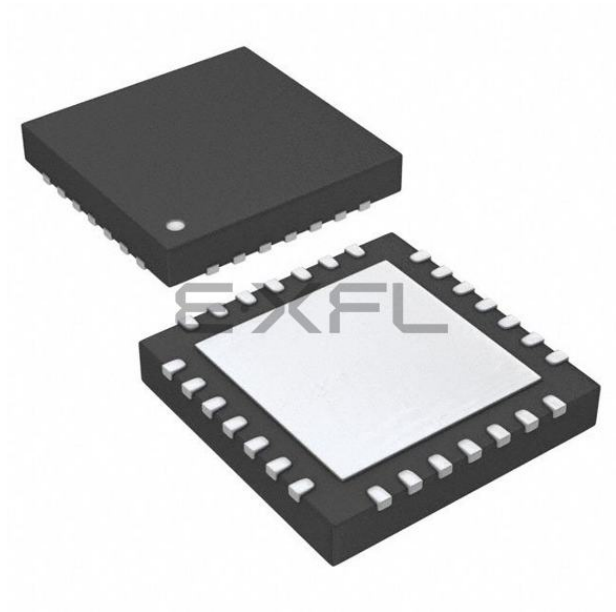

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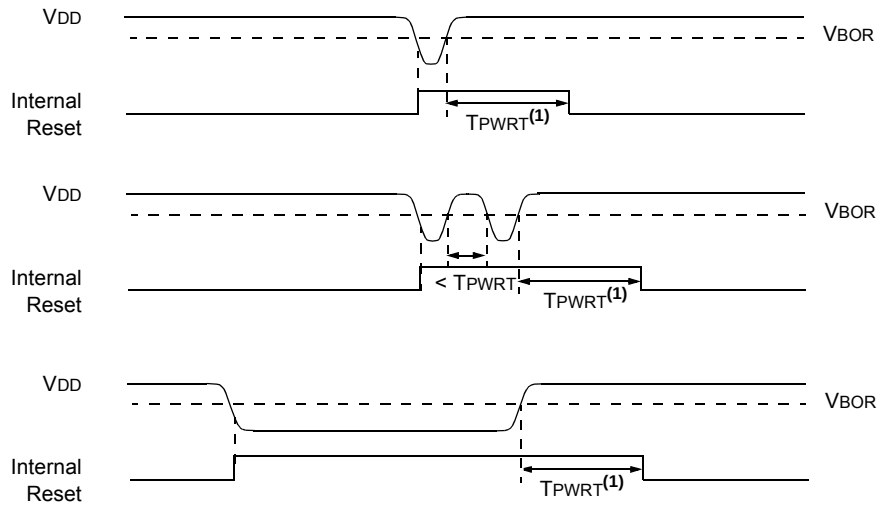
Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	32MHz
Connectivity	I²C, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	16
Program Memory Size	3.5KB (2K x 14)
Program Memory Type	FLASH
EEPROM Size	256 x 8
RAM Size	256 x 8
Voltage - Supply (Vcc/Vdd)	1.8V ~ 5.5V
Data Converters	A/D 12x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	28-VQFN Exposed Pad
Supplier Device Package	28-QFN (6x6)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16f1826t-i-ml

FIGURE 7-2: BROWN-OUT SITUATIONS



Note 1: TPWRT delay only if $\overline{\text{PWRTE}}$ bit is programmed to '0'.

REGISTER 7-1: BORCON: BROWN-OUT RESET CONTROL REGISTER

R/W-1/u	U-0	U-0	U-0	U-0	U-0	U-0	R-q/u
SBOREN	—	—	—	—	—	—	BORRDY
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 **SBOREN:** Software Brown-out Reset Enable bit
If BOREN <1:0> in Configuration Word 1 ≠ 01:
SBOREN is read/write, but has no effect on the BOR.
If BOREN <1:0> in Configuration Word 1 = 01:
1 = BOR Enabled
0 = BOR Disabled

bit 6-1 **Unimplemented:** Read as '0'

bit 0 **BORRDY:** Brown-out Reset Circuit Ready Status bit
1 = The Brown-out Reset circuit is active
0 = The Brown-out Reset circuit is inactive

10.1 Independent Clock Source

The WDT derives its time base from the 31 kHz LFINTOSC internal oscillator. Time intervals in this chapter are based on a nominal interval of 1 ms. See **Section 30.0 "Electrical Specifications"** for the LFINTOSC tolerances.

10.2 WDT Operating Modes

The Watchdog Timer module has four operating modes controlled by the WDTE<1:0> bits in Configuration Word 1. See Table 10-1.

10.2.1 WDT IS ALWAYS ON

When the WDTE bits of Configuration Word 1 are set to '11', the WDT is always on.

WDT protection is active during Sleep.

