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Details

Product Status	Obsolete
Core Processor	PIC
Core Size	8-Bit
Speed	20MHz
Connectivity	I ² C, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	22
Program Memory Size	14KB (8K x 14)
Program Memory Type	ROM
EEPROM Size	-
RAM Size	368 x 8
Voltage - Supply (Vcc/Vdd)	2V ~ 5.5V
Data Converters	A/D 5x8b
Oscillator Type	Internal
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/pic16cr76t-i-so

TABLE 1-2: PIC16CR73 AND PIC16CR76 PINOUT DESCRIPTION (CONTINUED)

Pin Name	PDIP SSOP SOIC Pin#	MLF Pin#	I/O/P Type	Buffer Type	Description
RC0/T1OSO/T1CKI RC0 T1OSO T1CKI	11	8	I/O O I	ST	PORTC is a bidirectional I/O port. Digital I/O. Timer1 oscillator output. Timer1 external clock input.
RC1/T1OSI/CCP2 RC1 T1OSI CCP2	12	9	I/O I I/O	ST	Digital I/O. Timer1 oscillator input. Capture2 input, Compare2 output, PWM2 output.
RC2/CCP1 RC2 CCP1	13	10	I/O I/O	ST	Digital I/O. Capture1 input/Compare1 output/PWM1 output.
RC3/SCK/SCL RC3 SCK SCL	14	11	I/O I/O I/O	ST	Digital I/O. Synchronous serial clock input/output for SPI mode. Synchronous serial clock input/output for I ² C™ mode.
RC4/SDI/SDA RC4 SDI SDA	15	12	I/O I I/O	ST	Digital I/O. SPI data in. I ² C™ data I/O.
RC5/SDO RC5 SDO	16	13	I/O O	ST	Digital I/O. SPI data out.
RC6/TX/CK RC6 TX CK	17	14	I/O O I/O	ST	Digital I/O. USART asynchronous transmit. USART 1 synchronous clock.
RC7/RX/DT RC7 RX DT	18	15	I/O I I/O	ST	Digital I/O. USART asynchronous receive. USART synchronous data.
VSS	8, 19	5, 16	P	—	Ground reference for logic and I/O pins.
VDD	20	17	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 Verify mode.
 3: This buffer is a Schmitt Trigger input when configured in RC Oscillator mode and a CMOS input otherwise.

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FIGURE 2-2: PIC16CR77/76 REGISTER FILE MAP

File Address		File Address		File Address		File Address	
Indirect addr.(*)	00h	Indirect addr.(*)	80h	Indirect addr.(*)	100h	Indirect addr.(*)	180h
TMR0	01h	OPTION_REG	81h	TMR0	101h	OPTION_REG	181h
PCL	02h	PCL	82h	PCL	102h	PCL	182h
STATUS	03h	STATUS	83h	STATUS	103h	STATUS	183h
FSR	04h	FSR	84h	FSR	104h	FSR	184h
PORTA	05h	TRISA	85h		105h		185h
PORTB	06h	TRISB	86h	PORTB	106h	TRISB	186h
PORTC	07h	TRISC	87h		107h		187h
PORTD ⁽¹⁾	08h	TRISD ⁽¹⁾	88h		108h		188h
PORTE ⁽¹⁾	09h	TRISE ⁽¹⁾	89h		109h		189h
PCLATH	0Ah	PCLATH	8Ah	PCLATH	10Ah	PCLATH	18Ah
INTCON	0Bh	INTCON	8Bh	INTCON	10Bh	INTCON	18Bh
PIR1	0Ch	PIE1	8Ch	PMDATA	10Ch	PMCON1	18Ch
PIR2	0Dh	PIE2	8Dh	PMADR	10Dh		18Dh
TMR1L	0Eh	PCON	8Eh	PMDATH	10Eh		18Eh
TMR1H	0Fh		8Fh	PMADRH	10Fh		18Fh
T1CON	10h		90h		110h		190h
TMR2	11h		91h		111h		191h
T2CON	12h	PR2	92h		112h		192h
SSPBUF	13h	SSPADDD	93h		113h		193h
SSPCON	14h	SSPSTAT	94h		114h		194h
CCPR1L	15h		95h		115h		195h
CCPR1H	16h		96h		116h		196h
CCP1CON	17h		97h	General Purpose Register 16 Bytes	117h	General Purpose Register 16 Bytes	197h
RCSTA	18h	TXSTA	98h		118h		198h
TXREG	19h	SPBRG	99h		119h		199h
RCREG	1Ah		9Ah		11Ah		19Ah
CCPR2L	1Bh		9Bh		11Bh		19Bh
CCPR2H	1Ch		9Ch		11Ch		19Ch
CCP2CON	1Dh		9Dh		11Dh		19Dh
ADRES	1Eh		9Eh		11Eh		19Eh
ADCON0	1Fh	ADCON1	9Fh		11Fh		19Fh
General Purpose Register 96 Bytes	20h		A0h		120h		1A0h
		General Purpose Register 80 Bytes	EFh	General Purpose Register 80 Bytes		General Purpose Register 80 Bytes	1EFh
		accesses 70h-7Fh	F0h				1F0h
			FFh	accesses 70h-7Fh	170h		1FFh
Bank 0	7Fh	Bank 1		Bank 2	17Fh	Bank 3	

■ Unimplemented data memory locations, read as '0'.

* Not a physical register.

