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Details

Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	20MHz
Connectivity	I ² C, SPI
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	22
Program Memory Size	3.5KB (2K x 14)
Program Memory Type	OTP
EEPROM Size	-
RAM Size	128 x 8
Voltage - Supply (Vcc/Vdd)	4V ~ 5.5V
Data Converters	A/D 5x8b
Oscillator Type	External
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	28-SOIC (0.295", 7.50mm Width)
Supplier Device Package	28-SOIC
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16c72a-20i-so

2.2.2 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. A list of these registers is given in Table 2-1.

The Special Function Registers can be classified into two sets; core (CPU) and peripheral. Those registers associated with the core functions are described in detail in this section. Those related to the operation of the peripheral features are described in detail in the peripheral feature section.

TABLE 2-1 SPECIAL FUNCTION REGISTER SUMMARY

Addr	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 (4)	
Bank 0												
00h	INDF ⁽¹⁾	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	PCL ⁽¹⁾	Program Counter's (PC) Least Significant Byte								0000 0000	0000 0000	
03h	STATUS ⁽¹⁾	IRP ⁽⁵⁾	RP1 ⁽⁵⁾	RP0	T \bar{O}	PD	Z	DC	C	0001 1xxx	000q quuu	
04h	FSR ⁽¹⁾	Indirect data memory address pointer								xxxx xxxx	uuuu uuuu	
05h	PORTA ^(6,7)	—	—	PORTA Data Latch when written: PORTA pins when read						--0x 0000	--0u 0000	
06h	PORTB ^(6,7)	PORTB Data Latch when written: PORTB pins when read								xxxx xxxx	uuuu uuuu	
07h	PORTC ^(6,7)	PORTC Data Latch when written: PORTC pins when read								xxxx xxxx	uuuu uuuu	
08h-09h	—	Unimplemented								—	—	
0Ah	PCLATH ^(1,2)	—	—	—	Write Buffer for the upper 5 bits of the Program Counter						---0 0000	---0 0000
0Bh	INTCON ⁽¹⁾	GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	0000 000x	0000 000u	
0Ch	PIR1	—	ADIF ⁽³⁾	—	—	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 \bar{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-1Dh	—	Unimplemented								—	—	
1Eh	ADRES ⁽³⁾	A/D Result Register								xxxx xxxx	uuuu uuuu	
1Fh	ADCON0 ⁽³⁾	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.
Note 2: The upper byte of the program counter is not directly accessible. PCLATH is a holding register for PC<12:8> whose contents are transferred to the upper byte of the program counter.
Note 3: A/D not implemented on the PIC16C62B, maintain as '0'.
Note 4: Other (non power-up) resets include: external reset through \overline{MCLR} and the Watchdog Timer Reset.
Note 5: The IRP and RP1 bits are reserved. Always maintain these bits clear.
Note 6: On any device reset, these pins are configured as inputs.
Note 7: This is the value that will be in the port output latch.

PIC16C62B/72A

TABLE 2-1 SPECIAL FUNCTION REGISTER SUMMARY (Cont'd)

Addr	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 (4)
Bank 1											
80h	INDF ⁽¹⁾	Addressing this location uses contents of FSR to address data memory (not a physical register)								0000 0000	0000 0000
81h	OPTION_REG	RBP \bar{U}	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0	1111 1111	1111 1111
82h	PCL ⁽¹⁾	Program Counter's (PC) Least Significant Byte								0000 0000	0000 0000
83h	STATUS ⁽¹⁾	IRP ⁽⁵⁾	RP1 ⁽⁵⁾	RP0	$\bar{T}O$	$\bar{P}D$	Z	DC	C	0001 1xxx	000q quuu
84h	FSR ⁽¹⁾	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-89h	—	Unimplemented								—	—
8Ah	PCLATH ^(1,2)	—	—	—	Write Buffer for the upper 5 bits of the Program Counter					---0 0000	---0 0000
8Bh	INTCON ⁽¹⁾	GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	0000 000x	0000 000u
8Ch	PIE1	—	ADIE ⁽³⁾	—	—	SSPIE	CCP1IE	TMR2IE	TMR1IE	-0-- 0000	-0-- 0000
8Dh	—	Unimplemented								—	—
8Eh	PCON	—	—	—	—	—	—	POR	BOR	---- --qq	---- --uu
8Fh-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	SMP	CKE	D/ \bar{A}	P	S	R/ \bar{W}	UA	BF	0000 0000	0000 0000
95h-9Eh	—	Unimplemented								—	—
9Fh	ADCON1 ⁽³⁾	—	—	—	—	—	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 PC<12:8> whose contents are transferred to the upper byte of the program counter.

3: A/D not implemented on the PIC16C62B, maintain as '0'.

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

5: The IRP and RP1 bits are reserved. Always maintain these bits clear.

6: On any device reset, these pins are configured as inputs.

7: This is the value that will be in the port output latch.

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2.5 Indirect Addressing, INDF and FSR Registers

The INDF register is not a physical register. Addressing INDF actually addresses the register whose address is contained in the FSR register (FSR is a *pointer*).

Reading INDF itself indirectly (FSR = 0) will produce 00h. Writing to the INDF register indirectly results in a no-operation (although STATUS bits may be affected).

A simple program to clear RAM locations 20h-2Fh using indirect addressing is shown in Example 2-1.

