Table 5-5:	PORTC Functions.....	48
Table 5-6:	Summary of Registers Associated with PORTC	48
Table 5-7:	PORTD Functions.....	49
Table 5-8:	Summary of Registers Associated with PORTD	50
Table 5-9:	PORTE Functions.....	52
Table 5-10:	Summary of Registers Associated with PORTE	52
Table 5-11:	Registers Associated with Parallel Slave Port	55
Table 7-1:	Registers Associated with Timer0, PIC16C70/71/71A.....	63
Table 7-2:	Registers Associated with Timer0, PIC16C72/73/73A/74/74A	63
Table 8-1:	Capacitor Selection for the Timer1 Oscillator.....	67
Table 8-2:	Registers Associated with Timer1 as a Timer/Counter.....	68
Table 9-1:	Registers Associated with Timer2 as a Timer/Counter.....	70
Table 10-1:	CCP Mode - Timer Resource	71
Table 10-2:	Interaction of Two CCP Modules	71
Table 10-3:	PWM Frequency vs. Resolution at 20 MHz	74
Table 10-4:	Example PWM Frequencies and Resolutions at 20 MHz	74
Table 10-5:	Registers Associated with Capture and Timer1.....	75
Table 10-6:	Registers Associated with Compare and Timer1.....	75
Table 10-7:	Registers Associated with PWM and Timer2.....	76
Table 11-1:	Registers Associated with SPI Operation ..	82
Table 11-2:	I ² C Bus Terminology.....	83
Table 11-3:	Data Transfer Received Byte Actions.....	88
Table 11-4:	Registers Associated with I ² C Operation...	91
Table 12-1:	Baud Rate Formula.....	95
Table 12-2:	Registers Associated with Baud Rate Generator.....	95
Table 12-3:	Baud Rates for Synchronous Mode.....	96
Table 12-4:	Baud Rates for Asynchronous Mode (BRGH = 0)	96
Table 12-5:	Baud Rates for Asynchronous Mode (BRGH = 1)	97
Table 12-6:	Registers Associated with Asynchronous Transmission	100
Table 12-7:	Registers Associated with Asynchronous Reception.....	102
Table 12-8:	Registers Associated with Synchronous Master Transmission	104
Table 12-9:	Registers Associated with Synchronous Master Reception.....	105
Table 12-10:	Registers Associated with Synchronous Slave Transmission	108
Table 12-11:	Registers Associated with Synchronous Slave Reception.....	108
Table 13-1:	TAD vs. Device Operating Frequencies, PIC16C71	115
Table 13-2:	TAD vs. Device Operating Frequencies, PIC16C70/71A/72/73/73A/74/74A	115