10.2.2 WDT IS OFF IN SLEEP

When the WDTE bits of Configuration Word 1 are set to '10', the WDT is on, except in Sleep.

WDT protection is not active during Sleep.

10.2.3 WDT CONTROLLED BY SOFTWARE

When the WDTE bits of Configuration Word 1 are set to '01', the WDT is controlled by the SWDTEN bit of the WDTCON register.

WDT protection is unchanged by Sleep. See Table 10-1 for more details.

TABLE 10-1: WDT OPERATING MODES

WDTE<1:0>	SWDTEN	Device Mode	WDT Mode
11	X	X	Active
10	X	Awake	Active
		Sleep	Disabled
01	1	X	Active
	0		Disabled
00	X	X	Disabled

10.3 Time-Out Period

The WDTPS bits of the WDTCON register set the time-out period from 1 ms to 256 seconds (nominal). After a Reset, the default time-out period is 2 seconds.

10.4 Clearing the WDT

The WDT is cleared when any of the following conditions occur:

- Any Reset
- CLRWDT instruction is executed
- Device enters Sleep
- Device wakes up from Sleep
- Oscillator fail event
- WDT is disabled
- Oscillator Start-up TImer (OST) is running

See Table 10-2 for more information.

10.5 Operation During Sleep

When the device enters Sleep, the WDT is cleared. If the WDT is enabled during Sleep, the WDT resumes counting.

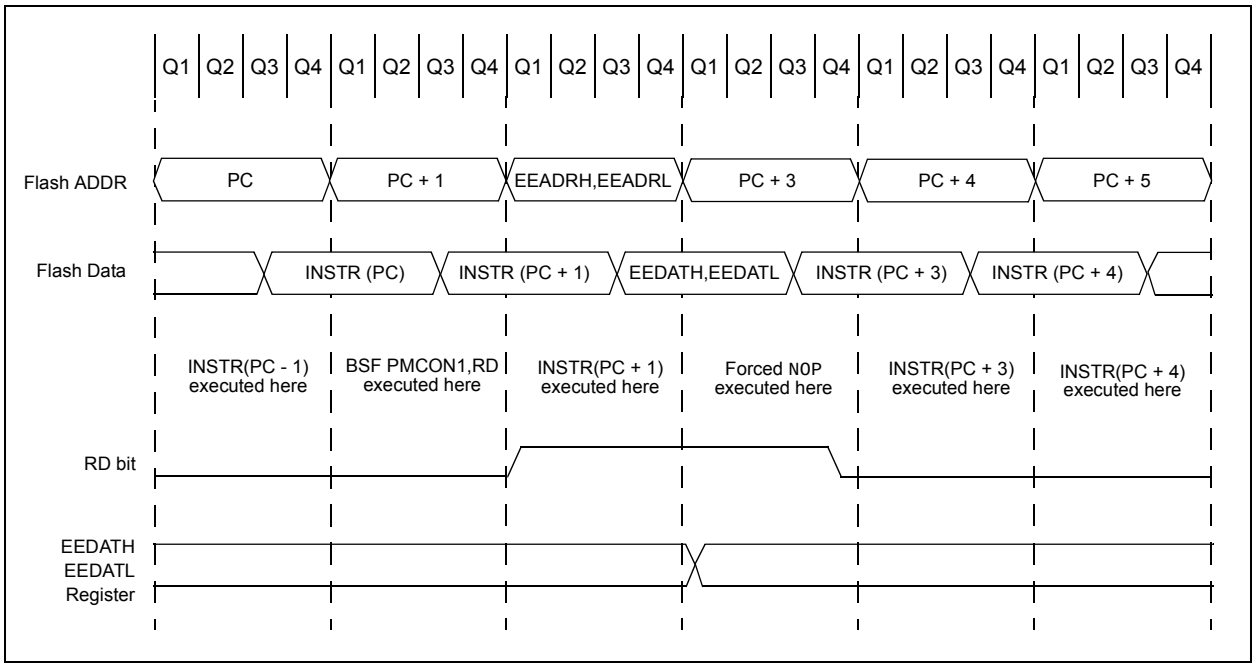
When the device exits Sleep, the WDT is cleared again. The WDT remains clear until the OST, if enabled, completes. See **Section 5.0 "Oscillator Module (With Fail-Safe Clock Monitor)"** for more information on the OST.

When a WDT time-out occurs while the device is in Sleep, no Reset is generated. Instead, the device wakes up and resumes operation. The $\overline{TO}$ and $\overline{PD}$ bits in the STATUS register are changed to indicate the event. See **Register 3-1** for more information.

