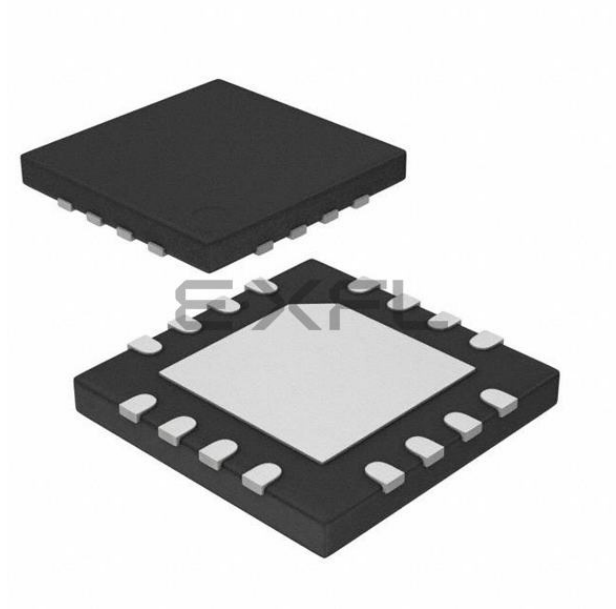

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Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	32MHz
Connectivity	LINbus, UART/USART
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	12
Program Memory Size	14KB (8K x 14)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	1K x 8
Voltage - Supply (Vcc/Vdd)	2.3V ~ 5.5V
Data Converters	A/D 8x10b; D/A 1x5b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	16-UQFN Exposed Pad
Supplier Device Package	16-UQFN (4x4)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16f1575-i-jq

3.3.2 SPECIAL FUNCTION REGISTER

The Special Function Registers are registers used by the application to control the desired operation of peripheral functions in the device. The Special Function Registers occupy the 20 bytes after the core registers of every data memory bank (addresses x0Ch/x8Ch through x1Fh/x9Fh). The registers associated with the operation of the peripherals are described in the appropriate peripheral chapter of this data sheet.

3.3.3 GENERAL PURPOSE RAM

There are up to 80 bytes of GPR in each data memory bank. The Special Function Registers occupy the 20 bytes after the core registers of every data memory bank (addresses x0Ch/x8Ch through x1Fh/x9Fh).

3.3.3.1 Linear Access to GPR

The general purpose RAM can be accessed in a non-banked method via the FSRs. This can simplify access to large memory structures. See **Section 3.6.2 "Linear Data Memory"** for more information.

3.3.4 COMMON RAM

There are 16 bytes of common RAM accessible from all banks.

3.3.5 DEVICE MEMORY MAPS

The memory maps are as shown in Table 3-3 through Table 3-13.

FIGURE 3-3: BANKED MEMORY PARTITIONING

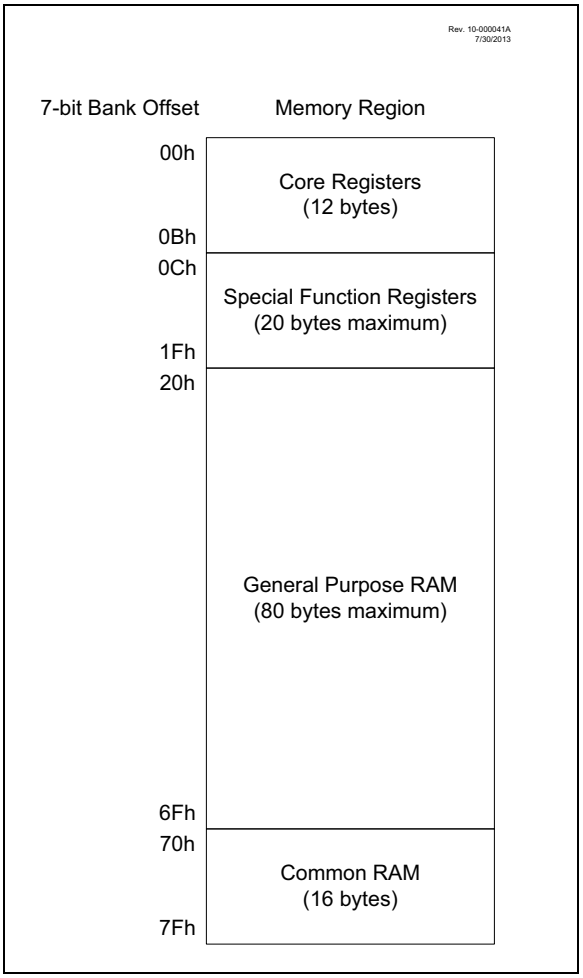


TABLE 3-15: SPECIAL FUNCTION REGISTER SUMMARY (CONTINUED)

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
Bank 10											
50Ch to 51Fh	—	Unimplemented								—	—
Bank 11											
58Ch to 59Fh	—	Unimplemented								—	—
Bank 12											
60Ch to 61Fh	—	Unimplemented								—	—
Bank 13											
68Ch to 690h	—	Unimplemented								—	—
691h	CWG1DBR	—	—	CWG1DBR<5:0>						--00 0000	--00 0000
692h	CWG1DBF	—	—	CWG1DBF<5:0>						--xx xxxx	--xx xxxx
693h	CWG1CON0	G1EN	—	—	G1POLB	G1POLA	—	—	G1CS0	0--0 0--0	0--0 0--0
694h	CWG1CON1	G1ASDLB<1:0>		G1ASDLA<1:0>		—	G1IS<2:0>			0000 -000	0000 -000
695h	CWG1CON2	G1ASE	G1ARSEN	—	—	G1ASDSC2	G1ASDSC1	G1ASDSPPS	—	00-- 000-	00-- 000-
696h to 69Fh	—	Unimplemented								—	—
Banks 14-26											
x0Ch/x8Ch — x1Fh/x9Fh	—	Unimplemented								—	—

Legend: x = unknown, u = unchanged, q = value depends on condition, - = unimplemented, r = reserved. Shaded locations are unimplemented, read as '0'.
Note 1: PIC16(L)F1578/9 only.
2: PIC16F1574/5/8/9 only.
3: Unimplemented, read as '1'.

5.0 OSCILLATOR MODULE

5.1 Overview

The oscillator module has a wide variety of clock sources and selection features that allow it to be used in a wide range of applications while maximizing performance and minimizing power consumption. Figure 5-1 illustrates a block diagram of the oscillator module.

Clock sources can be supplied from external logic level clocks. In addition, the system clock source can be supplied from one of two internal oscillators and PLL circuits, with a choice of speeds selectable via software. Additional clock features include:

- Selectable system clock source between external or internal sources via software.

The oscillator module can be configured in one of the following clock modes.

1. ECL – External Clock Low-Power mode (0 MHz to 0.5 MHz)
2. ECM – External Clock Medium Power mode (0.5 MHz to 4 MHz)
3. ECH – External Clock High-Power mode (4 MHz to 32 MHz)
4. INTOSC – Internal oscillator (31 kHz to 32 MHz).