PIC16C7X

Table 13-3:	Summary of A/D Registers, PIC16C70/71/71A.....	120	Table 19-7:	A/D Converter Characteristics: PIC16LC71-04 (Commercial, Industrial)	186
Table 13-4:	Summary of A/D Registers, PIC16C72 ...	120	Table 19-8:	A/D Conversion Requirements	187
Table 13-5:	Summary of A/D Registers, PIC16C73/73A/74/74A	120	Table 20-1:	RC Oscillator Frequencies	190
Table 14-1:	Ceramic Resonators PIC16C71	124	Table 20-2:	Input Capacitance*	196
Table 14-2:	Capacitor Selection for Crystal Oscillator for PIC16C71	124	Table 21-1:	Cross Reference of Device Specs for Oscillator Configurations and Frequencies of Operation (Commercial Devices)	198
Table 14-3:	Ceramic Resonators PIC16C70/71A/72/73/73A/74/74A	124	Table 21-2:	Clock Timing Requirements	204
Table 14-4:	Capacitor Selection for Crystal Oscillator for PIC16C70/71A/72/73/73A/74/74A	124	Table 21-3:	CLKOUT and I/O Timing Requirements	205
Table 14-5:	Time-out in Various Situations, PIC16C71/73/74	128	Table 21-4:	Reset, Watchdog Timer, Oscillator Start-up Timer and Power-up Timer Requirements	206
Table 14-6:	Time-out in Various Situations, PIC16C70/71A/72/73A/74A	128	Table 21-5:	Timer0 and Timer1 Clock Requirements	207
Table 14-7:	Status Bits and Their Significance, PIC16C71/73/74	128	Table 21-6:	Capture/Compare/PWM Requirements (CCP1)	208
Table 14-8:	Status Bits and Their Significance, PIC16C70/71A/72/73A/74A	128	Table 21-7:	SPI Mode Requirements	209
Table 14-9:	Reset Condition for Special Registers	129	Table 21-8:	I ² C Bus Start/Stop Bits Requirements	210
Table 14-10:	Initialization Conditions for all Registers ..	129	Table 21-9:	I ² C Bus Data Requirements	211
Table 15-1:	Opcode Field Descriptions	141	Table 21-10:	Serial Port Synchronous Transmission Requirements	212
Table 15-2:	PIC16CXX Instruction Set	142	Table 21-11:	Serial Port Synchronous Receive Requirements	212
Table 16-1:	PICMASTER Probe Specification	154	Table 21-12:	A/D Converter Characteristics: PIC16C72-04 (Commercial, Industrial, Automotive)	213
Table 16-2:	Development System Packages	157		PIC16C72-10 (Commercial, Industrial, Automotive)	213
Table 17-1:	Cross Reference of Device Specs for Oscillator Configurations and Frequencies of Operation (Commercial Devices)	160		PIC16C72-20 (Commercial, Industrial, Automotive)	213
Table 17-2:	Clock Timing Requirements	166	Table 21-13:	A/D Converter Characteristics: PIC16LC72-04 (Commercial, Industrial, Automotive)	214
Table 17-3:	CLKOUT and I/O Timing Requirements ..	167	Table 21-14:	A/D Conversion Requirements	215
Table 17-4:	Reset, Watchdog Timer, Oscillator Start-up Timer and Power-up Timer Requirements	168	Table 23-1:	Cross Reference of Device Specs for Oscillator Configurations and Frequencies of Operation (Commercial Devices)	220
Table 17-5:	Timer0 Clock Requirements	169	Table 23-2:	Clock Timing Requirements	226
Table 17-6:	A/D Converter Characteristics: PIC16C70-04 (Commercial, Industrial, Automotive)	170	Table 23-3:	CLKOUT and I/O Timing Requirements ..	228
	PIC16C71A-04 (Commercial, Industrial, Automotive)	170	Table 23-4:	Reset, Watchdog Timer, Oscillator Start-up Timer and Power-up Timer Requirements	229
	PIC16C70-10 (Commercial, Industrial, Automotive)	170	Table 23-5:	Timer0 and Timer1 Clock Requirements	230
	PIC16C71A-10 (Commercial, Industrial, Automotive)	170	Table 23-6:	Capture/Compare/PWM Requirements (CCP1 and CCP2)	231
	PIC16C70-20 (Commercial, Industrial, Automotive)	170	Table 23-7:	Parallel Slave Port Requirements for the PIC16C74 Only	232
	PIC16C71A-20 (Commercial, Industrial, Automotive)	170	Table 23-8:	SPI Mode Requirements	233
Table 17-7:	A/D Converter Characteristics: PIC16LC70-04 (Commercial, Industrial, Automotive)	171	Table 23-9:	I ² C Bus Start/Stop Bits Requirements	234
	PIC16LC71A-04 (Commercial, Industrial, Automotive)	171	Table 23-10:	I ² C Bus Data Requirements	235
Table 17-8:	A/D Conversion Requirements	172	Table 23-11:	Serial Port Synchronous Transmission Requirements	236
Table 19-1:	Cross Reference of Device Specs for Oscillator Configurations and Frequencies of Operation (Commercial Devices)	175	Table 23-12:	Serial Port Synchronous Receive Requirements	236
Table 19-2:	External Clock Timing Requirements	181	Table 23-13:	A/D Converter Characteristics: PIC16C73-04 (Commercial, Industrial)	237
Table 19-3:	CLKOUT and I/O Timing Requirements ..	182		PIC16C74-04 (Commercial, Industrial)	237
Table 19-4:	Reset, Watchdog Timer, Oscillator Start-up Timer and Power-up Timer Requirements	183		PIC16C73-10 (Commercial, Industrial)	237
Table 19-5:	Timer0 Clock Requirements	184		PIC16C74-10 (Commercial, Industrial)	237
Table 19-6:	A/D Converter Characteristics: PIC16C71-04 (Commercial, Industrial)	185		PIC16C73-20 (Commercial, Industrial)	237
	PIC16C71-20 (Commercial, Industrial) ...	185		PIC16C74-20 (Commercial, Industrial) ...	237
			Table 23-14:	A/D Converter Characteristics: PIC16LC73-04 (Commercial, Industrial)	238
				PIC16LC74-04 (Commercial, Industrial) ..	238
			Table 23-15:	A/D Conversion Requirements	239