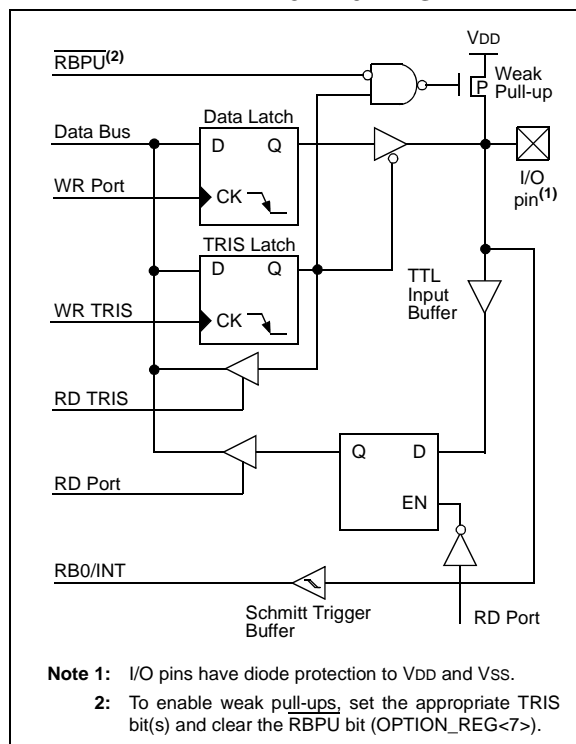
Note 1: These registers are not implemented on 28-pin devices.

4.2 PORTB and the TRISB Register

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

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

FIGURE 4-3: BLOCK DIAGRAM OF RB3:RB0 PINS



Four of the PORTB 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 ORed 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.

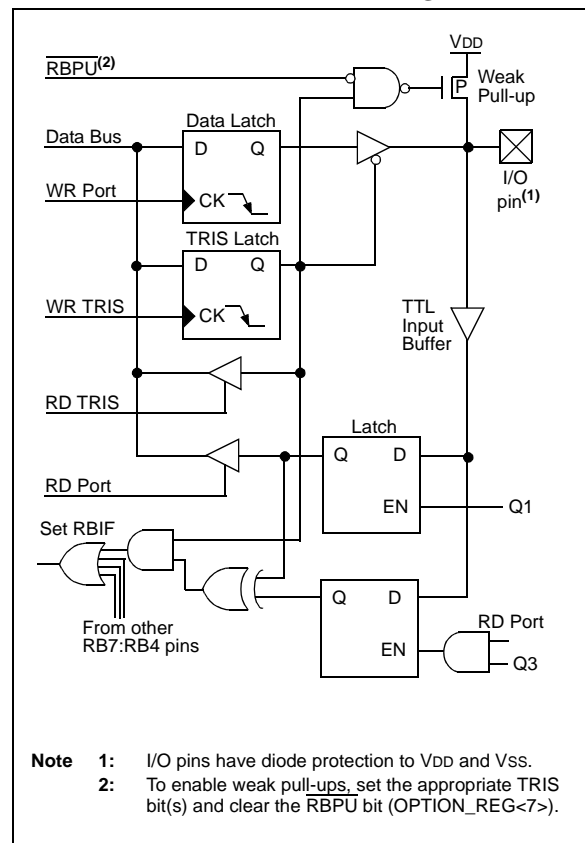
The interrupt-on-change feature is recommended for wake-up on key depression operation and operations where PORTB is only used for the interrupt-on-change feature. Polling of PORTB is not recommended while using the interrupt-on-change feature.

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

RB0/INT is an external interrupt input pin and is configured using the INTEDG bit (OPTION_REG<6>).

RB0/INT is discussed in detail in **Section 12.11.1 "INT Interrupt"**.

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



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REGISTER 4-1: TRISE: (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	—	Bit 2	Bit 1	Bit 0
bit 7							bit 0

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

-n = Value at POR

'1' = Bit is set

'0' = Bit is cleared

x = Bit is unknown

bit 7

Parallel Slave Port Status/Control bits:

IBF: Input Buffer Full Status bit

1 = A word has been received and is 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

PORTE Data Direction bits:

Bit 2: Direction Control bit for pin RE2/ $\overline{\text{CS}}$ /AN7

1 = Input

0 = Output

bit 1

Bit 1: Direction Control bit for pin RE1/ $\overline{\text{WR}}$ /AN6

1 = Input

0 = Output

bit 0

Bit 0: Direction Control bit for pin RE0/ $\overline{\text{RD}}$ /AN5

1 = Input

0 = Output

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6.5 Timer1 Oscillator

A crystal oscillator circuit is built-in between pins T1OSI (input) and T1OSO (amplifier output). It is enabled by setting control bit T1OSCEN (T1CON<3>). The oscillator is a low-power oscillator rated up to 200 kHz. It will continue to run during Sleep. It is primarily intended for use with a 32 kHz crystal. Table 6-1 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.

6.6 Resetting Timer1 using a CCP Trigger Output

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 register pair effectively becomes the period register for Timer1.

6.7 Resetting of Timer1 Register Pair (TMR1H, TMR1L)

TMR1H and TMR1L registers are not reset to 00h on a POR, or any other Reset, except by the CCP1 and CCP2 special event triggers.

TABLE 6-1: CAPACITOR SELECTION FOR THE TIMER1 OSCILLATOR

Osc Type	Frequency	Capacitors Used:	
		OSC1	OSC2
LP	32 kHz	47 pF	47 pF
	100 kHz	33 pF	33 pF
	200 kHz	15 pF	15 pF
Capacitor values are for design guidance only.			
These capacitors were tested with the crystals listed below for basic start-up and operation. These values were not optimized.			
Different capacitor values may be required to produce acceptable oscillator operation. The user should test the performance of the oscillator over the expected VDD and temperature range for the application.			
See the notes (below) table for additional information.			
Commonly Used Crystals:			
32.768 kHz	Epson C-001R32.768K-A		
100 kHz	Epson C-2 100.00 KC-P		
200 kHz	STD XTL 200.000 kHz		
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.			

T1CON register is reset to 00h on a Power-on Reset or a Brown-out Reset, which shuts off the timer and leaves a 1:1 prescale. In all other Resets, the register is unaffected.

6.8 Timer1 Prescaler

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

TABLE 6-2: 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, 10Bh, 18Bh	INTCON	GIE	PEIE	TMR0IE	INTE	RBIE	TMR0IF	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
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 PIC16CR73/76; always maintain these bits clear.