EXAMPLE 2-1: HOW TO CLEAR RAM USING INDIRECT ADDRESSING

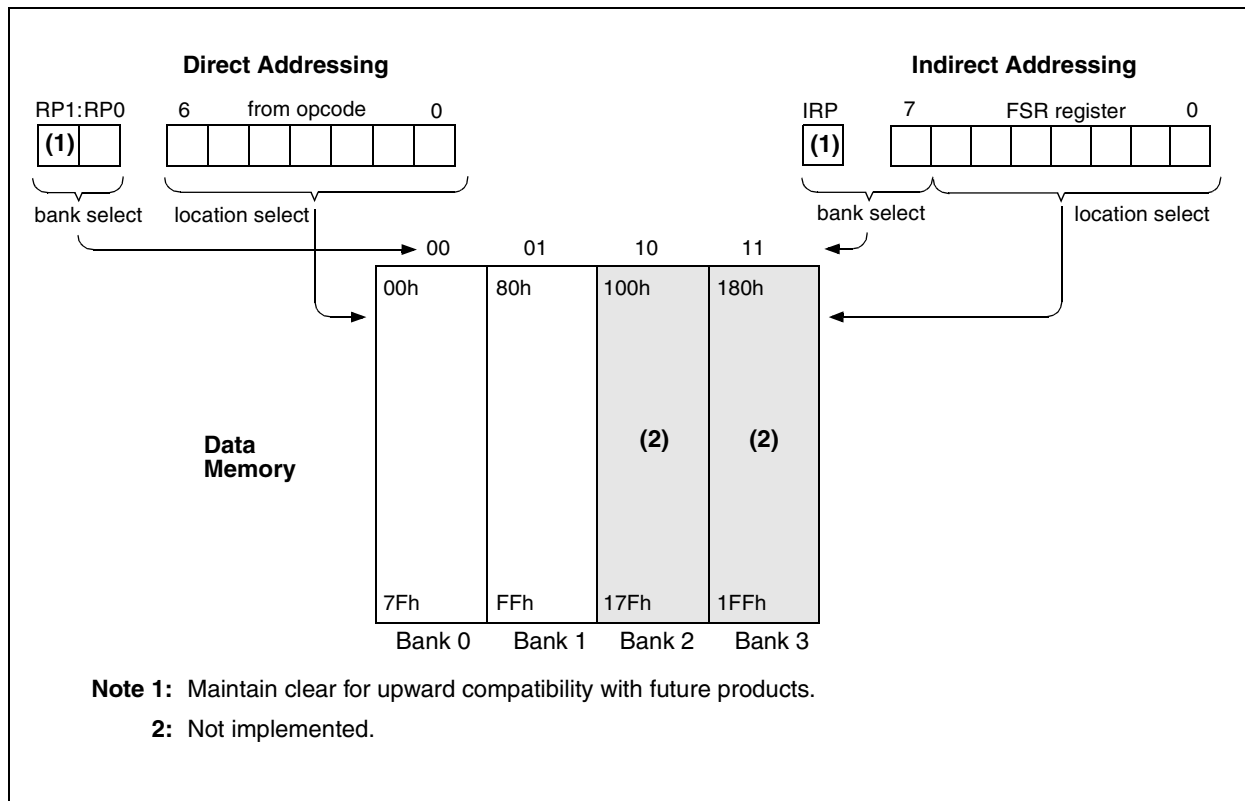
```

movlw 0x20 ;initialize pointer
movwf FSR ; to RAM
NEXT   clrf  INDF ;clear INDF register
       incf  FSR ;inc pointer
       btfss FSR,4 ;all done?
       goto NEXT ;NO, clear next

CONTINUE
       : ;YES, continue
    
```

An effective 9-bit address is obtained by concatenating the 8-bit FSR register and the IRP bit (STATUS<7>), as shown in Figure 2-3. However, IRP is not used in the PIC16C62B/72A.

FIGURE 2-3: DIRECT/INDIRECT ADDRESSING



PIC16C62B/72A

TABLE 3-5 PORTC FUNCTIONS

Name	Bit#	Buffer Type	Function	TRISC Override
RC0/T1OSO/T1CKI	bit0	ST	Input/output port pin or Timer1 oscillator output/Timer1 clock input	Yes
RC1/T1OSI	bit1	ST	Input/output port pin or Timer1 oscillator input	Yes
RC2/CCP1	bit2	ST	Input/output port pin or Capture1 input/Compare1 output/PWM1 output	No
RC3/SCK/SCL	bit3	ST	RC3 can also be the synchronous serial clock for both SPI and I ² C modes.	No
RC4/SDI/SDA	bit4	ST	RC4 can also be the SPI Data In (SPI mode) or data I/O (I ² C mode).	No
RC5/SDO	bit5	ST	Input/output port pin or Synchronous Serial Port data output	No
RC6	bit6	ST	Input/output port pin	No
RC7	bit7	ST	Input/output port pin	No

Legend: ST = Schmitt Trigger input

TABLE 3-6 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	PORTC Data Direction Register								1111 1111	1111 1111

Legend: x = unknown, u = unchanged.

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4.2.1 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, a specific instruction sequence (shown in the PIC® MCU Mid-Range Reference Manual, DS33023) must be executed when changing the prescaler assignment from Timer0 to the WDT. This sequence must be followed even if the WDT is disabled.

4.3 Timer0 Interrupt

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.

FIGURE 4-2: BLOCK DIAGRAM OF THE TIMER0/WDT PRESCALER

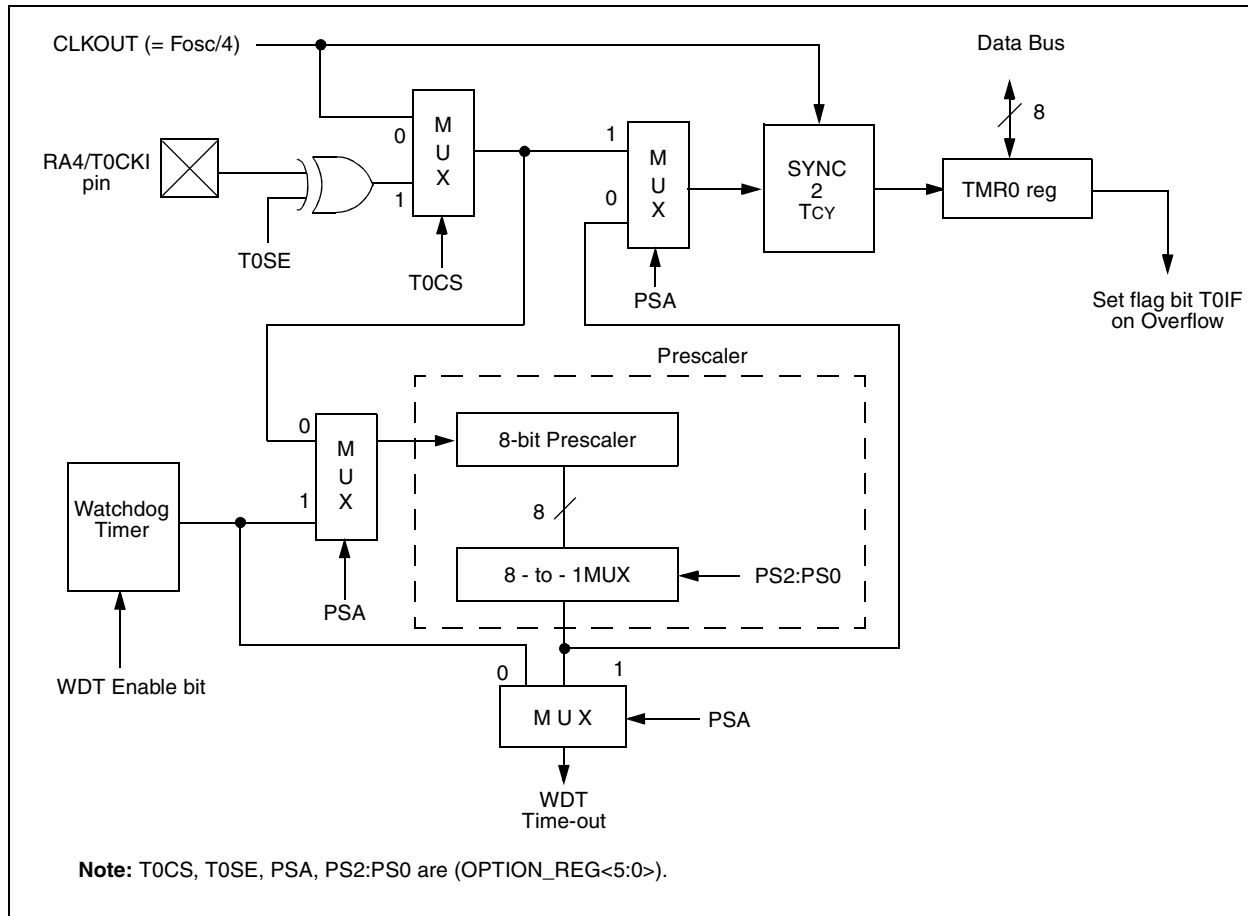


TABLE 4-1 REGISTERS ASSOCIATED WITH TIMER0

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	T0IE	INTE	RBIE	T0IF	INTF	RBIF	0000 000x	0000 000u
81h	OPTION_REG	RBPU	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0	1111 1111	1111 1111
85h	TRISA	—	—	PORTA Data Direction Register						--11 1111	--11 1111