Clock Source modes are selected by the FOSC<1:0> bits in the Configuration Words. The FOSC bits determine the type of oscillator that will be used when the device is first powered.

The ECH, ECM, and ECL clock modes rely on an external logic level signal as the device clock source.

The INTOSC internal oscillator block produces low, medium, and high-frequency clock sources, designated LFINTOSC, MFINTOSC and HFINTOSC. (see Internal Oscillator Block, Figure 5-1). A wide selection of device clock frequencies may be derived from these three clock sources.

REGISTER 5-2: OSCSTAT: OSCILLATOR STATUS REGISTER

U-0	R-0/q	R-q/q	R-0/q	R-0/q	R-q/q	R-0/q	R-0/q
—	PLLR	OSTS	HFIOFR	HFIOFL	MFIOFR	LFIOFR	HFIOFS
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
‘1’ = Bit is set	‘0’ = Bit is cleared	q = Conditional

bit 7 **Unimplemented:** Read as ‘0’

bit 6 **PLLR** 4x PLL Ready bit
1 = 4x PLL is ready
0 = 4x PLL is not ready

bit 5 **OSTS:** Oscillator Start-up Timer Status bit
1 = Running from the clock defined by the FOSC<1:0> bits of the Configuration Words
0 = Running from an internal oscillator (FOSC<1:0> = 00)

bit 4 **HFIOFR:** High-Frequency Internal Oscillator Ready bit
1 = HFINTOSC is ready
0 = HFINTOSC is not ready

bit 3 **HFIOFL:** High-Frequency Internal Oscillator Locked bit
1 = HFINTOSC is at least 2% accurate
0 = HFINTOSC is not 2% accurate

bit 2 **MFIOFR:** Medium-Frequency Internal Oscillator Ready bit
1 = MFINTOSC is ready
0 = MFINTOSC is not ready

bit 1 **LFIOFR:** Low-Frequency Internal Oscillator Ready bit
1 = LFINTOSC is ready
0 = LFINTOSC is not ready

bit 0 **HFIOFS:** High-Frequency Internal Oscillator Stable bit
1 = HFINTOSC is at least 0.5% accurate
0 = HFINTOSC is not 0.5% accurate

6.13 Power Control (PCON) Register

The Power Control (PCON) register contains flag bits to differentiate between a:

- Power-On Reset ($\overline{POR}$)
- Brown-Out Reset ($\overline{BOR}$)
- Reset Instruction Reset ($\overline{RI}$)
- $\overline{MCLR}$ Reset ($\overline{RMCLR}$)
- Watchdog Timer Reset ($\overline{RWDT}$)
- Stack Underflow Reset (STKUNF)
- Stack Overflow Reset (STKOVF)

The PCON register bits are shown in Register 6-2.

6.14 Register Definitions: Power Control

REGISTER 6-2: PCON: POWER CONTROL REGISTER

R/W/HS-0/q	R/W/HS-0/q	U-0	R/W/HC-1/q	R/W/HC-1/q	R/W/HC-1/q	R/W/HC-q/u	R/W/HC-q/u
STKOVF	STKUNF	—	$\overline{RWDT}$	$\overline{RMCLR}$	$\overline{RI}$	$\overline{POR}$	$\overline{BOR}$
bit 7							bit 0

Legend:		
HC = Bit is cleared by hardware		HS = Bit is set by hardware
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
‘1’ = Bit is set	‘0’ = Bit is cleared	q = Value depends on condition

bit 7 **STKOVF:** Stack Overflow Flag bit
1 = A Stack Overflow occurred
0 = A Stack Overflow has not occurred or cleared by firmware

bit 6 **STKUNF:** Stack Underflow Flag bit
1 = A Stack Underflow occurred
0 = A Stack Underflow has not occurred or cleared by firmware

bit 5 **Unimplemented:** Read as ‘0’

bit 4 **$\overline{RWDT}$:** Watchdog Timer Reset Flag bit
1 = A Watchdog Timer Reset has not occurred or set by firmware
0 = A Watchdog Timer Reset has occurred (cleared by hardware)

bit 3 **$\overline{RMCLR}$:** $\overline{MCLR}$ Reset Flag bit
1 = A $\overline{MCLR}$ Reset has not occurred or set by firmware
0 = A $\overline{MCLR}$ Reset has occurred (cleared by hardware)

bit 2 **$\overline{RI}$:** RESET Instruction Flag bit
1 = A RESET instruction has not been executed or set by firmware
0 = A RESET instruction has been executed (cleared by hardware)

bit 1 **$\overline{POR}$:** Power-On Reset Status bit
1 = No Power-on Reset occurred
0 = A Power-on Reset occurred (must be set in software after a Power-on Reset occurs)

bit 0 **$\overline{BOR}$:** Brown-Out Reset Status bit
1 = No Brown-out Reset occurred
0 = A Brown-out Reset occurred (must be set in software after a Power-on Reset or Brown-out Reset occurs)

REGISTER 11-20: ANSELC: PORTC ANALOG SELECT REGISTER

R/W-1/1	R/W-1/1	U-0	U-0	R/W-1/1	R/W-1/1	R/W-1/1	R/W-1/1
ANSC7(2)	ANSC6(2)	—	—	ANSC3	ANSC2	ANSC1	ANSC0
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
'1' = Bit is set	'0' = Bit is cleared	

bit 7-6 **ANSC<7:6>**: Analog Select between Analog or Digital Function on pins RC<7:6>, respectively(1, 2)
0 = Digital I/O. Pin is assigned to port or digital special function.
1 = Analog input. Pin is assigned as analog input(1). Digital input buffer disabled.

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

bit 3-0 **ANSC<3:0>**: Analog Select between Analog or Digital Function on pins RC<3:0>, respectively(1)
0 = Digital I/O. Pin is assigned to port or digital special function.
1 = Analog input. Pin is assigned as analog input(1). Digital input buffer disabled.

Note 1: When setting a pin to an analog input, the corresponding TRIS bit must be set to Input mode in order to allow external control of the voltage on the pin.
2: ANSC<7:6> are available on PIC16(L)F1578/9 only.

REGISTER 11-21: WPUC: WEAK PULL-UP PORTC REGISTER

R/W-1/1	R/W-1/1	R/W-1/1	R/W-1/1	R/W-1/1	R/W-1/1	R/W-1/1	R/W-1/1
WPUC7(3)	WPUC6(3)	WPUC5	WPUC4	WPUC3	WPUC2	WPUC1	WPUC0
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
'1' = Bit is set	'0' = Bit is cleared	

bit 7-0 **WPUC<7:0>**: Weak Pull-up Register bits(3)
1 = Pull-up enabled
0 = Pull-up disabled

Note 1: Global $\overline{\text{WPUEN}}$ bit of the OPTION_REG register must be cleared for individual pull-ups to be enabled.
2: The weak pull-up device is automatically disabled if the pin is configured as an output.
3: WPUC<7:6> are available on PIC16(L)F1578/9 only.