8.5 PWM Mode (PWM)

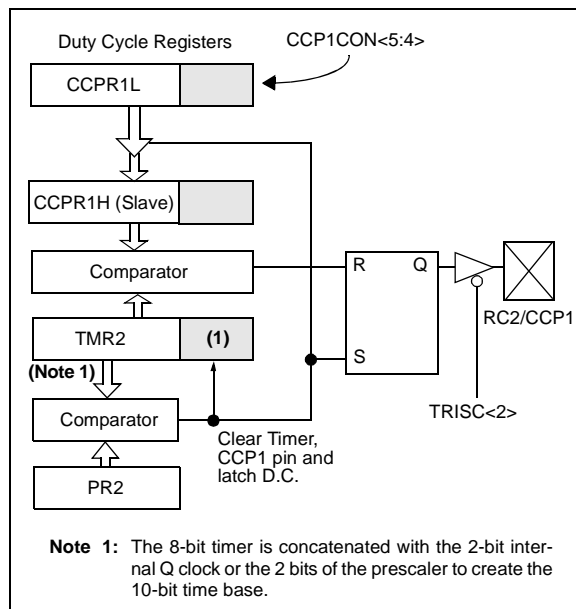
In Pulse Width Modulation mode, the CCPx pin produces up to a 10-bit resolution PWM output. Since the CCP1 pin is multiplexed with the PORTC data latch, the TRISC<2> bit must be cleared to make the CCP1 pin an output.

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

Figure 8-3 shows a simplified block diagram of the CCP module in PWM mode.

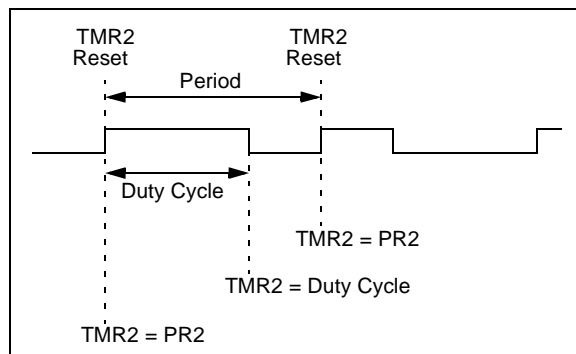
For a step-by-step procedure on how to set up the CCP module for PWM operation, see **Section 8.5.3 “SetUp for PWM Operation”**.

FIGURE 8-3: SIMPLIFIED PWM BLOCK DIAGRAM



A PWM output (Figure 8-4) has a time base (period) and a time that the output stays high (duty cycle). The frequency of the PWM is the inverse of the period (1/period).

FIGURE 8-4: PWM OUTPUT



8.5.1 PWM PERIOD

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

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

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

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

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

Note: The Timer2 postscaler (see **Section 8.3 “Capture Mode”**) 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.

8.5.2 PWM DUTY CYCLE

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

$$\text{PWM duty cycle} = (\text{CCPR1L:CCP1CON<5:4>}) \cdot T_{osc} \cdot (\text{TMR2 prescale value})$$

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

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

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

The maximum PWM resolution (bits) for a given PWM frequency is given by the formula:

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

Note: If the PWM duty cycle value is longer than the PWM period, the CCP1 pin will not be cleared.

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9.3.1.1 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:

- The SSPSR register value is loaded into the SSPBUF register.
- The Buffer Full bit, BF is set.
- An $\overline{\text{ACK}}$ pulse is generated.
- 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 9-7). The five Most Significant bits (MSBs) of the first address byte specify if this is a 10-bit address. Bit $\overline{\text{R/W}}$ (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 is as follows, with steps 7-9 for slave-transmitter:

- Receive first (high) byte of address (bits SSPIF, BF, and bit UA (SSPSTAT<1>) are set).
- Update the SSPADD register with second (low) byte of address (clears bit UA and releases the SCL line).
- Read the SSPBUF register (clears bit BF) and clear flag bit SSPIF.
- Receive second (low) byte of address (bits SSPIF, BF and UA are set).
- Update the SSPADD register with the first (high) byte of address, if match releases SCL line, this will clear bit UA.
- Read the SSPBUF register (clears bit BF) and clear flag bit SSPIF.
- Receive Repeated Start condition.
- Receive first (high) byte of address (bits SSPIF and BF are set).
- Read the SSPBUF register (clears bit BF) and clear flag bit SSPIF.

TABLE 9-2: DATA TRANSFER RECEIVED BYTE ACTIONS

Status Bits as Data Transfer is Received		SSPSR → SSPBUF	Generate $\overline{\text{ACK}}$ 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

Note: Shaded cells show the conditions where the user software did not properly clear the overflow condition.

9.3.1.2 Reception

When the $\overline{\text{R/W}}$ bit of the address byte is clear and an address match occurs, the $\overline{\text{R/W}}$ 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 (ACK) pulse is given. An overflow condition is defined as either bit BF (SSPSTAT<0>) is set, or bit SSPOV (SSPCON<6>) is set. This is an error condition due to the user's firmware.

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.

10.2 USART Asynchronous Mode

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

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

The USART Asynchronous module consists of the following important elements:

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

10.2.1 USART ASYNCHRONOUS TRANSMITTER

The USART transmitter block diagram is shown in Figure 10-1. The heart of the transmitter is the Transmit (serial) Shift Register (TSR). The shift register obtains its data from the read/write transmit buffer, TXREG. The TXREG register is loaded with data by firmware. The TSR register is not loaded until the Stop bit has been transmitted from the previous load. As soon as the Stop bit is transmitted, the TSR is loaded with new data from the TXREG register (if available). Once the TXREG register transfers the data to the TSR register, the TXREG register is empty. One instruction cycle later, flag bit TXIF (PIR1<4>) and flag bit TRMT (TXSTA<1>) are set. The TXIF interrupt can be enabled/disabled by setting/clearing enable bit TXIE (PIE1<4>). Flag bit TXIF will be set, regardless of the state of enable bit TXIE and cannot be cleared in software. It will reset only when new data is loaded into the TXREG register. While flag bit TXIF indicates the status of the TXREG register, another bit TRMT (TXSTA<1>) shows the status of the TSR register. Status bit TRMT is a read-only bit, which is set one instruction cycle after the TSR register becomes empty, and is cleared one instruction cycle after the TSR register is loaded. No interrupt logic is tied to this bit, so the user has to poll this bit in order to determine if the TSR register is empty.