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

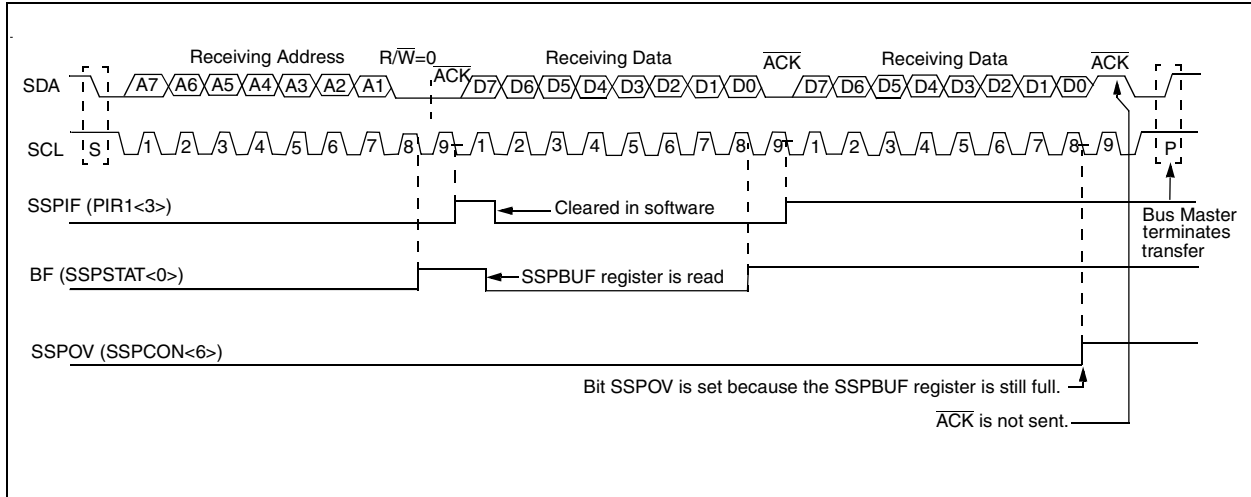
8.3.1.2 RECEPTION

When the $\overline{R/W}$ bit of the address byte is clear and an address match occurs, the $\overline{R/W}$ 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. The SSPSTAT register is used to determine the status of the byte.

FIGURE 8-3: I²C WAVEFORMS FOR RECEPTION (7-BIT ADDRESS)



9.0 ANALOG-TO-DIGITAL CONVERTER (A/D) MODULE

Note: This section applies to the PIC16C72A only.

The analog-to-digital (A/D) converter module has five input channels.

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 the feature of being able to operate while the device is in SLEEP mode. To operate in sleep, the A/D conversion clock must be derived from the A/D's internal RC oscillator.

Additional information on the A/D module is available in the PIC[®] MCU Mid-Range Reference Manual, (DS33023).

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)

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 ADCON0 register, shown in Figure 9-1, controls the operation of the A/D module. The ADCON1 register, shown in Figure 9-2, 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.

REGISTER 9-1: ADCON0 REGISTER (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 internal RC oscillator)

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)

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

10.0 SPECIAL FEATURES OF THE CPU

The PIC16C62B/72A devices have a host of features intended to maximize system reliability, minimize cost through elimination of external components, provide power saving operating modes and offer code protection. These are:

- Oscillator Mode 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™ (ICSP)

These devices have 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 on power-up only and is 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.

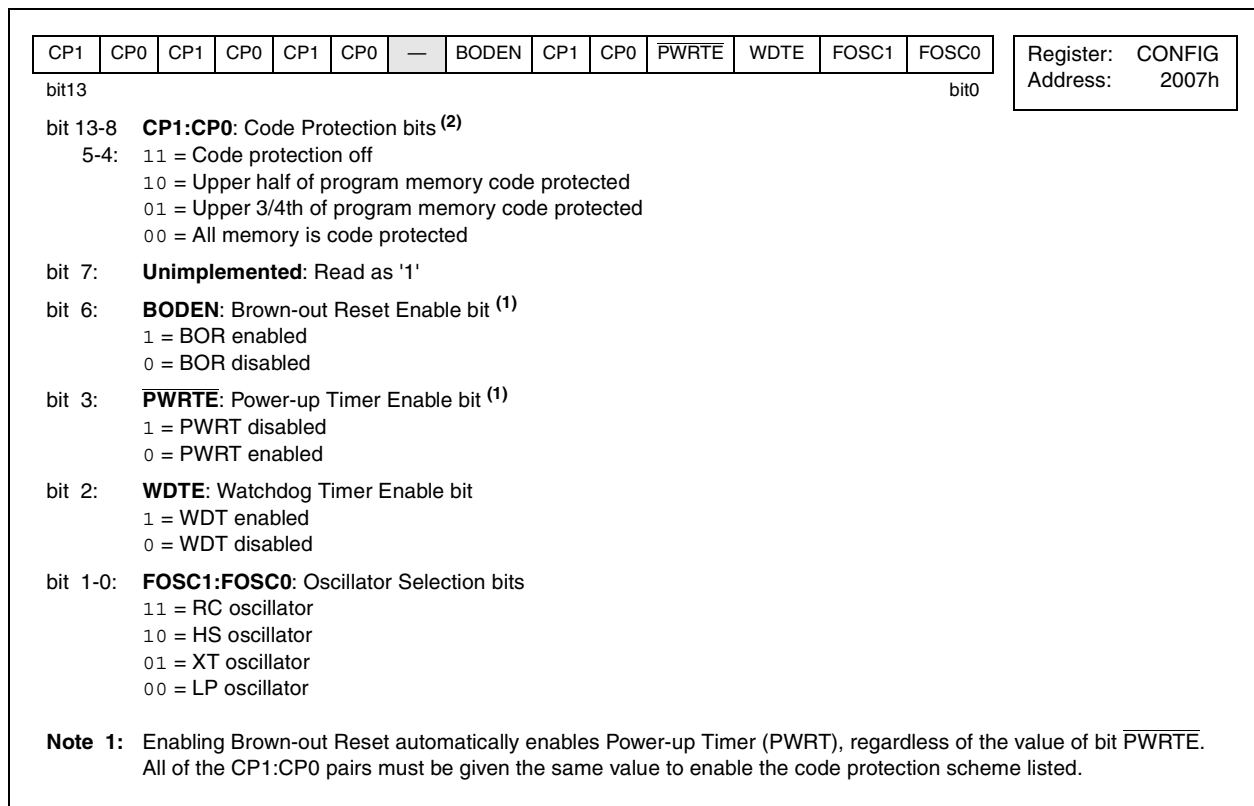
Additional information on special features is available in the PIC® MCU Mid-Range Reference Manual, (DS33023).