Table 25-1:	Cross Reference of Device Specs for Oscillator Configurations and Frequencies of Operation (Commercial Devices)	244	Table 25-14:	A/D Converter Characteristics: PIC16LC73A-04 (Commercial, Industrial, Automotive)	
Table 25-2:	Clock Timing Requirements	250		PIC16LC74A-04 (Commercial, Industrial, Automotive).....	262
Table 25-3:	CLKOUT and I/O Timing Requirements..	252	Table 25-15:	A/D Conversion Requirements	263
Table 25-4:	Reset, Watchdog Timer, Oscillator Start-up Timer and Power-up Timer Requirements.....	253	Table E-1:	PIC16C5X Family of Devices	285
Table 25-5:	Timer0 and Timer1 Clock Requirements	254	Table E-2:	PIC16C62X Family of Devices	286
Table 25-6:	Capture/Compare/PWM Requirements (CCP1 and CCP2).....	255	Table E-3:	PIC16C6X Family of Devices	287
Table 25-7:	Parallel Slave Port Requirements for the PIC16C74A Only.....	256	Table E-4:	PIC16C7X Family of Devices	288
Table 25-8:	SPI Mode Requirements	257	Table E-5:	PIC16C8X Family of Devices	289
Table 25-9:	I ² C Bus Start/Stop Bits Requirements	258	Table E-6:	PIC17CXX Family of Devices.....	290
Table 25-10:	I ² C Bus Data Requirements.....	259	Table E-7:	Pin Compatible Devices.....	291
Table 25-11:	Serial Port Synchronous Transmission Requirements.....	260			
Table 25-12:	Serial Port Synchronous Receive Requirements.....	260			
Table 25-13:	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)	261			

PIC16C7X

NOTES:

CONNECTING TO MICROCHIP BBS

Connect worldwide to the Microchip BBS using the CompuServe® communications network. In most cases a local call is your only expense. The Microchip BBS connection does not use CompuServe membership services, therefore **you do not need CompuServe membership to join Microchip's BBS.**

There is **no charge** for connecting to the BBS, except for a toll charge to the CompuServe access number, where applicable. You do not need to be a CompuServe member to take advantage of this connection (you never actually log in to CompuServe).

The procedure to connect will vary slightly from country to country. Please check with your local CompuServe agent for details if you have a problem. CompuServe service allows multiple users at baud rates up to 14400 bps.

The following connect procedure applies in most locations:

1. Set your modem to 8 bit, No parity, and One stop (8N1). This is not the normal CompuServe setting which is 7E1.
2. Dial your local CompuServe access number.
3. Depress **<ENTER>** and a garbage string will appear because CompuServe is expecting a 7E1 setting.
4. Type **+**, depress **<ENTER>** and Host Name: will appear.
5. Type **MCHIPBBS**, depress **< ENTER>** and you will be connected to the Microchip BBS.

In the United States, to find CompuServe's phone number closest to you, set your modem to 7E1 and dial (800) 848-4480 for 300-2400 baud or (800) 331-7166 for 9600-14400 baud connection. After the system responds with Host Name:, type

NETWORK, depress **< ENTER>** and follow CompuServe's directions.

For voice information (or calling from overseas), you may call (614) 457-1550 for your local CompuServe number.

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PIC16C7X Product Identification System

To order or obtain information, e.g., on pricing or delivery refer to the factory or the listed sales office.

PART NO.	-XX	X	/XX	XXX			Examples
					Pattern:	QTP, SQTP, ROM Code or Special Requirements	a) PIC16C71 - 04/P 301
					Package:	JW = Windowed CERDIP PQ = MQFP (Metric PQFP) TQ = TQFP (Thin Quad Flatpack) SO = SOIC SP = Skinny plastic carrier SJ = Skinny CERDIP P = PDIP L = PLCC	Commercial Temp., PDIP Package, 4 MHz, normal V _{DD} limits, QTP pattern #301
					Temperature Range:	- = 0°C to +70°C (T for Tape/Reel) I = -40°C to +85°C (S for Tape/Reel) E = -40°C to +125°C	b) PIC16LC73 - 041/SO Industrial Temp., SOIC package, 4 MHz, extended V _{DD} limits
					Frequency Range:	04 = 200 kHz (PIC16C7X-04) 04 = 4 MHz 10 = 10 MHz 16 = 16 MHz 20 = 20 MHz	c) PIC16C74A - 10E/P Automotive Temp., PDIP package, 10 MHz, normal V _{DD} limits
					Device	PIC16C7X :V _{DD} range 4.0V to 6.0V PIC16C7XT :V _{DD} range 4.0V to 6.0V (Tape/Reel) PIC16LC7X :V _{DD} range 3.0V to 6.0V PIC16LC7XT :V _{DD} range 3.0V to 6.0V (Tape/Reel)	

* JW Devices are UV erasable and can be programmed to any device configuration. JW Devices meet the electrical requirement of each oscillator type (including LC devices).

Sales and Support

Products supported by a preliminary Data Sheet may possibly have an errata sheet describing minor operational differences and recommended workarounds. To determine if an errata sheet exists for a particular device, please contact one of the following:

1. Your local Microchip sales office (see below)
2. The Microchip Corporate Literature Center U.S. FAX: (602) 786-7277
3. The Microchip's Bulletin Board, via your local CompuServe number (CompuServe membership NOT required).

Please specify which device, revision of silicon and Data Sheet (include Literature #) you are using.

For latest version information and upgrade kits for Microchip Development Tools, please call 1-800-755-2345 or 1-602-786-7302.

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