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

2: Flag bit TXIF is set when enable bit TXEN is set. TXIF is cleared by loading TXREG.

Transmission is enabled by setting enable bit TXEN (TXSTA<5>). The actual transmission will not occur until the TXREG register has been loaded with data and the baud rate generator (BRG) has produced a shift clock (Figure 10-2). The transmission can also be started by first loading the TXREG register and then setting enable bit TXEN. Normally, when transmission is first started, the TSR register is empty. At that point, transfer to the TXREG register will result in an immediate transfer to TSR, resulting in an empty TXREG. A back-to-back transfer is thus possible (Figure 10-3). Clearing enable bit TXEN during a transmission will cause the transmission to be aborted and will reset the transmitter. As a result, the RC6/TX/CK pin will revert to high-impedance.

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

FIGURE 10-3: ASYNCHRONOUS MASTER TRANSMISSION (BACK-TO-BACK)

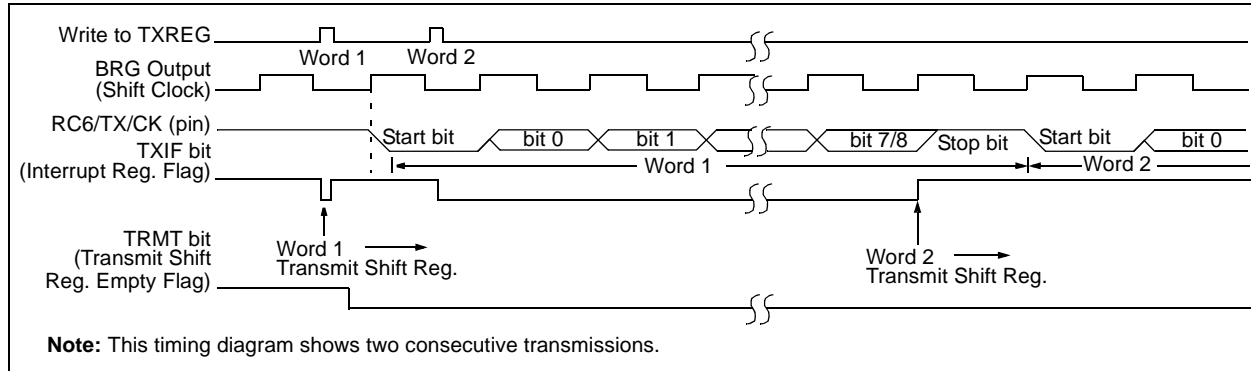


TABLE 10-5: REGISTERS ASSOCIATED WITH ASYNCHRONOUS TRANSMISSION

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
0Bh, 8Bh, 10Bh, 18Bh	INTCON	GIE	PEIE	TMR0IE	INTE	RBIE	TMR0IF	INTF	RBF	0000 000x	0000 000u
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	USART Transmit Data Register								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 PIC16CR73/76; always maintain these bits clear.

10.2.2 USART ASYNCHRONOUS RECEIVER

The receiver block diagram is shown in Figure 10-4. The data is received on the RC7/RX/DT pin and drives the data recovery block. The data recovery block is actually a high-speed shifter operating at x16 times the baud rate, whereas the main receive serial shifter operates at the bit rate, or at Fosc.

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

The heart of the receiver is the Receive (serial) Shift Register (RSR). After sampling the Stop bit, the received data in the RSR is transferred to the RCREG register (if it is empty). If the transfer is complete, flag bit RCIF (PIR1<5>) is set. The actual interrupt can be enabled/disabled by setting/clearing enable bit RCIE (PIE1<5>). Flag bit RCIF is a read-only bit which is cleared by the hardware. It is cleared when the RCREG register has been read and is empty. The RCREG is a double buffered register (i.e., it is a two-deep FIFO). It is possible for two bytes of data to be received and transferred to the RCREG FIFO and a third byte to begin shifting to the RSR register. On the detection of the Stop bit of the third byte, if the RCREG register is still full, the 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 and no further data will be received, therefore, 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 10-6: SYNCHRONOUS TRANSMISSION

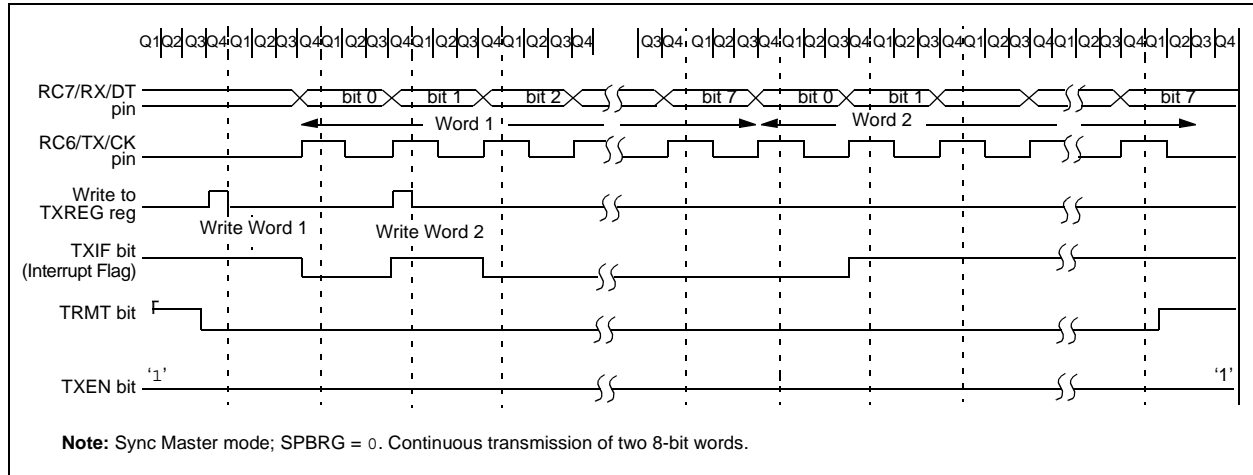


FIGURE 10-7: SYNCHRONOUS TRANSMISSION (THROUGH TXEN)