10.1 Configuration Bits

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 10-1: CONFIGURATION WORD



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10.2 Oscillator Configurations

10.2.1 OSCILLATOR TYPES

The PIC16CXXX 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

10.2.2 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 10-2). The PIC16CXXX 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 use an external clock source to drive the OSC1/CLKIN pin (Figure 10-3).

FIGURE 10-2: CRYSTAL/CERAMIC RESONATOR OPERATION (HS, XT OR LP OSC CONFIGURATION)

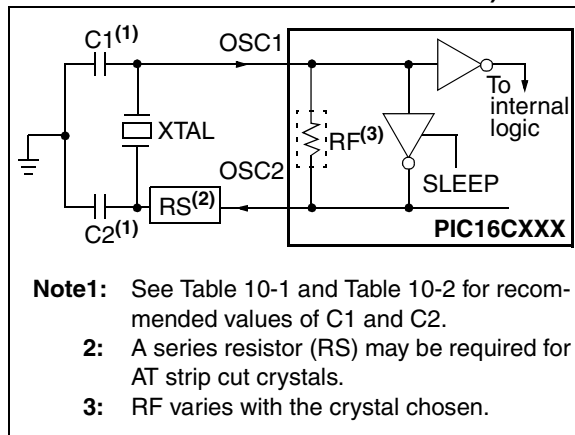


FIGURE 10-3: EXTERNAL CLOCK INPUT OPERATION (HS, XT OR LP OSC CONFIGURATION)

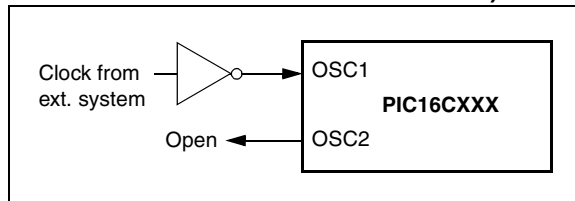


TABLE 10-1 CERAMIC RESONATORS

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
These values are for design guidance only. See notes at bottom of page.			
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%	
Resonators did not have built-in capacitors.			

TABLE 10-2 CAPACITOR SELECTION FOR CRYSTAL OSCILLATOR

Osc Type	Crystal Freq	Cap. Range C1	Cap. Range C2
LP	32 kHz	33 pF	33 pF
	200 kHz	15 pF	15 pF
XT	200 kHz	47-68 pF	47-68 pF
	1 MHz	15 pF	15 pF
	4 MHz	15 pF	15 pF
HS	4 MHz	15 pF	15 pF
	8 MHz	15-33 pF	15-33 pF
	20 MHz	15-33 pF	15-33 pF
These values are for design guidance only. See notes at bottom of page.			
Crystals Used			
32 kHz	Epson C-001R32.768K-A	± 20 PPM	
200 kHz	STD XTL 200.000KHz	± 20 PPM	
1 MHz	ECS ECS-10-13-1	± 50 PPM	
4 MHz	ECS ECS-40-20-1	± 50 PPM	
8 MHz	EPSON CA-301 8.000M-C	± 30 PPM	
20 MHz	EPSON CA-301 20.000M-C	± 30 PPM	

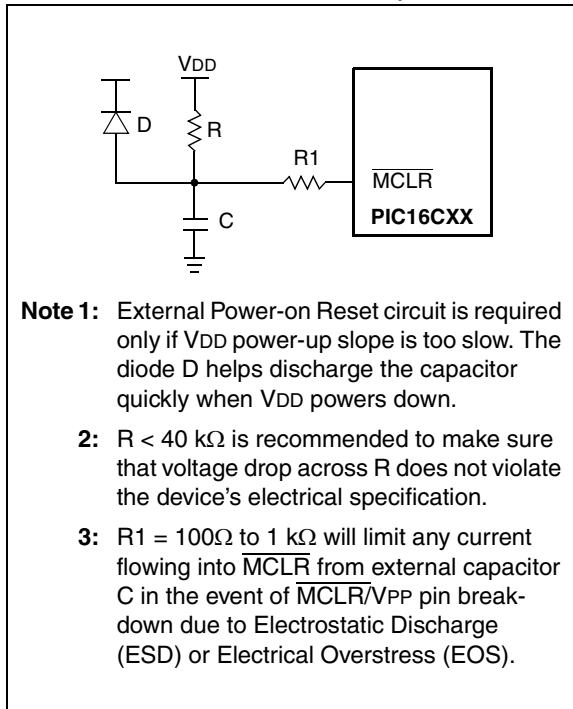
- Note 1:** Higher capacitance increases the stability of the oscillator, but also increases the start-up time.
2: Since each resonator/crystal has its own characteristics, the user should consult the resonator/crystal manufacturer for appropriate values of external components.
3: Rs may be required in HS mode, as well as XT mode, to avoid overdriving crystals with low drive level specification.
4: Oscillator performance should be verified when migrating between devices (including PIC16C62A to PIC16C62B and PIC16C72 to PIC16C72A)

10.4 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 $\overline{\text{MCLR}}$ 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 (SVDD, parameter D004). For a slow rise time, see Figure 10-6.

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. Brown-out Reset may be used to meet the start-up conditions.

FIGURE 10-6: EXTERNAL POWER-ON RESET CIRCUIT (FOR SLOW VDD POWER-UP)



10.5 Power-up Timer (PWRT)

The Power-up Timer provides a fixed nominal time-out (TPWRT, parameter #33) from the POR. The Power-up Timer operates on an internal RC oscillator. The chip is kept in reset as long as the PWRT is active. The PWRT's time delay allows VDD to rise to an acceptable level. A configuration bit is provided to enable/disable the PWRT.

The power-up time delay will vary from chip-to-chip due to VDD, temperature and process variation. See DC parameters for details.

10.6 Oscillator Start-up Timer (OST)

The Oscillator Start-up Timer (OST) provides a delay of 1024 oscillator cycles (from OSC1 input) after the PWRT delay is over (TOST, parameter #32). 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.

Note: The OST delay may not occur when the device wakes from SLEEP.

10.7 Brown-Out Reset (BOR)

The configuration bit, BODEN, can enable or disable the Brown-Out Reset circuit. If VPP falls below Vbor (parameter #35, about $100\mu\text{S}$), the brown-out situation will reset the device. If VDD falls below VBOR for less than TBOR, a reset may not occur.