TABLE 10-2: WDT CLEARING CONDITIONS

Conditions	WDT
WDTE<1:0> = 00	Cleared
WDTE<1:0> = 01 and SWDTEN = 0	
WDTE<1:0> = 10 and enter Sleep	
CLRWDT Command	
Oscillator Fail Detected	
Exit Sleep + System Clock = T1OSC, EXTRC, INTOSC, EXTCLK	
Exit Sleep + System Clock = XT, HS, LP	Cleared until the end of OST
Change INTOSC divider (IRCF bits)	Unaffected

FIGURE 11-1: FLASH PROGRAM MEMORY READ CYCLE EXECUTION



REGISTER 12-8: PORTB: PORTB REGISTER

R/W-x/x	R/W-x/x	R/W-x/x	R/W-x/x	R/W-x/x	R/W-x/x	R/W-x/x	R/W-x/x
RB7	RB6	RB5	RB4	RB3	RB2	RB1	RB0
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 **RB<7:0>**: PORTB I/O Pin bit
1 = Port pin is > VIH
0 = Port pin is < VIL

REGISTER 12-9: TRISB: PORTB TRI-STATE 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
TRISB7	TRISB6	TRISB5	TRISB4	TRISB3	TRISB2	TRISB1	TRISB0
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 **TRISB<7:0>:** PORTB Tri-State Control bit
1 = PORTB pin configured as an input (tri-stated)
0 = PORTB pin configured as an output

REGISTER 12-10: LATB: PORTB DATA LATCH 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
LATB7	LATB6	LATB5	LATB4	LATB3	LATB2	LATB1	LATB0
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 **LATB<7:0>**: PORTB Output Latch Value bits(1)

Note 1: Writes to PORTB are actually written to corresponding LATB register. Reads from PORTB register is return of actual I/O pin values.

13.0 INTERRUPT-ON-CHANGE

The PORTB pins can be configured to operate as Interrupt-On-Change (IOC) pins. An interrupt can be generated by detecting a signal that has either a rising edge or a falling edge. Any individual PORTB pin can be configured to generate an interrupt. The interrupt-on-change module has the following features:

- Interrupt-on-Change enable (Master Switch)
- Individual pin configuration
- Rising and falling edge detection
- Individual pin interrupt flags

Figure 13-1 is a block diagram of the IOC module.

13.1 Enabling the Module

To allow individual port pins to generate an interrupt, the IOCIE bit of the INTCON register must be set. If the IOCIE bit is disabled, the edge detection on the pin will still occur, but an interrupt will not be generated.

13.2 Individual Pin Configuration

For each port pin, a rising edge detector and a falling edge detector are present. To enable a pin to detect a rising edge, the associated IOCBPx bit of the IOCBP register is set. To enable a pin to detect a falling edge, the associated IOCBNx bit of the IOCBN register is set.

A pin can be configured to detect rising and falling edges simultaneously by setting both the IOCBPx bit and the IOCBNx bit of the IOCBP and IOCBN registers, respectively.

13.3 Interrupt Flags

The IOCBFx bits located in the IOCBF register are status flags that correspond to the Interrupt-on-change pins of the port. If an expected edge is detected on an appropriately enabled pin, then the status flag for that pin will be set, and an interrupt will be generated if the IOCIE bit is set. The IOCIF bit of the INTCON register reflects the status of all IOCBFx bits.

13.4 Clearing Interrupt Flags

The individual status flags, (IOCBFx bits), can be cleared by resetting them to zero. If another edge is detected during this clearing operation, the associated status flag will be set at the end of the sequence, regardless of the value actually being written.

In order to ensure that no detected edge is lost while clearing flags, only AND operations masking out known changed bits should be performed. The following sequence is an example of what should be performed.

EXAMPLE 13-1:

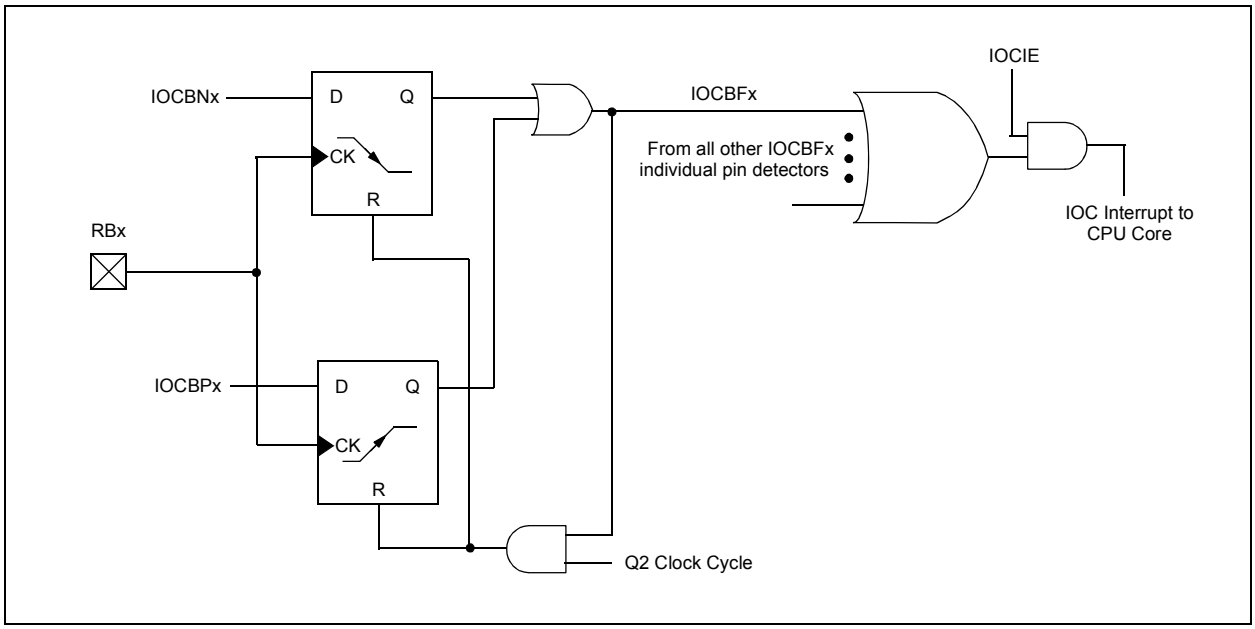
```
MOVLW  0xff
XORWF  IOCBF, W
ANDWF  IOCBF, F
```