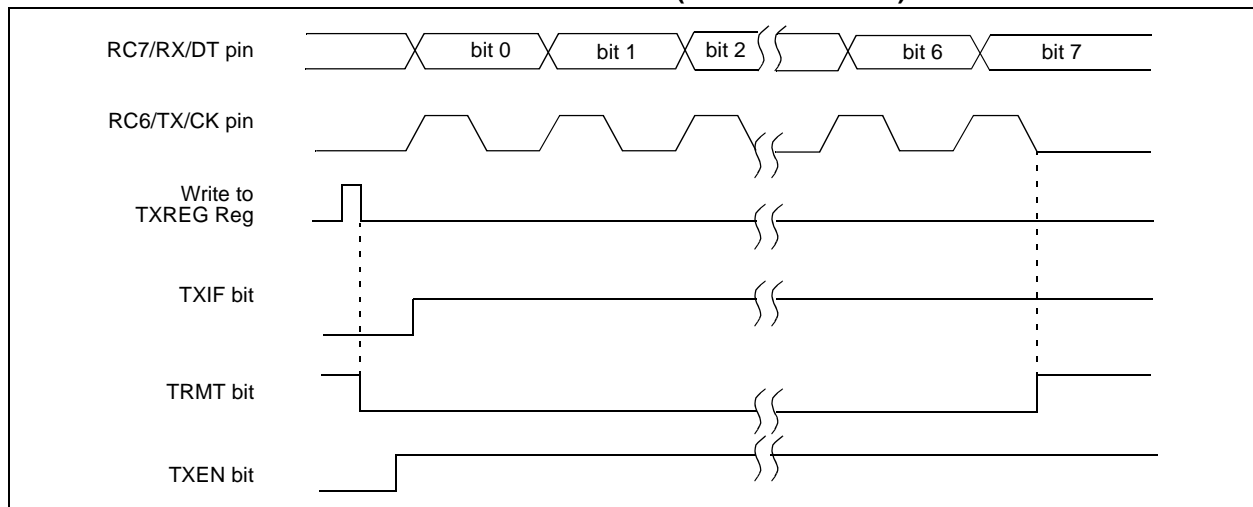


TABLE 10-7: REGISTERS ASSOCIATED WITH SYNCHRONOUS MASTER TRANSMISSION

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
0Bh, 8Bh, 10Bh, 18Bh	INTCON	GIE	PEIE	TMR0IE	INTE	RBIE	TMR0IF	INTF	RBIF	0000 000x	0000 000u
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	USART Transmit Data Register								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 PIC16CR73/76 devices; always maintain these bits clear.

PIC16CR7X

REGISTER 11-2: ADCON1: (ADDRESS 1Fh)

U-0	U-0	U-0	U-0	U-0	R/W-0	R/W-0	R/W-0
—	—	—	—	—	PCFG2	PCFG1	PCFG0
bit 7							bit 0

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

-n = Value at POR

'1' = Bit is set

'0' = Bit is cleared

x = Bit is unknown

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 ⁽¹⁾	RE1 ⁽¹⁾	RE2 ⁽¹⁾	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	VDD

A = Analog input

D = Digital I/O

Note 1: RE0, RE1 and RE2 are implemented on the PIC16CR74/77 only.

PIC16CR7X

REGISTER 12-1: CONFIGURATION WORD: (ADDRESS 2007h⁽¹⁾)

U-0	U-0	U-0	U-0	U-0	U-0	U-0
—	—	—	—	—	—	—
bit 13						bit 7

R/P-1	U-0	R/P-1	R/P-1	R/P-1	R/P-1	R/P-1
BOREN	—	CP0	$\overline{\text{PWRTE}}\text{N}$	WDTEN	FOSC1	FOSC0
bit 6						bit 0

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

-n = Value at POR

'1' = Bit is set

'0' = Bit is cleared

x = Bit is
unknown

bit 13-7

Unimplemented: Read as '1'

bit 6

BOREN: Brown-out Reset Enable bit

1 = BOR enabled

0 = BOR disabled

bit 5

Unimplemented: Read as '1'

bit 4

CP0: ROM Program Memory Code Protection bit

1 = Code protection off

0 = All memory locations code protected

bit 3

PWRTEN: Power-up Timer Enable bit

1 = PWRT disabled

0 = PWRT enabled

bit 2

WDTEN: 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: The erased (unprogrammed) value of the Configuration Word is 3FFFh.

PIC16CR7X

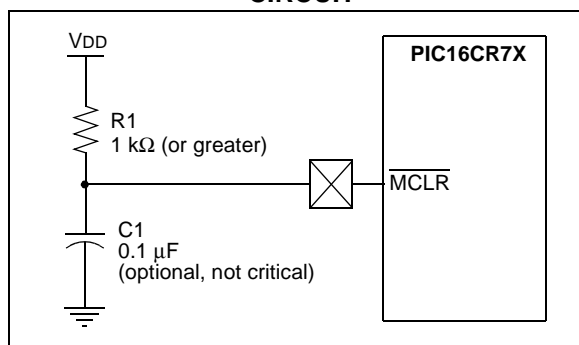
12.4 MCLR

PIC16CR7X devices have a 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.

The behavior of the ESD protection on the $\overline{\text{MCLR}}$ pin has been altered from previous devices of this family. Voltages applied to the pin that exceed its specification can result in both $\overline{\text{MCLR}}$ Resets and excessive current beyond the device specification during the ESD event. For this reason, Microchip recommends that the $\overline{\text{MCLR}}$ pin no longer be tied directly to VDD. The use of an RC network, as shown in Figure 12-5, is suggested.

FIGURE 12-5: RECOMMENDED MCLR CIRCUIT



12.5 Power-on Reset (POR)

A Power-on Reset pulse is generated on-chip when VDD rise is detected (in the range of 1.2V-1.7V). To take advantage of the POR, tie the $\overline{\text{MCLR}}$ pin to VDD as described in **Section 12.4 “MCLR”**. A maximum rise time for VDD is specified. See the 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” (DS00607).