REGISTER 13-4: IOCBP: INTERRUPT-ON-CHANGE PORTB POSITIVE EDGE REGISTER(1)

R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	U-0	U-0	U-0	U-0
IOCBP7	IOCBP6	IOCBP5	IOCBP4	—	—	—	—
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
'1' = Bit is set	'0' = Bit is cleared	

bit 7-4 **IOCBP<7:4>**: Interrupt-on-Change PORTB Positive Edge Enable bits
1 = Interrupt-on-Change enabled on the pin for a positive going edge. IOCBFx bit and IOCIF flag will be set upon detecting an edge.
0 = Interrupt-on-Change disabled for the associated pin.

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

Note 1: PORTB functions available on PIC16(L)F1578/9 devices only.

REGISTER 13-5: IOCBN: INTERRUPT-ON-CHANGE PORTB NEGATIVE EDGE REGISTER(1)

R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	U-0	U-0	U-0	U-0
IOCBN7	IOCBN6	IOCBN5	IOCBN4	—	—	—	—
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
'1' = Bit is set	'0' = Bit is cleared	

bit 7-4 **IOCBN<7:4>**: Interrupt-on-Change PORTB Negative Edge Enable bits
1 = Interrupt-on-Change enabled on the pin for a negative going edge. IOCBFx bit and IOCIF flag will be set upon detecting an edge.
0 = Interrupt-on-Change disabled for the associated pin.

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

Note 1: PORTB functions available on PIC16(L)F1578/9 devices only.

REGISTER 13-6: IOCBF: INTERRUPT-ON-CHANGE PORTB FLAG REGISTER(1)

R/W/HS-0/0	R/W/HS-0/0	R/W/HS-0/0	R/W/HS-0/0	U-0	U-0	U-0	U-0
IOCBF7	IOCBF6	IOCBF5	IOCBF4	—	—	—	—
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
'1' = Bit is set	'0' = Bit is cleared	HS - Bit is set in hardware

bit 7-4 **IOCBF<7:4>**: Interrupt-on-Change PORTB Flag bits
1 = An enabled change was detected on the associated pin.
Set when IOCBPx = 1 and a rising edge was detected on RBx, or when IOCBNx = 1 and a falling edge was detected on RBx.
0 = No change was detected, or the user cleared the detected change.

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

Note 1: PORTB functions available on PIC16(L)F1578/9 devices only.

16.1.5 INTERRUPTS

The ADC module allows for the ability to generate an interrupt upon completion of an Analog-to-Digital conversion. The ADC Interrupt Flag is the ADIF bit in the PIR1 register. The ADC Interrupt Enable is the ADIE bit in the PIE1 register. The ADIF bit must be cleared in software.

Note 1:	The ADIF bit is set at the completion of every conversion, regardless of whether or not the ADC interrupt is enabled.
2:	The ADC operates during Sleep only when the FRC oscillator is selected.

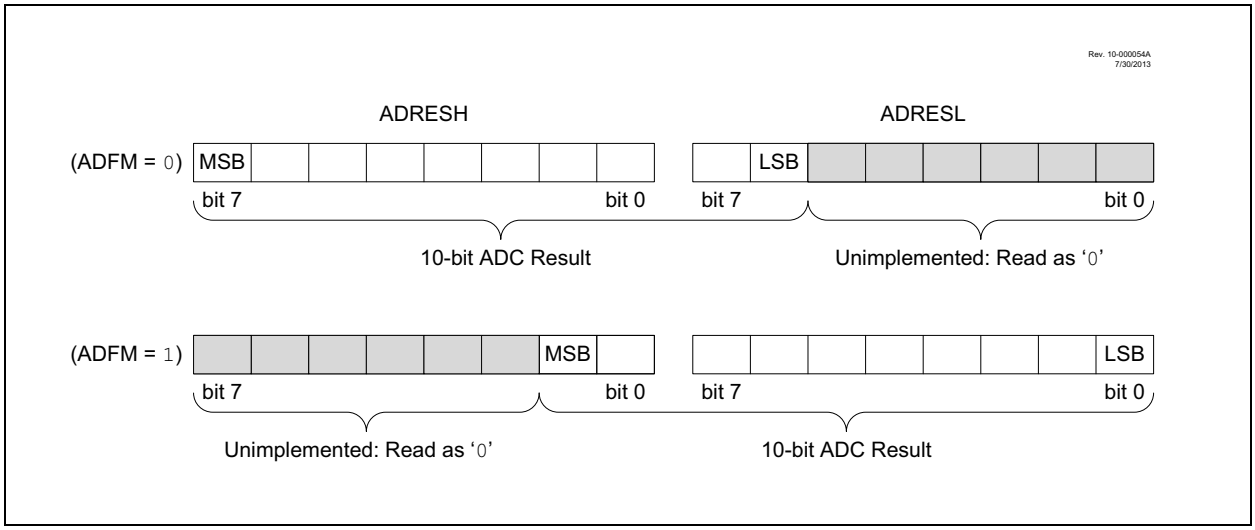
This interrupt can be generated while the device is operating or while in Sleep. If the device is in Sleep, the interrupt will wake-up the device. Upon waking from Sleep, the next instruction following the SLEEP instruction is always executed. If the user is attempting to wake-up from Sleep and resume in-line code execution, the ADIE bit of the PIE1 register and the PEIE bit of the INTCON register must both be set and the GIE bit of the INTCON register must be cleared. If all three of these bits are set, the execution will switch to the Interrupt Service Routine.

16.1.6 RESULT FORMATTING

The 10-bit ADC conversion result can be supplied in two formats, left justified or right justified. The ADFM bit of the ADCON1 register controls the output format.

Figure 16-3 shows the two output formats.

FIGURE 16-3: 10-BIT ADC CONVERSION RESULT FORMAT



16.2 ADC Operation

16.2.1 STARTING A CONVERSION

To enable the ADC module, the ADON bit of the ADCON0 register must be set to a '1'. Setting the GO/DONE bit of the ADCON0 register to a '1' will start the Analog-to-Digital conversion.

Note:	The GO/DONE bit should not be set in the same instruction that turns on the ADC. Refer to **Section 16.2.6 "ADC Conversion Procedure"**.

16.2.2 COMPLETION OF A CONVERSION

When the conversion is complete, the ADC module will:

- Clear the GO/DONE bit
- Set the ADIF Interrupt Flag bit
- Update the ADRESH and ADRESL registers with new conversion result

16.2.3 TERMINATING A CONVERSION

If a conversion must be terminated before completion, the GO/DONE bit can be cleared in software. The ADRESH and ADRESL registers will be updated with the partially complete Analog-to-Digital conversion sample. Incomplete bits will match the last bit converted.

Note:	A device Reset forces all registers to their Reset state. Thus, the ADC module is turned off and any pending conversion is terminated.

16.2.4 ADC OPERATION DURING SLEEP

The ADC module can operate during Sleep. This requires the ADC clock source to be set to the FRC option. Performing the ADC conversion during Sleep can reduce system noise. If the ADC interrupt is enabled, the device will wake-up from Sleep when the conversion completes. If the ADC interrupt is disabled, the ADC module is turned off after the conversion completes, although the ADON bit remains set.