13.5 Operation in Sleep

The interrupt-on-change interrupt sequence will wake the device from Sleep mode, if the IOCIE bit is set.

If an edge is detected while in Sleep mode, the IOCBF register will be updated prior to the first instruction executed out of Sleep.

FIGURE 13-1: INTERRUPT-ON-CHANGE BLOCK DIAGRAM



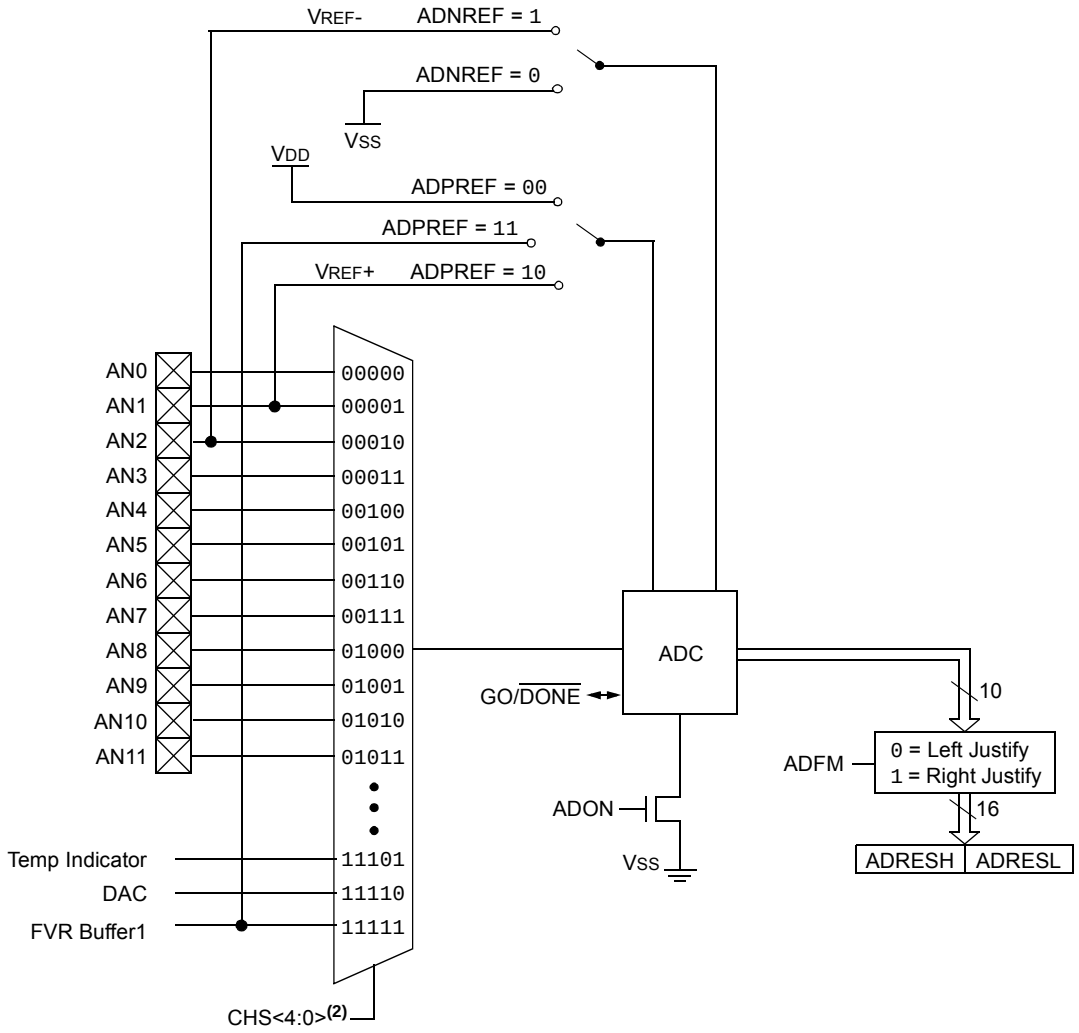
16.0 ANALOG-TO-DIGITAL CONVERTER (ADC) MODULE