12.6 Power-up Timer (PWRT)

The Power-up Timer provides a fixed 72 ms nominal time-out on power-up only from the POR. The Power-up Timer operates on an internal RC oscillator. The chip is kept in Reset as long as the PWRT is active. The PWRT's time delay allows VDD to rise to an acceptable level. A Configuration bit is provided to enable/disable the PWRT.

The power-up time delay will vary from chip-to-chip, due to VDD, temperature and process variation. See DC parameters for details (TPWRT, parameter #33).

12.7 Oscillator Start-up Timer (OST)

The Oscillator Start-up Timer (OST) provides 1024 oscillator cycles (from OSC1 input) delay after the PWRT delay is over (if enabled). This helps to ensure 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.

12.8 Brown-out Reset (BOR)

The Configuration bit, BODEN, can enable or disable the Brown-out Reset circuit. If VDD falls below VBOR (parameter D005, about 4V) for longer than TBOR (parameter #35, about 100 μS), 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 72 mS). 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 PWRT Configuration bit.

12.9 Time-out Sequence

On power-up, the time-out sequence is as follows: the PWRT delay starts (if enabled) when a POR Reset occurs. Then, OST starts counting 1024 oscillator cycles when PWRT ends (LP, XT, HS). When the OST ends, the device comes out of Reset.

If $\overline{\text{MCLR}}$ is kept low long enough, all delays will expire. Bringing $\overline{\text{MCLR}}$ high will begin execution immediately. This is useful for testing purposes or to synchronize more than one PIC16CR7X device operating in parallel.

Table 12-5 shows the Reset conditions for the STATUS, PCON and PC registers, while Table 12-6 shows the Reset conditions for all the registers.

12.10 Power Control/Status Register (PCON)

The Power Control/Status Register, PCON, has two bits to indicate the type of Reset that last occurred.

Bit 0 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 Brown-out Reset occurred. When the Brown-out Reset is disabled, the state of the $\overline{\text{BOR}}$ bit is unpredictable.

Bit 1 is $\overline{\text{POR}}$ (Power-on Reset Status bit). It is cleared on a Power-on Reset and unaffected otherwise. The user must set this bit following a Power-on Reset.

TABLE 12-3: TIME-OUT IN VARIOUS SITUATIONS

Oscillator Configuration	Power-up		Brown-out	Wake-up from Sleep
	$\overline{\text{PWRTE}} = 0$	$\overline{\text{PWRTE}} = 1$		
XT, HS, LP	72 ms + 1024 Tosc	1024 Tosc	72 ms + 1024 Tosc	1024 Tosc
RC	72 ms	—	72 ms	—

TABLE 12-4: STATUS BITS AND THEIR SIGNIFICANCE

$\overline{\text{POR}}$ (PCON<1>)	$\overline{\text{BOR}}$ (PCON<0>)	$\overline{\text{TO}}$ (STATUS<4>)	$\overline{\text{PD}}$ (STATUS<3>)	Significance
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	1	1	Brown-out Reset
1	1	0	1	WDT Reset
1	1	0	0	WDT Wake-up
1	1	u	u	MCLR Reset during normal operation
1	1	1	0	MCLR Reset during Sleep or interrupt wake-up from Sleep

TABLE 12-5: RESET CONDITION FOR SPECIAL REGISTERS

Condition	Program Counter	STATUS Register	PCON Register
Power-on Reset	000h	0001 1xxx	---- --0x
MCLR Reset during normal operation	000h	000u uuuu	---- --uu
MCLR Reset during Sleep	000h	0001 0uuu	---- --uu
WDT Reset	000h	0000 1uuu	---- --uu
WDT Wake-up	PC + 1	uuu0 0uuu	---- --uu
Brown-out Reset	000h	0001 1uuu	---- --u0
Interrupt wake-up from Sleep	PC + 1 ⁽¹⁾	uuu1 0uuu	---- --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).

12.13 Watchdog Timer (WDT)

The Watchdog Timer is 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 \overline{TO} bit in the STATUS register will be cleared upon a Watchdog Timer time-out.

The WDT can be permanently disabled by clearing Configuration bit, WDTE (Section 12.1 “Configuration Bits”).

WDT time-out period values may be found in the Electrical Specifications section under parameter #31. Values for the WDT prescaler (actually a postscaler, but shared with the Timer0 prescaler), may be assigned using the OPTION_REG register.

Note 1: 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.

2: When a CLRWDT instruction is executed and the prescaler is assigned to the WDT, the prescaler count will be cleared, but the prescaler assignment is not changed.