Once the brown-out occurs, the device will remain in brown-out reset until VDD rises above VBOR. The power-up timer then keeps the device in reset for TPWRT (parameter #33, about 72mS). If VDD should fall below VBOR during TPWRT, the brown-out reset process will restart when VDD rises above VBOR with the power-up timer reset. The power-up timer is always enabled when the brown-out reset circuit is enabled, regardless of the state of the $\overline{\text{PWRT}}$ configuration bit.

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10.10 Interrupts

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 or disables 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 flag 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 and sets the GIE bit, which re-enables interrupts.

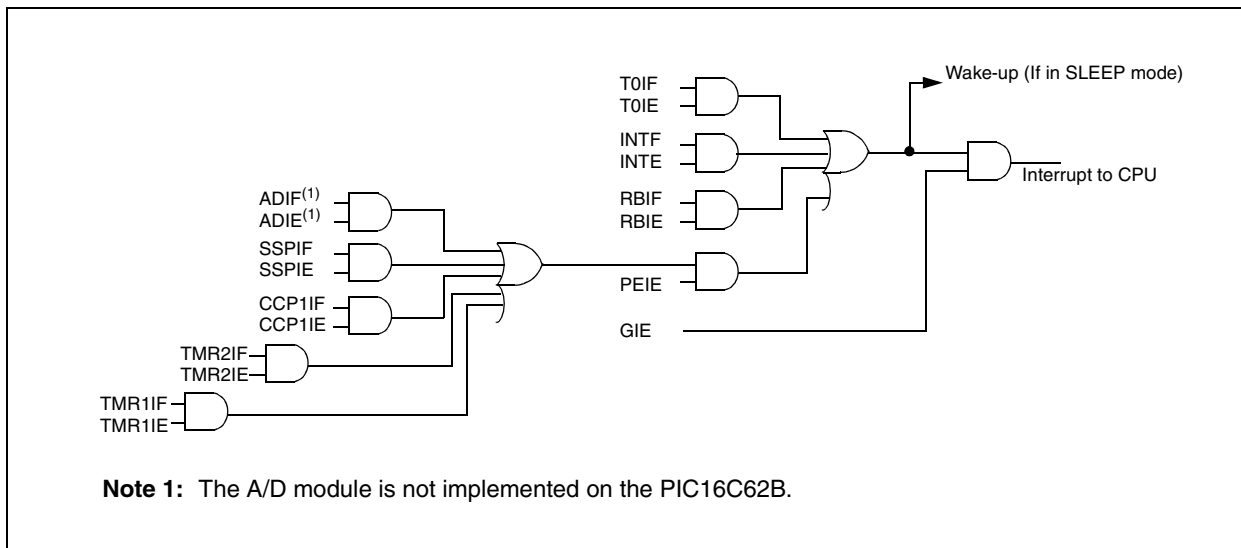
The RBO/INT pin interrupt, the RB port change interrupt and the TMR0 overflow interrupt flags are contained in the INTCON register.

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 interrupts, the return address is pushed onto the stack and the PC is loaded with 0004h. Once in the interrupt service routine, the source of the interrupt can be determined by polling the interrupt flag bits. The interrupt flag bit 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, depending on when the interrupt event occurs. 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

FIGURE 10-7: INTERRUPT LOGIC



10.13 Power-down Mode (SLEEP)

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 and 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 `TOCKI` 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} , parameter D042).

10.13.1 WAKE-UP FROM SLEEP

The device can wake up from `SLEEP` through one of the following events:

1. External reset input on \overline{MCLR} pin.
2. Watchdog Timer Wake-up (if `WDT` was enabled).
3. Interrupt from `INT` pin, `RB` port change, or some Peripheral Interrupts.

External \overline{MCLR} Reset will cause a device reset. All other events are considered a continuation of program execution and cause a "wake-up". The \overline{TO} and \overline{PD} bits in the `STATUS` register can be used to determine the cause of device reset. The \overline{PD} bit, which is set on power-up, is cleared when `SLEEP` is invoked. The \overline{TO} bit is cleared if a `WDT` time-out occurred (and caused wake-up).

The following peripheral interrupts can wake the device from `SLEEP`:

1. `TMR1` interrupt. `Timer1` must be operating as an asynchronous counter.
2. `CCP` capture mode interrupt.
3. Special event trigger (`Timer1` in asynchronous mode using an external clock. `CCP1` is in compare mode).
4. `SSP` (Start/Stop) bit detect interrupt.
5. `SSP` transmit or receive in slave mode (`SPI/I2C`).
6. `USART` RX or TX (synchronous slave mode).

Other peripherals cannot generate interrupts since during `SLEEP`, no on-chip 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 resumes 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, a `NOOP` should follow the `SLEEP` instruction.

10.13.2 WAKE-UP USING INTERRUPTS

When global interrupts are disabled (`GIE` cleared) and any interrupt source has both its interrupt enable bit and interrupt flag bit set, one of the following will occur:

- If the interrupt occurs **before** the execution of a `SLEEP` instruction, the `SLEEP` instruction will complete as a `NOOP`. Therefore, the `WDT` and `WDT` postscaler will not be cleared, the \overline{TO} bit will not be set and \overline{PD} bits will not be cleared.
- If the interrupt occurs **during or after** the execution of a `SLEEP` instruction, the device will immediately wake up from sleep. The `SLEEP` instruction will be completely executed before the wake-up. Therefore, the `WDT` and `WDT` postscaler will be cleared, the \overline{TO} bit will be set and the \overline{PD} bit will be cleared.

Even if the flag bits were checked before executing a `SLEEP` instruction, it may be possible for flag bits to become set before the `SLEEP` instruction completes. To determine whether a `SLEEP` instruction executed, test the \overline{PD} bit. If the \overline{PD} bit is set, the `SLEEP` instruction was executed as a `NOOP`.

To ensure that the `WDT` is cleared, a `CLRWDT` instruction should be executed before a `SLEEP` instruction.

11.0 INSTRUCTION SET SUMMARY

Each PIC16CXXX 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 11-2 lists **byte-oriented**, **bit-oriented**, and **literal and control** operations. Table 11-1 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 11-1 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
PC	Program Counter
TO	Time-out bit
PD	Power-down bit
Z	Zero bit
DC	Digit Carry bit
C	Carry bit

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

Table 11-2 lists the instructions recognized by the MPASM assembler.

Figure 11-1 shows the general formats that the instructions can have.