When the ADC clock source is something other than FRC, a SLEEP instruction causes the present conversion to be aborted and the ADC module is turned off, although the ADON bit remains set.

16.2.5 AUTO-CONVERSION TRIGGER

The auto-conversion trigger allows periodic ADC measurements without software intervention. When a rising edge of the selected source occurs, the GO/DONE bit is set by hardware.

The auto-conversion trigger source is selected with the TRIGSEL<3:0> bits of the ADCON2 register.

Using the auto-conversion trigger does not assure proper ADC timing. It is the user's responsibility to ensure that the ADC timing requirements are met.

The PWM module can trigger the ADC in two ways, directly through the PWMx_OF_match or through the interrupts generated by all four match signals. See **Section 23.0 "16-bit Pulse-Width Modulation (PWM) Module"**. If the interrupts are chosen, each enabled interrupt in PWMxINTE will trigger a conversion. Refer to Figure 16-4 for more information.

See Table 16-2 for auto-conversion sources.

FIGURE 16-4: 16-BIT PWM INTERRUPT BLOCK DIAGRAM

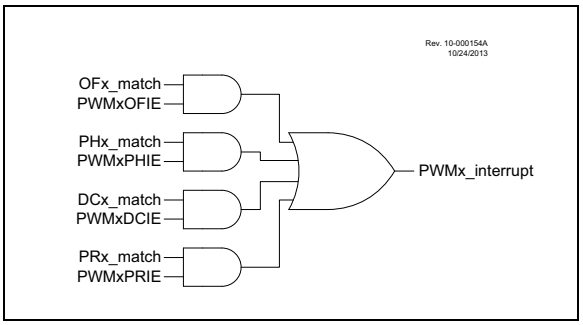


TABLE 16-2: AUTO-CONVERSION SOURCES

Source Peripheral	Signal Name
Timer0	T0_overflow
Timer1	T1_overflow
Timer2	T2_match
Comparator C1	C1OUT_sync
Comparator C2	C2OUT_sync
PWM1	PWM1_OF_match
PWM1	PWM1_interrupt
PWM2	PWM2_OF_match
PWM2	PWM2_interrupt
PWM3	PWM3_OF_match
PWM3	PWM3_interrupt
PWM4	PWM4_OF_match
PWM4	PWM4_interrupt
ADC Trigger	ADCACT
CWG Input Pin	CWGIN

REGISTER 16-6: ADRESH: ADC RESULT REGISTER HIGH (ADRESH) ADFM = 1

R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u
—	—	—	—	—	—	ADRES<9:8>	
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
‘1’ = Bit is set	‘0’ = Bit is cleared	

bit 7-2 **Reserved**: Do not use.

bit 1-0 **ADRES<9:8>**: ADC Result Register bits
Upper two bits of 10-bit conversion result

REGISTER 16-7: ADRESL: ADC RESULT REGISTER LOW (ADRESL) ADFM = 1

R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u
ADRES<7:0>							
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
‘1’ = Bit is set	‘0’ = Bit is cleared	

bit 7-0 **ADRES<7:0>**: ADC Result Register bits
Lower eight bits of 10-bit conversion result

20.3 Timer1 Prescaler

Timer1 has four prescaler options allowing 1, 2, 4 or 8 divisions of the clock input. The T1CKPS bits of the T1CON register control the prescale counter. The prescale counter is not directly readable or writable; however, the prescaler counter is cleared upon a write to TMR1H or TMR1L.

20.4 Timer1 Operation in Asynchronous Counter Mode

If control bit $\overline{\text{T1SYNC}}$ of the T1CON register is set, the external clock input is not synchronized. The timer increments asynchronously to the internal phase clocks. If the external clock source is selected then 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 (see **Section 20.4.1 "Reading and Writing Timer1 in Asynchronous Counter Mode"**).

Note:	When switching from synchronous to asynchronous operation, it is possible to skip an increment. When switching from asynchronous to synchronous operation, it is possible to produce an additional increment.

20.4.1 READING AND WRITING TIMER1 IN ASYNCHRONOUS COUNTER MODE

Reading TMR1H or TMR1L while the timer is running from an external asynchronous clock will ensure 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 TMR1H:TMR1L register pair.

20.5 Timer1 Gate

Timer1 can be configured to count freely or the count can be enabled and disabled using Timer1 gate circuitry. This is also referred to as Timer1 Gate Enable.

Timer1 gate can also be driven by multiple selectable sources.

20.5.1 TIMER1 GATE ENABLE

The Timer1 Gate Enable mode is enabled by setting the TMR1GE bit of the T1GCON register. The polarity of the Timer1 Gate Enable mode is configured using the T1GPOL bit of the T1GCON register.

When Timer1 Gate Enable mode is enabled, Timer1 will increment on the rising edge of the Timer1 clock source. When Timer1 Gate Enable mode is disabled, no incrementing will occur and Timer1 will hold the current count. See Figure 20-3 for timing details.

TABLE 20-3: TIMER1 GATE ENABLE SELECTIONS

T1CLK	T1GPOL	T1G	Timer1 Operation
↑	0	0	Counts
↑	0	1	Holds Count
↑	1	0	Holds Count
↑	1	1	Counts

20.5.2 TIMER1 GATE SOURCE SELECTION

Timer1 gate source selections are shown in Table 20-4. Source selection is controlled by the T1GSS<1:0> bits of the T1GCON register. The polarity for each available source is also selectable. Polarity selection is controlled by the T1GPOL bit of the T1GCON register.

TABLE 20-4: TIMER1 GATE SOURCES

T1GSS	Timer1 Gate Source
00	Timer1 Gate pin (T1G)
01	Overflow of Timer0 (T0_overflow) (TMR0 increments from FFh to 00h)
10	Comparator 1 Output (C1OUT_sync)(1)
11	Comparator 2 Output (C2OUT_sync)(1)

Note 1: Optionally synchronized comparator output.