FIGURE 12-11: WATCHDOG TIMER BLOCK DIAGRAM

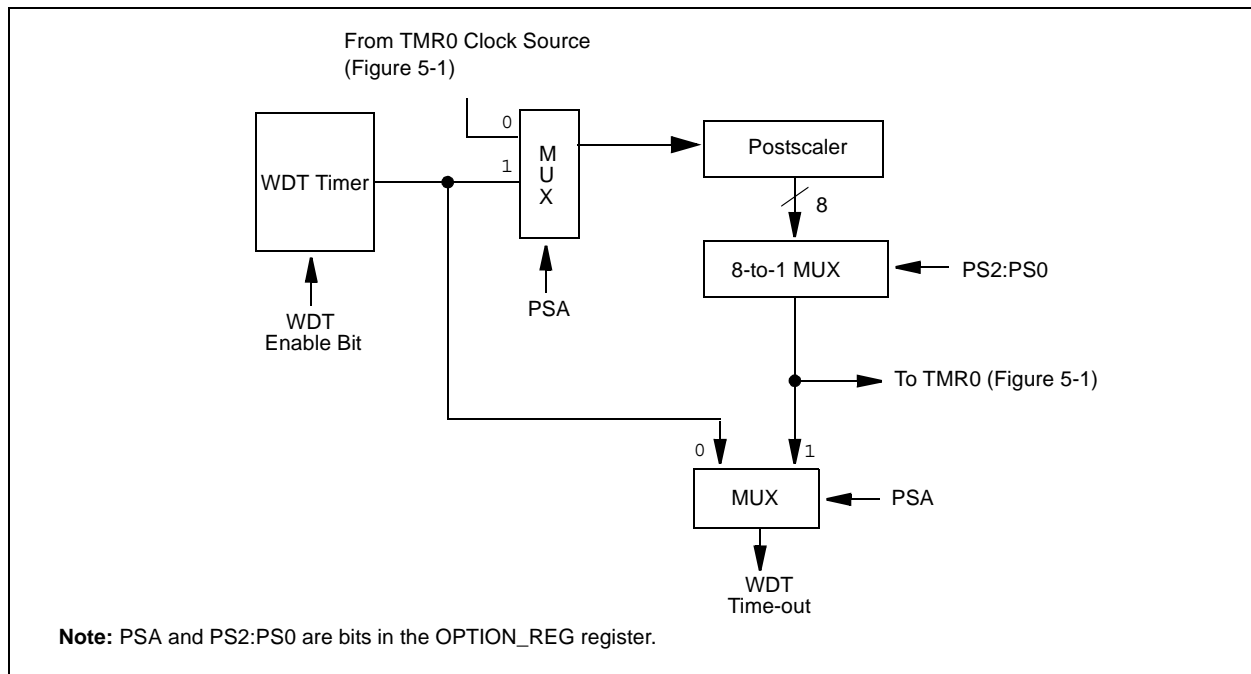


TABLE 12-7: SUMMARY OF WATCHDOG TIMER REGISTERS

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
2007h	Config. bits	(1)	BOREN ⁽¹⁾	—	CP0	PWRTEN ⁽¹⁾	WDTEN	FOSC1	FOSC0
81h,181h	OPTION_REG	\overline{RBPU}	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0

Legend: Shaded cells are not used by the Watchdog Timer.

Note 1: See Register 12-1 for operation of these bits.

FIGURE 16-13: TYPICAL, MINIMUM AND MAXIMUM WDT PERIOD vs. V_{DD} (-40°C TO 125°C)

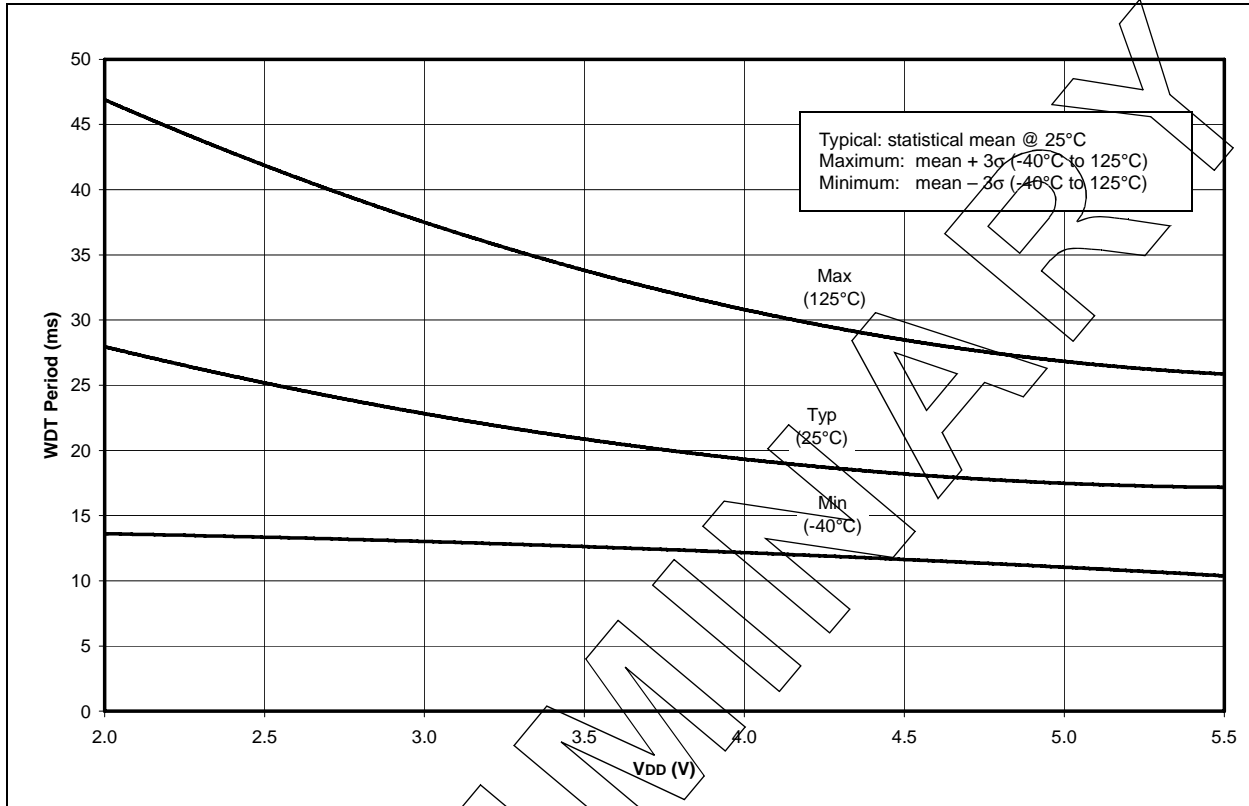
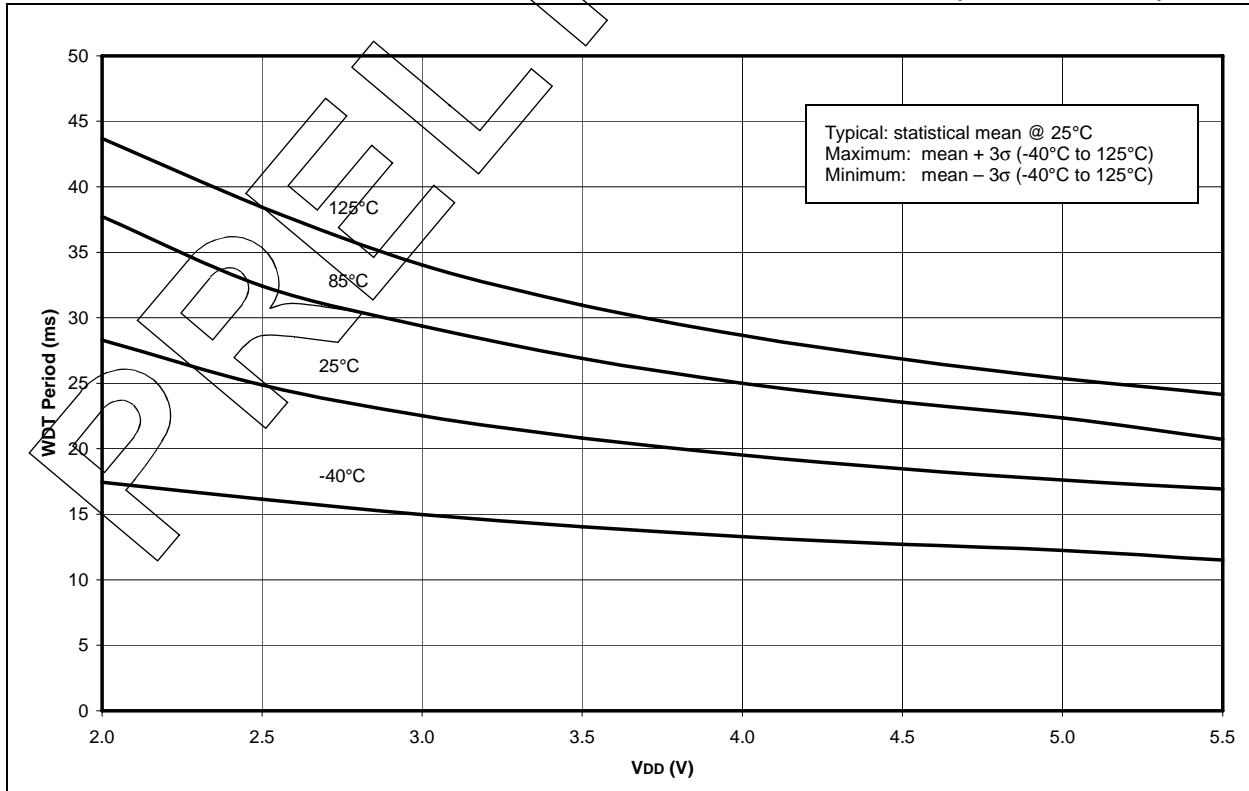