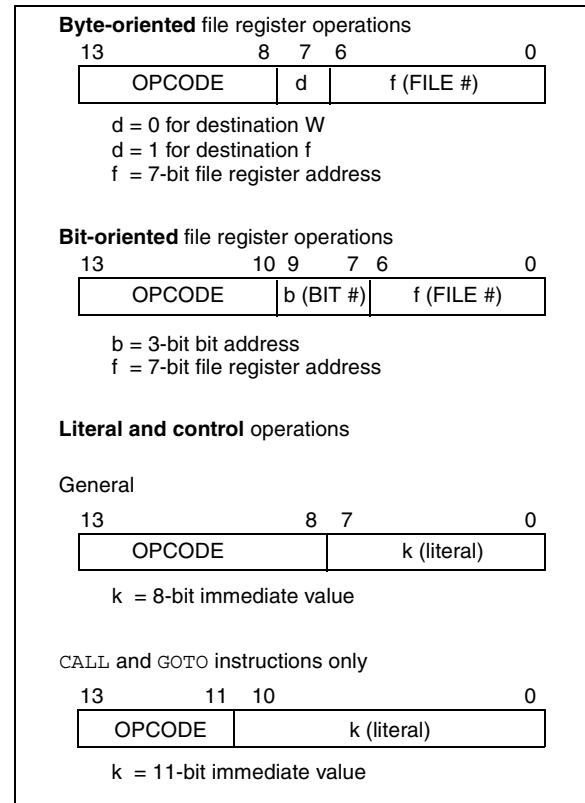
Note: To maintain upward compatibility with future PIC16CXXX products, do not use the **OPTION** and **TRIS** instructions.

All examples use the following format to represent a hexadecimal number:

0xhh

where h signifies a hexadecimal digit.

FIGURE 11-1: GENERAL FORMAT FOR INSTRUCTIONS



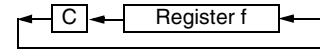
A description of each instruction is available in the PIC[®] MCU Mid-Range Reference Manual, (DS33023).

RETFIE **Return from Interrupt**

Syntax: [*label*] RETFIE
 Operands: None
 Operation: TOS → PC,
 1 → GIE
 Status Affected: None

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
 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'.

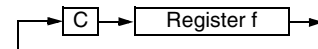


RETLW **Return with Literal in W**

Syntax: [*label*] RETLW k
 Operands: $0 \leq k \leq 255$
 Operation: $k \rightarrow (W)$;
 TOS → PC
 Status Affected: None
 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.

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
 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'.



RETURN **Return from Subroutine**

Syntax: [*label*] RETURN
 Operands: None
 Operation: TOS → PC
 Status Affected: None
 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.

SLEEP

Syntax: [*label*] SLEEP
 Operands: None
 Operation: 00h → WDT,
 0 → WDT prescaler,
 1 → \overline{TO} ,
 0 → \overline{PD}
 Status Affected: \overline{TO} , \overline{PD}
 Description: The power-down status bit, \overline{PD} is cleared. Time-out status bit, \overline{TO} is set. Watchdog Timer and its prescaler are cleared. The processor is put into SLEEP mode with the oscillator stopped. See Section 10.13 for more details.

12.0 DEVELOPMENT SUPPORT

The PIC[®] microcontrollers are supported with a full range of hardware and software development tools:

- Integrated Development Environment
 - MPLAB[™] IDE Software
- Assemblers/Compilers/Linkers
 - MPASM Assembler
 - MPLAB-C17 and MPLAB-C18 C Compilers
 - MPLINK/MPLIB Linker/Librarian
- Simulators
 - MPLAB-SIM Software Simulator
- Emulators
 - MPLAB-ICE Real-Time In-Circuit Emulator
 - PICMASTER[®]/PICMASTER-CE In-Circuit Emulator
 - ICEPIC[™]
- In-Circuit Debugger
 - MPLAB-ICD for PIC16F877
- Device Programmers
 - PRO MATE[®] II Universal Programmer
 - PICSTART[®] Plus Entry-Level Prototype Programmer
- Low-Cost Demonstration Boards
 - SIMICE
 - PICDEM-1
 - PICDEM-2
 - PICDEM-3
 - PICDEM-17
 - SEEVAL[®]
 - KEELOQ[®]

12.1 MPLAB Integrated Development Environment Software

- The MPLAB IDE software brings an ease of software development previously unseen in the 8-bit microcontroller market. MPLAB is a Windows[®]-based application which contains:
- Multiple functionality
 - editor
 - simulator
 - programmer (sold separately)
 - emulator (sold separately)
- A full featured editor
- A project manager
- Customizable tool bar and key mapping
- A status bar
- On-line help

MPLAB allows you to:

- Edit your source files (either assembly or 'C')
- One touch assemble (or compile) and download to PIC MCU tools (automatically updates all project information)
- Debug using:
 - source files
 - absolute listing file
 - object code

The ability to use MPLAB with Microchip's simulator, MPLAB-SIM, allows a consistent platform and the ability to easily switch from the cost-effective simulator to the full featured emulator with minimal retraining.

12.2 MPASM Assembler

MPASM is a full featured universal macro assembler for all PIC MCUs. It can produce absolute code directly in the form of HEX files for device programmers, or it can generate relocatable objects for MPLINK.

MPASM has a command line interface and a Windows shell and can be used as a standalone application on a Windows 3.x or greater system. MPASM generates relocatable object files, Intel standard HEX files, MAP files to detail memory usage and symbol reference, an absolute LST file which contains source lines and generated machine code, and a COD file for MPLAB debugging.

MPASM features include:

- MPASM and MPLINK are integrated into MPLAB projects.
- MPASM allows user defined macros to be created for streamlined assembly.
- MPASM allows conditional assembly for multi purpose source files.
- MPASM directives allow complete control over the assembly process.

12.3 MPLAB-C17 and MPLAB-C18 C Compilers

The MPLAB-C17 and MPLAB-C18 Code Development Systems are complete ANSI 'C' compilers and integrated development environments for Microchip's PIC17CXXX and PIC18CXXX family of microcontrollers, respectively. These compilers provide powerful integration capabilities and ease of use not found with other compilers.

For easier source level debugging, the compilers provide symbol information that is compatible with the MPLAB IDE memory display.

12.4 MPLINK/MPLIB Linker/Librarian

MPLINK is a relocatable linker for MPASM and MPLAB-C17 and MPLAB-C18. It can link relocatable objects from assembly or C source files along with pre-compiled libraries using directives from a linker script.