FIGURE 20-4: TIMER1 GATE TOGGLE MODE

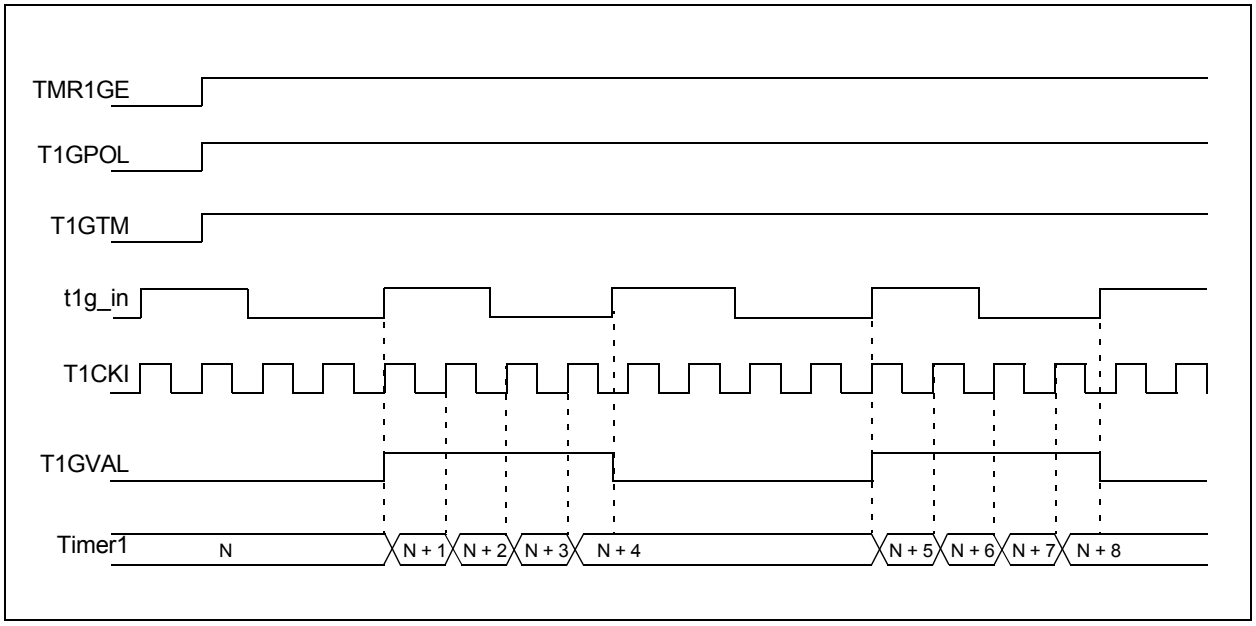
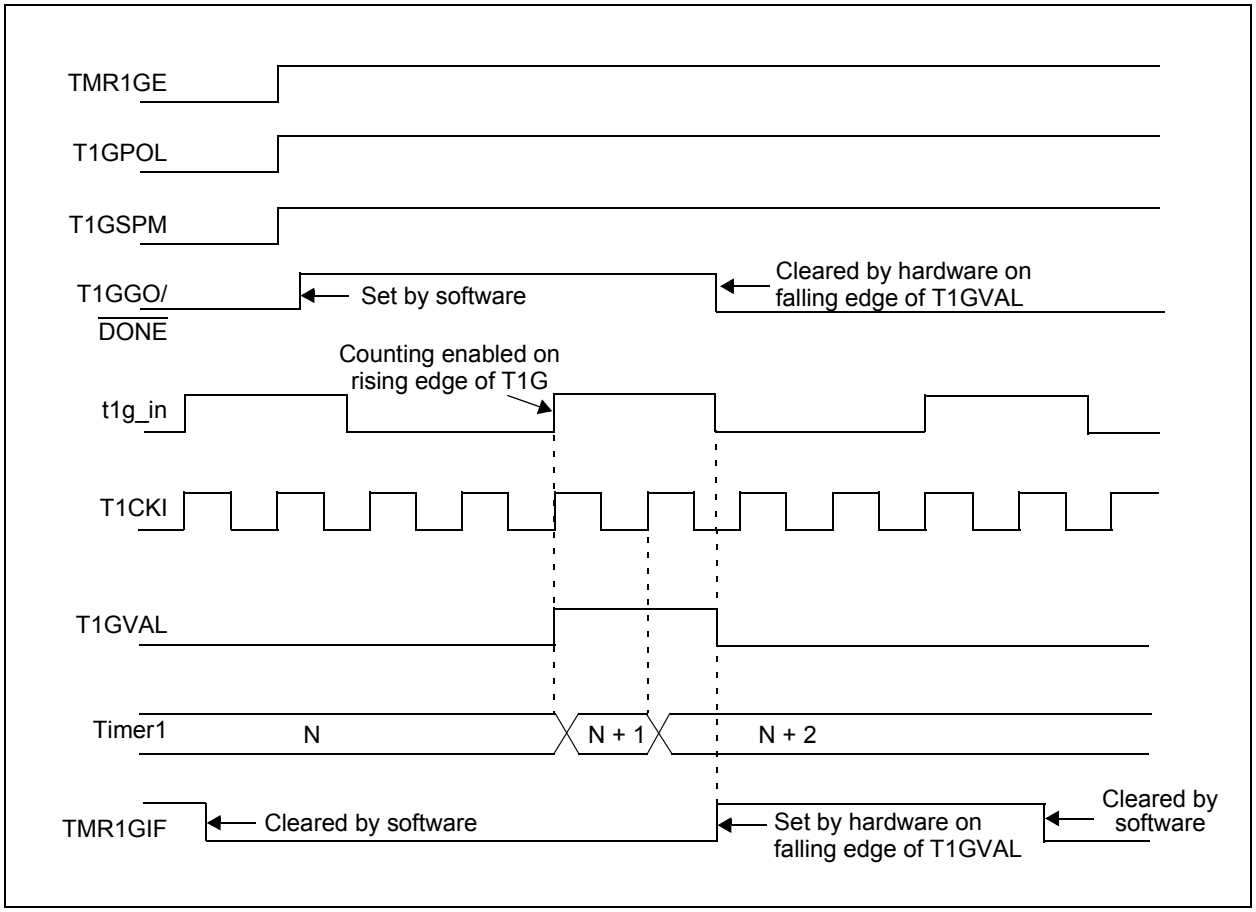


FIGURE 20-5: TIMER1 GATE SINGLE-PULSE MODE



22.1.2 EUSART ASYNCHRONOUS RECEIVER

The Asynchronous mode is typically used in RS-232 systems. The receiver block diagram is shown in Figure 22-2. The data is received on the RX/DT pin and drives the data recovery block. The data recovery block is actually a high-speed shifter operating at 16 times the baud rate, whereas the serial Receive Shift Register (RSR) operates at the bit rate. When all eight or nine bits of the character have been shifted in, they are immediately transferred to a two character First-In-First-Out (FIFO) memory. The FIFO buffering allows reception of two complete characters and the start of a third character before software must start servicing the EUSART receiver. The FIFO and RSR registers are not directly accessible by software. Access to the received data is via the RCREG register.

22.1.2.1 Enabling the Receiver

The EUSART receiver is enabled for asynchronous operation by configuring the following three control bits:

- CREN = 1
- SYNC = 0
- SPEN = 1

All other EUSART control bits are assumed to be in their default state.

Setting the CREN bit of the RCSTA register enables the receiver circuitry of the EUSART. Clearing the SYNC bit of the TXSTA register configures the EUSART for asynchronous operation. Setting the SPEN bit of the RCSTA register enables the EUSART. The programmer must set the corresponding TRIS bit to configure the RX/DT I/O pin as an input.

Note:	If the RX/DT function is on an analog pin, the corresponding ANSEL bit must be cleared for the receiver to function.