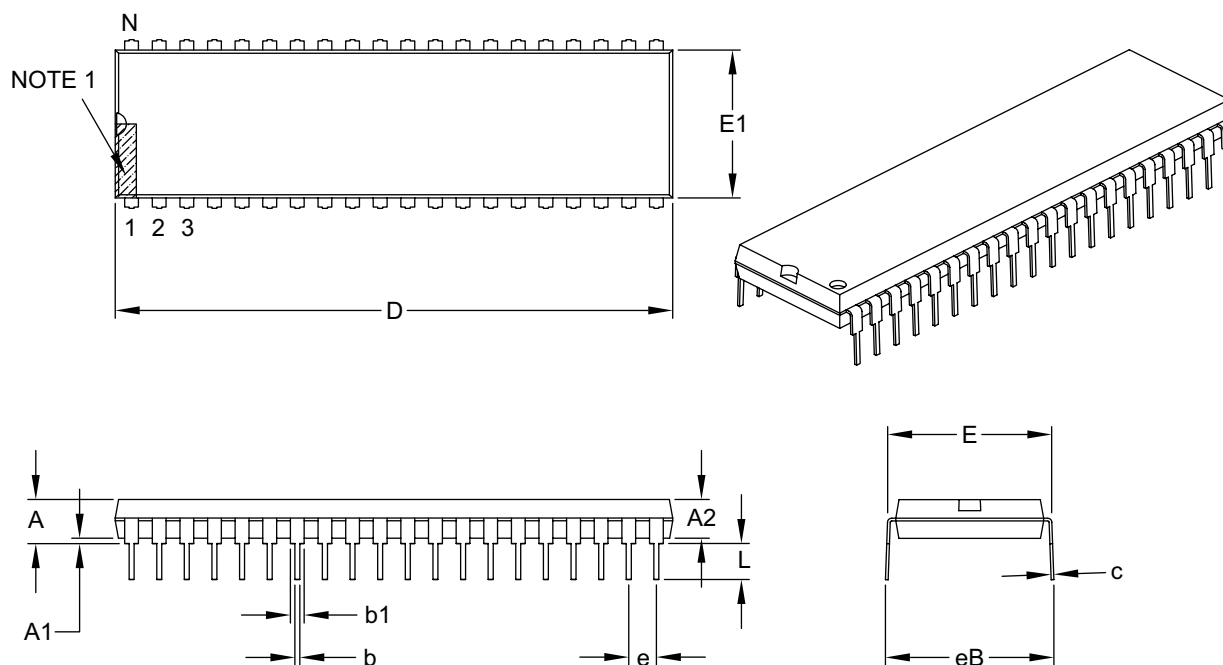
FIGURE 16-14: AVERAGE WDT PERIOD vs. V_{DD} OVER TEMPERATURE (-40°C TO 125°C)



PIC16CR7X

40-Lead Plastic Dual In-Line (P) – 600 mil Body [PDIP]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



Units		INCHES		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N	40		
Pitch	e	.100 BSC		
Top to Seating Plane	A	–	–	.250
Molded Package Thickness	A2	.125	–	.195
Base to Seating Plane	A1	.015	–	–
Shoulder to Shoulder Width	E	.590	–	.625
Molded Package Width	E1	.485	–	.580
Overall Length	D	1.980	–	2.095
Tip to Seating Plane	L	.115	–	.200
Lead Thickness	c	.008	–	.015
Upper Lead Width	b1	.030	–	.070
Lower Lead Width	b	.014	–	.023
Overall Row Spacing §	eB	–	–	.700

Notes:

- Pin 1 visual index feature may vary, but must be located within the hatched area.
- § Significant Characteristic.
- Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" per side.
- Dimensioning and tolerancing per ASME Y14.5M.

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-016B

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