PIC16C62B/72A

FIGURE 13-12: EXAMPLE SPI MASTER MODE TIMING (CKE = 1)

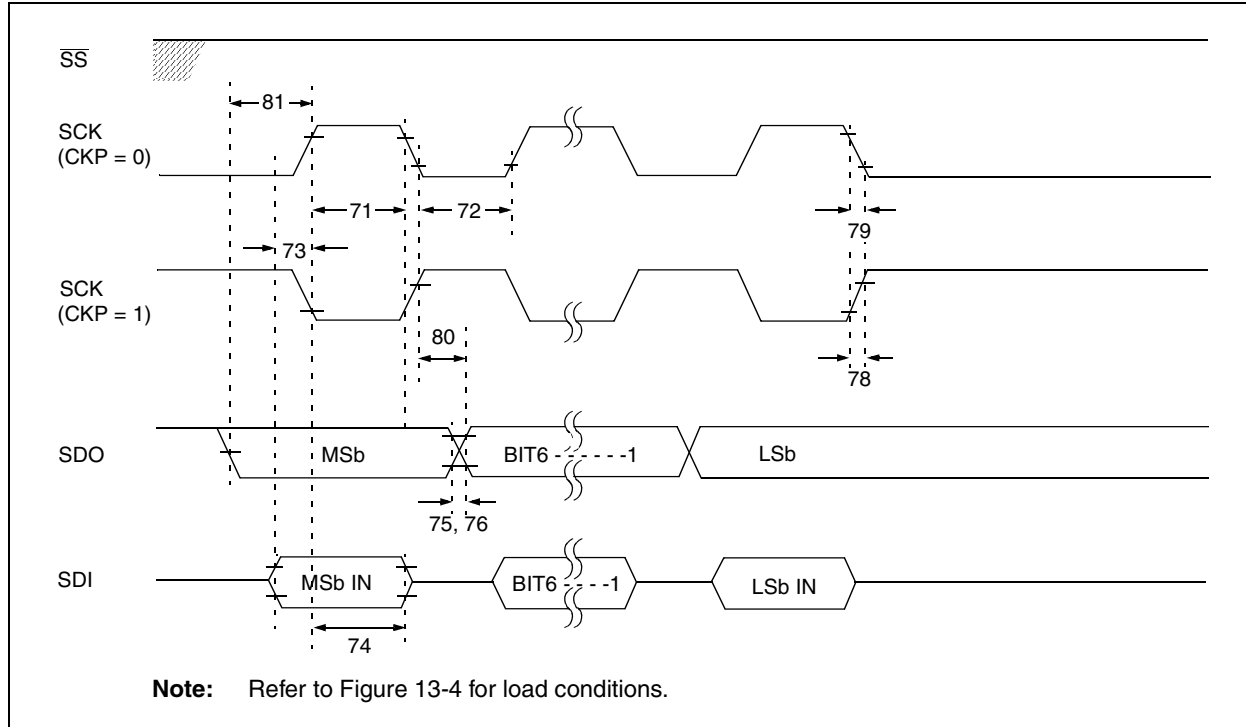


TABLE 13-8: EXAMPLE SPI MODE REQUIREMENTS (MASTER MODE, CKE = 1)

Param. No.	Symbol	Characteristic	Min	Typ†	Max	Units	Conditions
71	TscH	SCK input high time (slave mode)	Continuous	1.25T _{CY} + 30	—	—	ns
71A			Single Byte	40	—	—	ns
72	TscL	SCK input low time (slave mode)	Continuous	1.25T _{CY} + 30	—	—	ns
72A			Single Byte	40	—	—	ns
73	TdiV2sch, TdiV2scl	Setup time of SDI data input to SCK edge	100	—	—	ns	
73A	TB2B	Last clock edge of Byte1 to the 1st clock edge of Byte2	1.5T _{CY} + 40	—	—	ns	Note 1
74	Tsch2diL, TscL2diL	Hold time of SDI data input to SCK edge	100	—	—	ns	
75	TdoR	SDO data output rise time	PIC16CXX	—	10	25	ns
			PIC16LCXX	—	20	45	ns
76	TdoF	SDO data output fall time	—	10	25	ns	
78	TscR	SCK output rise time (master mode)	PIC16CXX	—	10	25	ns
			PIC16LCXX	—	20	45	ns
79	TscF	SCK output fall time (master mode)	—	10	25	ns	
80	Tsch2doV, TscL2doV	SDO data output valid after SCK edge	PIC16CXX	—	—	50	ns
			PIC16LCXX	—	—	100	ns
81	TdoV2sch, TdoV2scl	SDO data output setup to SCK edge	T _{CY}	—	—	ns	