22.1.2.2 Receiving Data

The receiver data recovery circuit initiates character reception on the falling edge of the first bit. The first bit, also known as the Start bit, is always a zero. The data recovery circuit counts one-half bit time to the center of the Start bit and verifies that the bit is still a zero. If it is not a zero then the data recovery circuit aborts character reception, without generating an error, and resumes looking for the falling edge of the Start bit. If the Start bit zero verification succeeds then the data recovery circuit counts a full bit time to the center of the next bit. The bit is then sampled by a majority detect circuit and the resulting '0' or '1' is shifted into the RSR. This repeats until all data bits have been sampled and shifted into the RSR. One final bit time is measured and the level sampled. This is the Stop bit, which is always a '1'. If the data recovery circuit samples a '0' in the Stop bit position then a framing error is set for this character, otherwise the framing error is cleared for this character. See **Section 22.1.2.4 "Receive Framing Error"** for more information on framing errors.

Immediately after all data bits and the Stop bit have been received, the character in the RSR is transferred to the EUSART receive FIFO and the RCIF interrupt flag bit of the PIR1 register is set. The top character in the FIFO is transferred out of the FIFO by reading the RCREG register.

Note:	If the receive FIFO is overrun, no additional characters will be received until the overrun condition is cleared. See **Section 22.1.2.5 "Receive Overrun Error"** for more information on overrun errors.

22.1.2.3 Receive Interrupts

The RCIF interrupt flag bit of the PIR1 register is set whenever the EUSART receiver is enabled and there is an unread character in the receive FIFO. The RCIF interrupt flag bit is read-only, it cannot be set or cleared by software.

RCIF interrupts are enabled by setting all of the following bits:

- RCIE, Interrupt Enable bit of the PIE1 register
- PEIE, Peripheral Interrupt Enable bit of the INTCON register
- GIE, Global Interrupt Enable bit of the INTCON register

The RCIF interrupt flag bit will be set when there is an unread character in the FIFO, regardless of the state of interrupt enable bits.

22.3 Register Definitions: EUSART Control

REGISTER 22-1: TXSTA: TRANSMIT STATUS AND CONTROL REGISTER

R/W-/0	R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	R-1/1	R/W-0/0
CSRC	TX9	TXEN(1)	SYNC	SENDB	BRGH	TRMT	TX9D
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
'1' = Bit is set	'0' = Bit is cleared	

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)
1 = Transmit enabled
0 = Transmit disabled

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

bit 3 **SENDB:** Send Break Character bit
Asynchronous mode:
1 = Send Sync Break on next transmission (cleared by hardware upon completion)
0 = Sync Break transmission completed
Synchronous mode:
Don't care

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:** Ninth bit of Transmit Data
Can be address/data bit or a parity bit.

Note 1: SREN/CREN overrides TXEN in Sync mode.

22.5.1.5 Synchronous Master Reception

Data is received at the RX/DT pin. The RX/DT pin output driver is automatically disabled when the EUSART is configured for synchronous master receive operation.

In Synchronous mode, reception is enabled by setting either the Single Receive Enable bit (SREN of the RCSTA register) or the Continuous Receive Enable bit (CREN of the RCSTA register).

When SREN is set and CREN is clear, only as many clock cycles are generated as there are data bits in a single character. The SREN bit is automatically cleared at the completion of one character. When CREN is set, clocks are continuously generated until CREN is cleared. If CREN is cleared in the middle of a character the CK clock stops immediately and the partial character is discarded. If SREN and CREN are both set, then SREN is cleared at the completion of the first character and CREN takes precedence.

To initiate reception, set either SREN or CREN. Data is sampled at the RX/DT pin on the trailing edge of the TX/CK clock pin and is shifted into the Receive Shift Register (RSR). When a complete character is received into the RSR, the RCIF bit is set and the character is automatically transferred to the two character receive FIFO. The Least Significant eight bits of the top character in the receive FIFO are available in RCREG. The RCIF bit remains set as long as there are unread characters in the receive FIFO.

Note:	If the RX/DT function is on an analog pin, the corresponding ANSEL bit must be cleared for the receiver to function.

22.5.1.6 Slave Clock

Synchronous data transfers use a separate clock line, which is synchronous with the data. A device configured as a slave receives the clock on the TX/CK line. The TX/CK pin output driver is automatically disabled when the device is configured for synchronous slave transmit or receive operation. Serial data bits change on the leading edge to ensure they are valid at the trailing edge of each clock. One data bit is transferred for each clock cycle. Only as many clock cycles should be received as there are data bits.

Note:	If the device is configured as a slave and the TX/CK function is on an analog pin, the corresponding ANSEL bit must be cleared.

22.5.1.7 Receive Overrun Error

The receive FIFO buffer can hold two characters. An overrun error will be generated if a third character, in its entirety, is received before RCREG is read to access the FIFO. When this happens the OERR bit of the RCSTA register is set. Previous data in the FIFO will not be overwritten. The two characters in the FIFO buffer can be read, however, no additional characters will be received until the error is cleared. The OERR bit can only be cleared by clearing the overrun condition. If the overrun error occurred when the SREN bit is set and CREN is clear then the error is cleared by reading RCREG. If the overrun occurred when the CREN bit is set then the error condition is cleared by either clearing the CREN bit of the RCSTA register or by clearing the SPEN bit which resets the EUSART.

22.5.1.8 Receiving 9-bit Characters

The EUSART supports 9-bit character reception. When the RX9 bit of the RCSTA register is set the EUSART will shift nine bits into the RSR for each character received. The RX9D bit of the RCSTA register is the ninth, and Most Significant, data bit of the top unread character in the receive FIFO. When reading 9-bit data from the receive FIFO buffer, the RX9D data bit must be read before reading the eight Least Significant bits from the RCREG.

22.5.1.9 Synchronous Master Reception Set-up:

1. Initialize the SPBRGH, SPBRGL register pair for the appropriate baud rate. Set or clear the BRGH and BRG16 bits, as required, to achieve the desired baud rate.
2. Clear the ANSEL bit for the RX pin (if applicable).
3. Enable the synchronous master serial port by setting bits SYNC, SPEN and CSRC.
4. Ensure bits CREN and SREN are clear.
5. If interrupts are desired, set the RCIE bit of the PIE1 register and the GIE and PEIE bits of the INTCON register.
6. If 9-bit reception is desired, set bit RX9.
7. Start reception by setting the SREN bit or for continuous reception, set the CREN bit.
8. Interrupt flag bit RCIF will be set when reception of a character is complete. An interrupt will be generated if the enable bit RCIE was set.
9. Read the RCSTA register to get the ninth bit (if enabled) and determine if any error occurred during reception.
10. Read the 8-bit received data by reading the RCREG register.
11. If an overrun error occurs, clear the error by either clearing the CREN bit of the RCSTA register or by clearing the SPEN bit which resets the EUSART.