The Analog-to-Digital Converter (ADC) allows conversion of an analog input signal to a 10-bit binary representation of that signal. This device uses analog inputs, which are multiplexed into a single sample and hold circuit. The output of the sample and hold is connected to the input of the converter. The converter generates a 10-bit binary result via successive approximation and stores the conversion result into the ADC result registers (ADRESH:ADRESL register pair). Figure 16-1 shows the block diagram of the ADC.

The ADC voltage reference is software selectable to be either internally generated or externally supplied.

The ADC can generate an interrupt upon completion of a conversion. This interrupt can be used to wake-up the device from Sleep.

FIGURE 16-1: ADC BLOCK DIAGRAM



Note 1: When ADON = 0, all multiplexer inputs are disconnected.

2: See ADCON0 register (Register 16-1) for detailed analog channel selection per device.

17.7 DAC Control Registers

REGISTER 17-1: DACCON0: VOLTAGE REFERENCE CONTROL REGISTER 0

R/W-0/0	R/W-0/0	R/W-0/0	U-0	R/W-0/0	R/W-0/0	U-0	R/W-0/0
DACEN	DACLPS	DACOE	—	DACPSS<1:0>		—	DACNSS
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 **DACEN:** DAC Enable bit
1 = DAC is enabled
0 = DAC is disabled

bit 6 **DACLPS:** DAC Low-Power Voltage State Select bit
1 = DAC Positive reference source selected
0 = DAC Negative reference source selected

bit 5 **DACOE:** DAC Voltage Output Enable bit
1 = DAC voltage level is also an output on the DACOUT pin
0 = DAC voltage level is disconnected from the DACOUT pin

bit 4 **Unimplemented:** Read as ‘0’

bit 3-2 **DACPSS<1:0>:** DAC Positive Source Select bits
00 = V_{DD}
01 = V_{REF}+ pin
10 = FVR Buffer2 output
11 = Reserved, do not use

bit 1 **Unimplemented:** Read as ‘0’

bit 0 **DACNSS:** DAC Negative Source Select bits
1 = V_{REF}-
0 = V_{SS}

REGISTER 17-2: DACCON1: VOLTAGE REFERENCE CONTROL REGISTER 1

U-0	U-0	U-0	R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0
—	—	—	DACR<4:0>				
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 7-5 **Unimplemented:** Read as ‘0’

bit 4-0 **DACR<4:0>:** DAC Voltage Output Select bits

TABLE 17-1: SUMMARY OF REGISTERS ASSOCIATED WITH THE DAC MODULE

Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Register on page
FVRCON	FVREN	FVRRDY	Reserved	Reserved	CDAFVR1	CDAFVR0	ADFVR1	ADFVR0	138
DACCON0	DACEN	DACLPS	DACOE	—	DACPSS1	DACPSS0	—	DACNSS	156
DACCON1	—	—	—	DACR4	DACR3	DACR2	DACR1	DACR0	156

Legend: — = unimplemented, read as ‘0’. Shaded cells are unused with the DAC module.

24.3.7 OPERATION IN SLEEP MODE

In Sleep mode, the TMRx register will not increment and the state of the module will not change. If the CCPx pin is driving a value, it will continue to drive that value. When the device wakes up, TMRx will continue from its previous state.

24.3.8 CHANGES IN SYSTEM CLOCK FREQUENCY

The PWM frequency is derived from the system clock frequency. Any changes in the system clock frequency will result in changes to the PWM frequency. See **Section 5.0 "Oscillator Module (With Fail-Safe Clock Monitor)"** for additional details.

24.3.9 EFFECTS OF RESET

Any Reset will force all ports to Input mode and the CCP registers to their Reset states.

24.3.10 ALTERNATE PIN LOCATIONS

This module incorporates I/O pins that can be moved to other locations with the use of the alternate pin function registers, APFCON0 and APFCON1. To determine which pins can be moved and what their default locations are upon a reset, see **Section 12.1 "Alternate Pin Function"** for more information.