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

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

PIC16C62B/72A

FIGURE 13-16: I²C BUS DATA TIMING

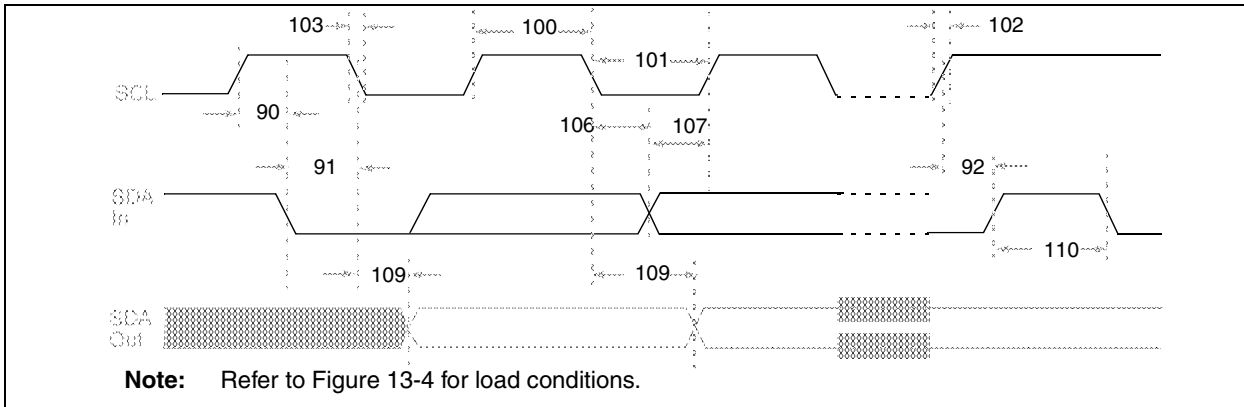


TABLE 13-12: I²C BUS DATA REQUIREMENTS

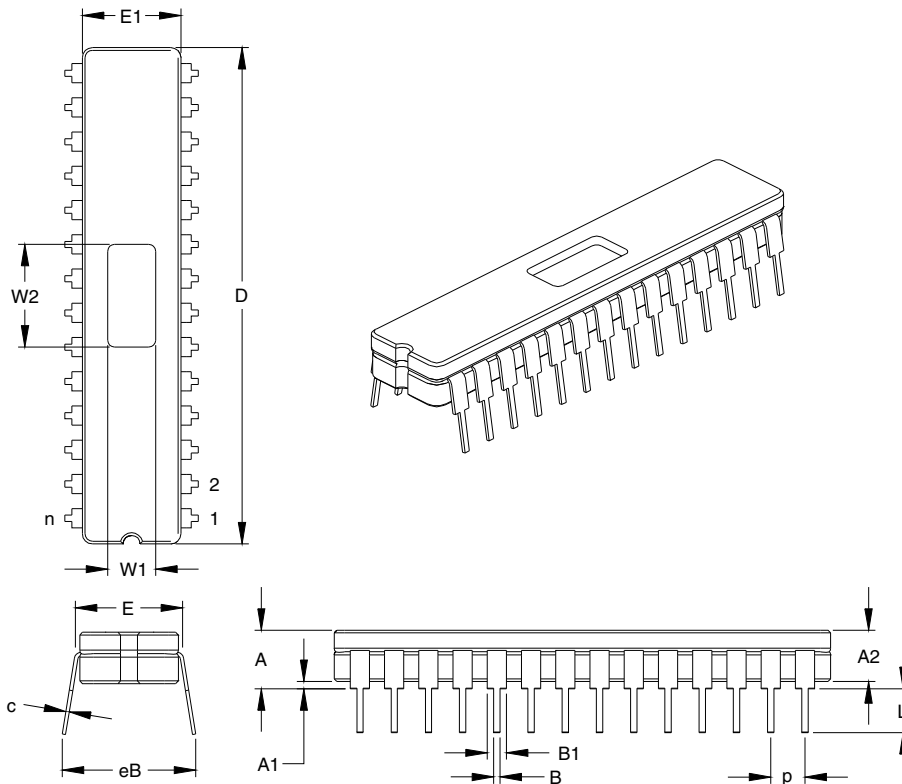
Param. No.	Sym	Characteristic	Min	Max	Units	Conditions	
100*	THIGH	Clock high time	100 kHz mode	4.0	—	μs	Device must operate at a minimum of 1.5 MHz
			400 kHz mode	0.6	—	μs	Device must operate at a minimum of 10 MHz
			SSP Module	1.5T _{cy}	—		
101*	TLOW	Clock low time	100 kHz mode	4.7	—	μs	Device must operate at a minimum of 1.5 MHz
			400 kHz mode	1.3	—	μs	Device must operate at a minimum of 10 MHz
			SSP Module	1.5T _{cy}	—		
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 10-400 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 10-400 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		

* These parameters are characterized but not tested.

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 (400 kHz) I²C-bus device can be used in a standard-mode (100 kHz) I²C-bus system, but the requirement $T_{su:DAT} \geq 250$ 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 $\max. + t_{su:DAT} = 1000 + 250 = 1250$ ns (according to the standard-mode I²C bus specification) before the SCL line is released.

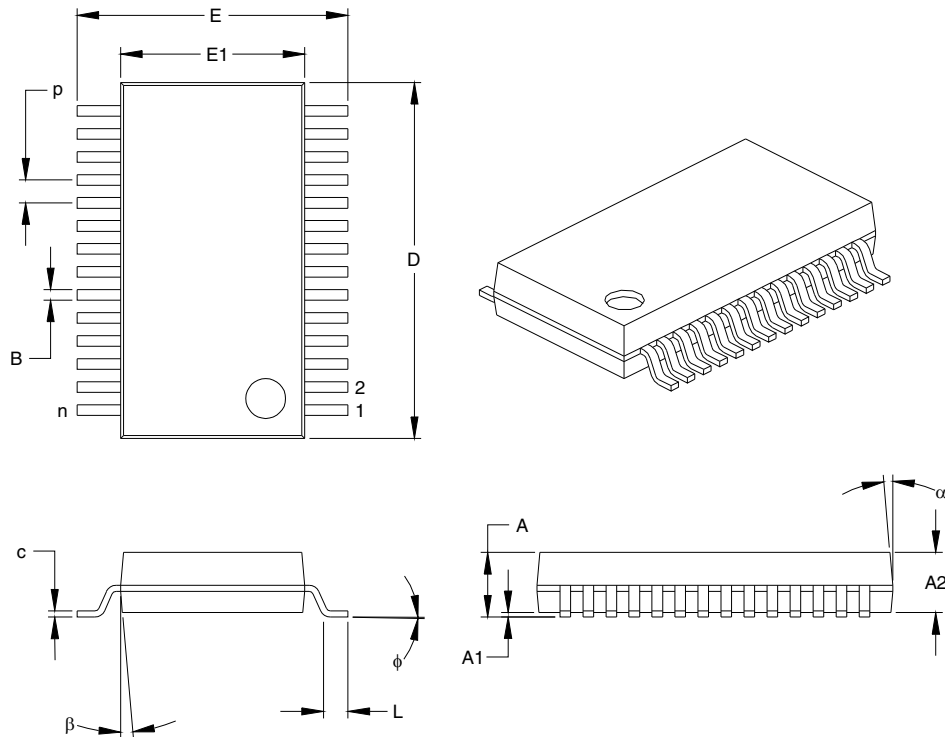
15.3 28-Lead Ceramic Dual In-line with Window (JW) – 300 mil (CERDIP)



Dimension Limits	Units	INCHES*			MILLIMETERS		
		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		28			28	
Pitch	p		.100			2.54	
Top to Seating Plane	A	.170	.183	.195	4.32	4.64	4.95
Ceramic Package Height	A2	.155	.160	.165	3.94	4.06	4.19
Standoff	A1	.015	.023	.030	0.38	0.57	0.76
Shoulder to Shoulder Width	E	.300	.313	.325	7.62	7.94	8.26
Ceramic Pkg. Width	E1	.285	.290	.295	7.24	7.37	7.49
Overall Length	D	1.430	1.458	1.485	36.32	37.02	37.72
Tip to Seating Plane	L	.135	.140	.145	3.43	3.56	3.68
Lead Thickness	c	.008	.010	.012	0.20	0.25	0.30
Upper Lead Width	B1	.050	.058	.065	1.27	1.46	1.65
Lower Lead Width	B	.016	.019	.021	0.41	0.47	0.53
Overall Row Spacing	eB	.345	.385	.425	8.76	9.78	10.80
Window Width	W1	.130	.140	.150	3.30	3.56	3.81
Window Length	W2	.290	.300	.310	7.37	7.62	7.87

*Controlling Parameter
JEDEC Equivalent: MO-058
Drawing No. C04-080

15.5 28-Lead Plastic Shrink Small Outline (SS) – 209 mil, 5.30 mm (SSOP)



Units		INCHES			MILLIMETERS*		
Dimension Limits		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		28			28	
Pitch	P		.026			0.66	
Overall Height	A	.068	.073	.078	1.73	1.85	1.98
Molded Package Thickness	A2	.064	.068	.072	1.63	1.73	1.83
Standoff	A1	.002	.006	.010	0.05	0.15	0.25
Overall Width	E	.299	.309	.319	7.59	7.85	8.10
Molded Package Width	E1	.201	.207	.212	5.11	5.25	5.38
Overall Length	D	.396	.402	.407	10.06	10.20	10.34
Foot Length	L	.022	.030	.037	0.56	0.75	0.94
Lead Thickness	c	.004	.007	.010	0.10	0.18	0.25
Foot Angle	ϕ	0	4	8	0.00	101.60	203.20
Lead Width	B	.010	.013	.015	0.25	0.32	0.38
Mold Draft Angle Top	α	0	5	10	0	5	10
Mold Draft Angle Bottom	β	0	5	10	0	5	10

*Controlling Parameter

Notes:

Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" (0.254mm) per side.

JEDEC Equivalent: MS-150

Drawing No. C04-073

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