FIGURE 23-6: TOGGLE-ON MATCH PWM MODE TIMING DIAGRAM

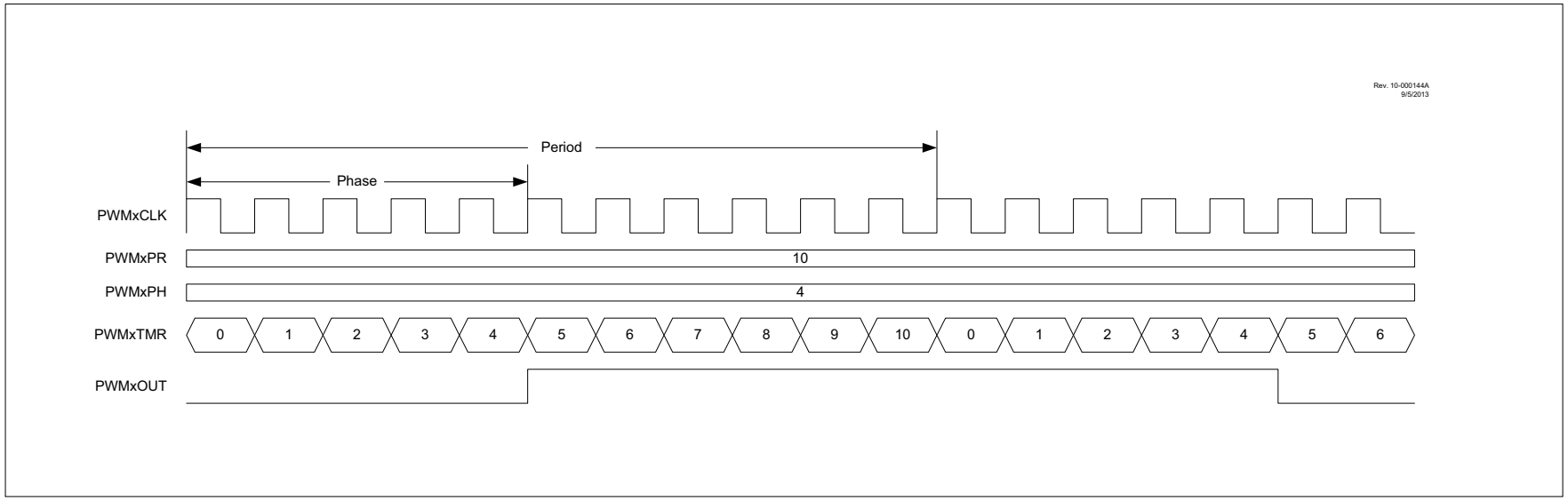
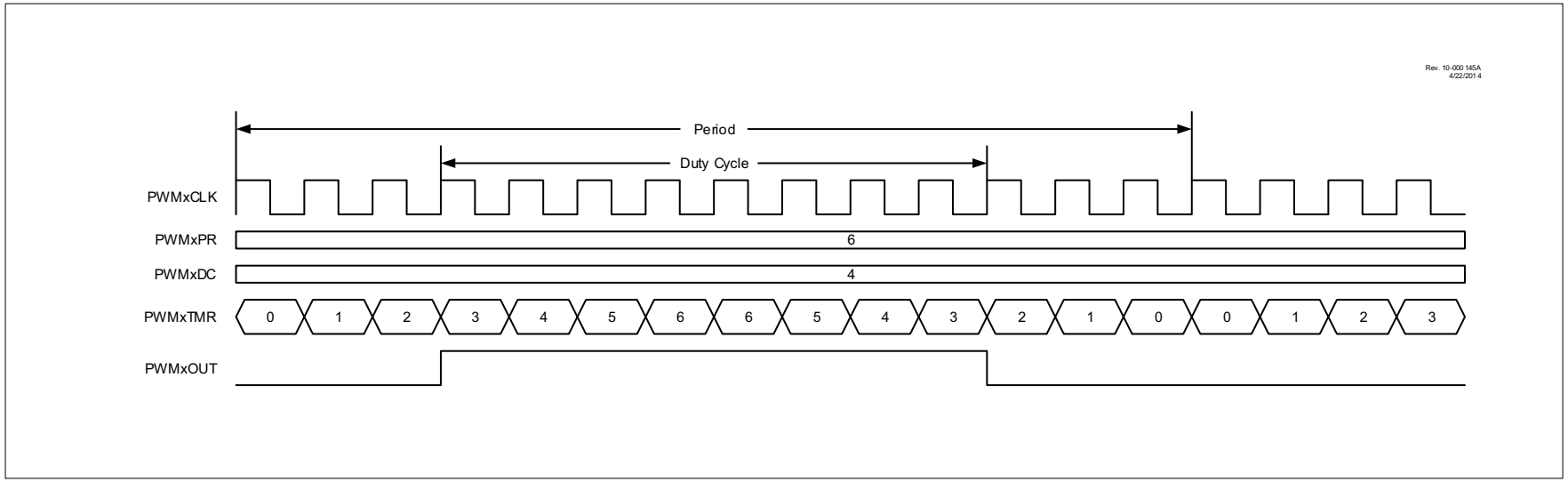


FIGURE 23-7: CENTER-ALIGNED PWM MODE TIMING DIAGRAM



REGISTER 23-13: PWMxOFH: PWMx OFFSET COUNT HIGH REGISTER

R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u
OF<15:8>							
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
‘1’ = Bit is set	‘0’ = Bit is cleared	

bit 7-0 **OF<15:8>**: PWM Offset High bits
Upper eight bits of PWM offset count

REGISTER 23-14: PWMxOFL: PWMx OFFSET COUNT LOW REGISTER

R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u
OF<7:0>							
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
‘1’ = Bit is set	‘0’ = Bit is cleared	

bit 7-0 **OF<7:0>**: PWM Offset Low bits
Lower eight bits of PWM offset count

REGISTER 24-2: CWGxCON1: CWG CONTROL REGISTER 1

R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	U-0	R/W-0/0	R/W-0/0	R/W-0/0
GxASDLB<1:0>		GxASDLA<1:0>		—	GxIS<2:0>		
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
'1' = Bit is set	'0' = Bit is cleared	q = Value depends on condition

bit 7-6 **GxASDLB<1:0>:** CWGx Shutdown State for CWGxB
When an auto shutdown event is present (GxASE = 1):
11 = CWGxB pin is driven to '1', regardless of the setting of the GxPOLB bit.
10 = CWGxB pin is driven to '0', regardless of the setting of the GxPOLB bit.
01 = CWGxB pin is tri-stated
00 = CWGxB pin is driven to its inactive state after the selected dead-band interval. GxPOLB still will control the polarity of the output.

bit 5-4 **GxASDLA<1:0>:** CWGx Shutdown State for CWGxA
When an auto shutdown event is present (GxASE = 1):
11 = CWGxA pin is driven to '1', regardless of the setting of the GxPOLA bit.
10 = CWGxA pin is driven to '0', regardless of the setting of the GxPOLA bit.
01 = CWGxA pin is tri-stated
00 = CWGxA pin is driven to its inactive state after the selected dead-band interval. GxPOLA still will control the polarity of the output.