TABLE 24-8: SUMMARY OF REGISTERS ASSOCIATED WITH STANDARD PWM

Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Register on Page
APFCON0	RXDTSEL	SDO1SEL	SS1SEL	P2BSEL(2)	CCP2SEL(2)	P1DSEL	P1CSEL	CCP1SEL	119
CCPxCON	PxM1(1)	PxM0(1)	DCxB1	DCxB0	CCPxM3	CCPxM2	CCPxM1	CCPxM0	226
CCPxAS	CCPxASE	CCPxAS2	CCPxAS1	CCPxAS0	PSSxAC1	PSSxAC0	PSSxBD1	PSSxBD0	228
CCPTMRS	C4TSEL1	C4TSEL0	C3TSEL1	C3TSEL0	C2TSEL1	C2TSEL0	C1TSEL1	C1TSEL0	227
INTCON	GIE	PEIE	TMR0IE	INTE	IOCIE	TMR0IF	INTF	IOCIF	86
PR2	Timer2 Period Register								189*
PR4	Timer4 Module Period Register								189*
PR6	Timer6 Module Period Register								189*
PSTRxCON	—	—	—	STRxSYNC	STRxD	STRxC	STRxB	STRxA	230
PWMxCON	PxRSEN	PxDC6	PxDC5	PxDC4	PxDC3	PxDC2	PxDC1	PxDC0	229
T2CON	—	T2OUTPS3	T2OUTPS2	T2OUTPS1	T2OUTPS0	TMR2ON	T2CKPS1	T2CKPS0	191
T4CON	—	T4OUTPS3	T4OUTPS2	T4OUTPS1	T4OUTPS0	TMR4ON	T4CKPS1	T4CKPS0	191
T6CON	—	T6OUTPS3	T6OUTPS2	T6OUTPS1	T6OUTPS0	TMR6ON	T6CKPS1	T6CKPS0	191
TMR2	Holding Register for the 8-bit TMR2 Time Base								189*
TMR4	Holding Register for the 8-bit TMR4 Time Base(1)								189*
TMR6	Holding Register for the 8-bit TMR6 Time Base(1)								189*
TRISB	TRISB7	TRISB6	TRISB5	TRISB4	TRISB3	TRISB2	TRISB1	TRISB0	127

Legend: — = Unimplemented locations, read as '0'. Shaded cells are not used by the PWM.

* Page provides register information.

Note 1: Applies to ECCP modules only.

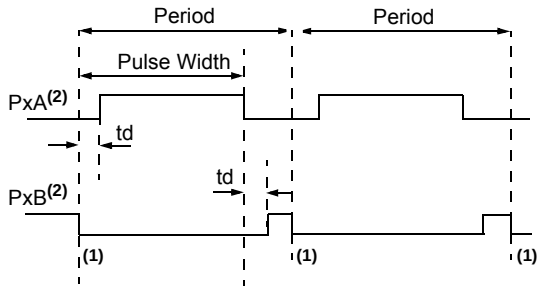
2: PIC16(L)F1827 only.

24.4.5 PROGRAMMABLE DEAD-BAND DELAY MODE

In Half-Bridge applications where all power switches are modulated at the PWM frequency, the power switches normally require more time to turn off than to turn on. If both the upper and lower power switches are switched at the same time (one turned on, and the other turned off), both switches may be on for a short period of time until one switch completely turns off. During this brief interval, a very high current (*shoot-through current*) will flow through both power switches, shorting the bridge supply. To avoid this potentially destructive shoot-through current from flowing during switching, turning on either of the power switches is normally delayed to allow the other switch to completely turn off.

In Half-Bridge mode, a digitally programmable dead-band delay is available to avoid shoot-through current from destroying the bridge power switches. The delay occurs at the signal transition from the non-active state to the active state. See Figure 24-16 for illustration. The lower seven bits of the associated PWMxCON register (Register 24-4) sets the delay period in terms of microcontroller instruction cycles (TCY or 4 TOSC).

FIGURE 24-16: EXAMPLE OF HALF-BRIDGE PWM OUTPUT



td = Dead-Band Delay

Note 1: At this time, the TMRx register is equal to the PRx register.

2: Output signals are shown as active-high.