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

bit 2-0 **GxIS<2:0>:** CWGx Input Source Select bits
111 = Reserved
110 = CWG input pin
101 = PWM4 – PWM4_out
100 = PWM3 – PWM3_out
011 = PWM2 – PWM2_out
010 = PWM1 – PWM1_out
001 = Comparator C2 – C2OUT_sync
000 = Comparator C1 – C1OUT_sync

FIGURE 27-10: TIMER0 AND TIMER1 EXTERNAL CLOCK TIMINGS

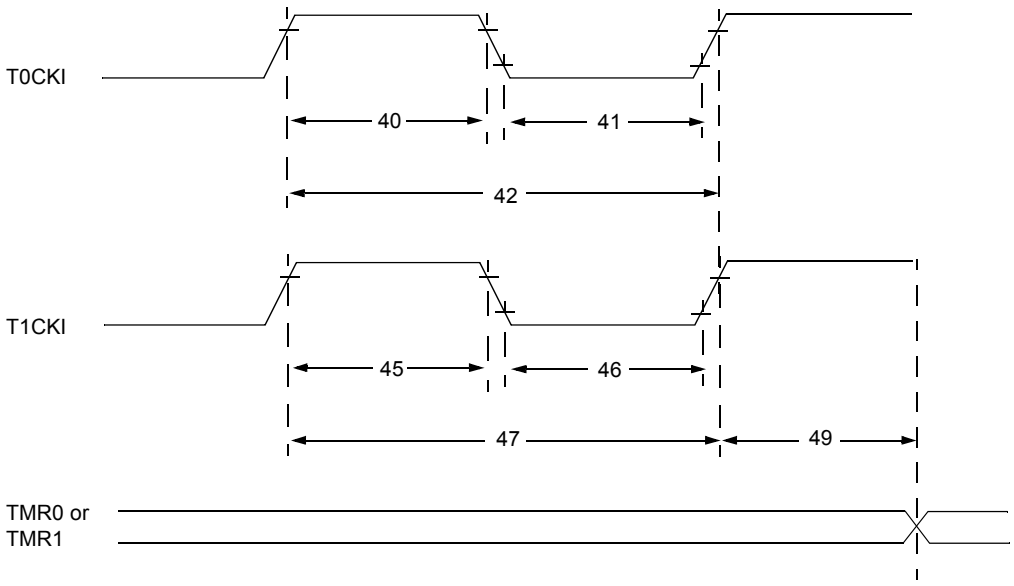


TABLE 27-12: TIMER0 AND TIMER1 EXTERNAL CLOCK REQUIREMENTS

Standard Operating Conditions (unless otherwise stated)								
Param. No.	**Sym.**	**Characteristic**		**Min.**	**Typ†**	**Max.**	**Units**	**Conditions**
40*	TT0H	T0CKI High Pulse Width	No Prescaler	0.5 TCY + 20	—	—	ns	
			With Prescaler	10	—	—	ns	
41*	TT0L	T0CKI Low Pulse Width	No Prescaler	0.5 TCY + 20	—	—	ns	
			With Prescaler	10	—	—	ns	
42*	TT0P	T0CKI Period		Greater of: 20 or TCY + 40 / N	—	—	ns	N = prescale value
45*	TT1H	T1CKI High Time	Synchronous, No Prescaler	0.5 TCY + 20	—	—	ns	
			Synchronous, with Prescaler	15	—	—	ns	
			Asynchronous	30	—	—	ns	
46*	TT1L	T1CKI Low Time	Synchronous, No Prescaler	0.5 TCY + 20	—	—	ns	
			Synchronous, with Prescaler	15	—	—	ns	
			Asynchronous	30	—	—	ns	
47*	TT1P	T1CKI Input Period	Synchronous	Greater of: 30 or TCY + 40 / N	—	—	ns	N = prescale value
			Asynchronous	60	—	—	ns	
49*	TCKEZTMR1	Delay from External Clock Edge to Timer Increment		2 TOSC	—	7 TOSC	—	Timers in Sync mode

* These parameters are characterized but not tested.

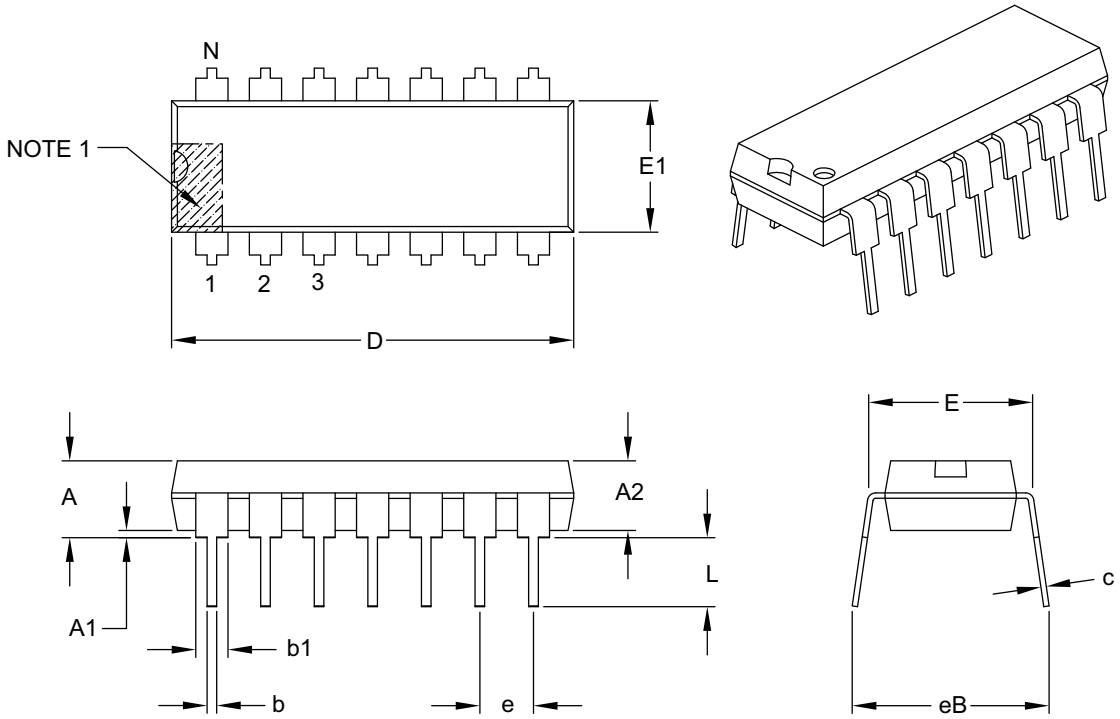
† Data in "Typ" column is at 3.0V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

30.2 Package Details

The following sections give the technical details of the packages.

14-Lead Plastic Dual In-Line (P) – 300 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		14	
Pitch	e		.100 BSC	
Top to Seating Plane	A	–	–	.210
Molded Package Thickness	A2	.115	.130	.195
Base to Seating Plane	A1	.015	–	–
Shoulder to Shoulder Width	E	.290	.310	.325
Molded Package Width	E1	.240	.250	.280
Overall Length	D	.735	.750	.775
Tip to Seating Plane	L	.115	.130	.150
Lead Thickness	c	.008	.010	.015
Upper Lead Width	b1	.045	.060	.070
Lower Lead Width	b	.014	.018	.022
Overall Row Spacing §	eB	–	–	.430

Notes:

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

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

Microchip Technology Drawing C04-005B