FIGURE 24-17: EXAMPLE OF HALF-BRIDGE APPLICATIONS

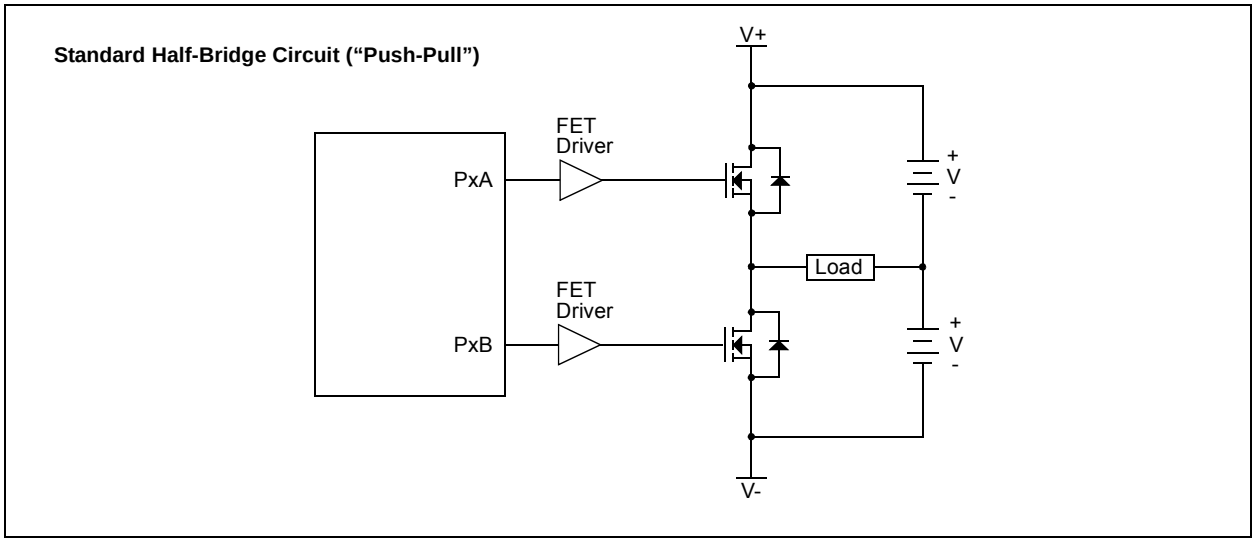


FIGURE 25-15: I²C SLAVE, 7-BIT ADDRESS, RECEPTION (SEN = 1, AHEN = 0, DHEN = 0)

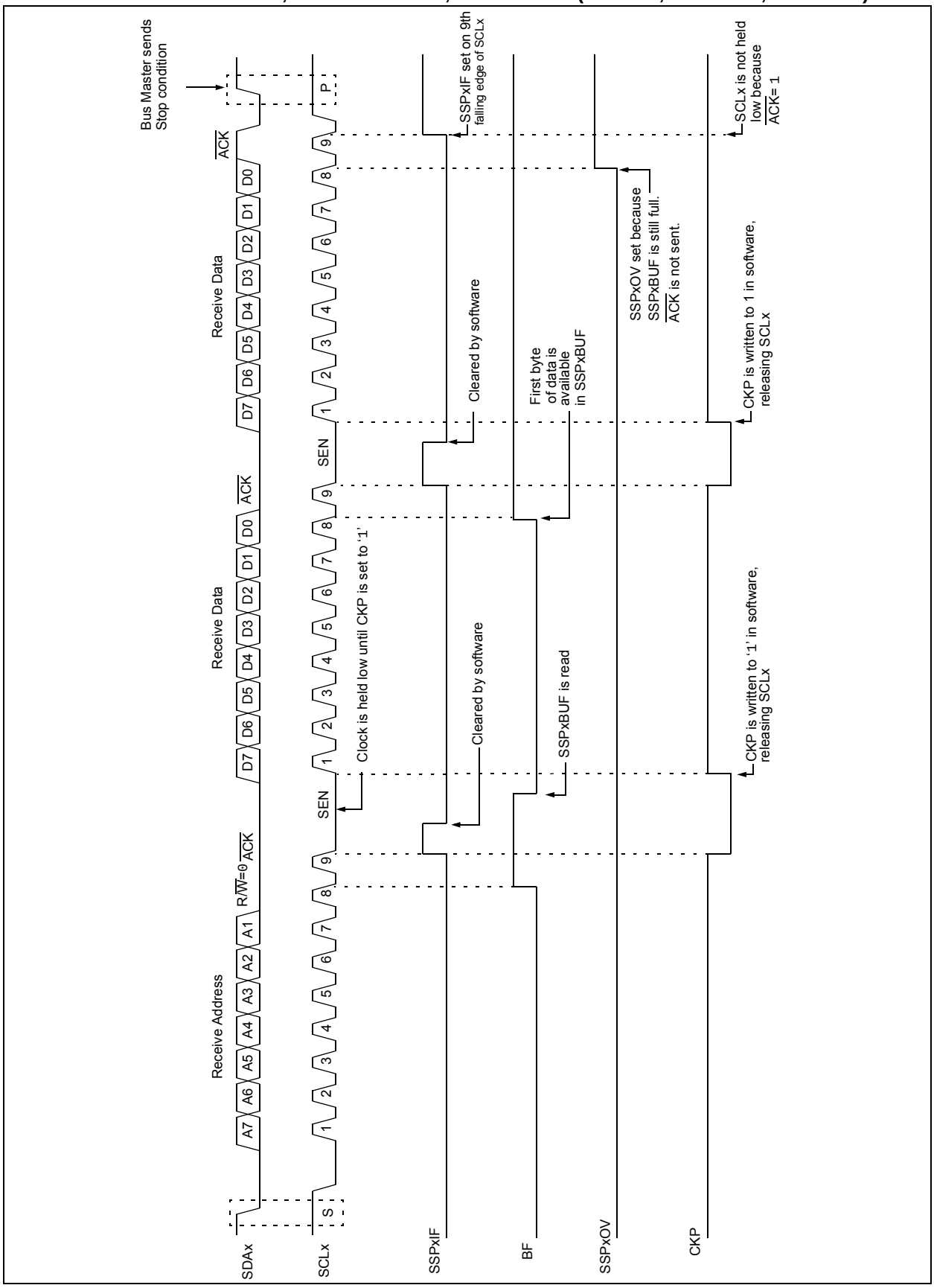
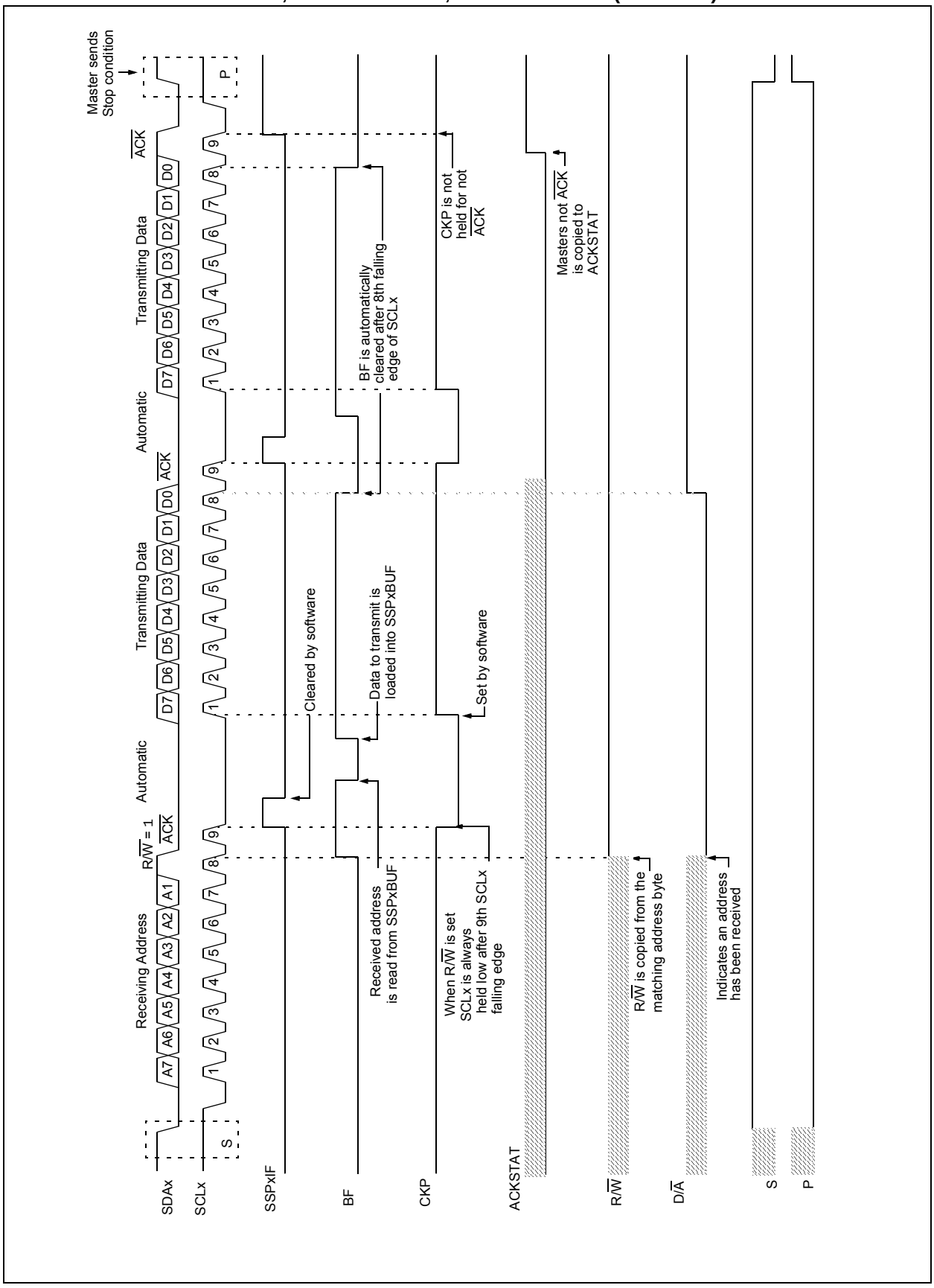


FIGURE 25-18: I²C SLAVE, 7-BIT ADDRESS, TRANSMISSION (AHEN = 0)



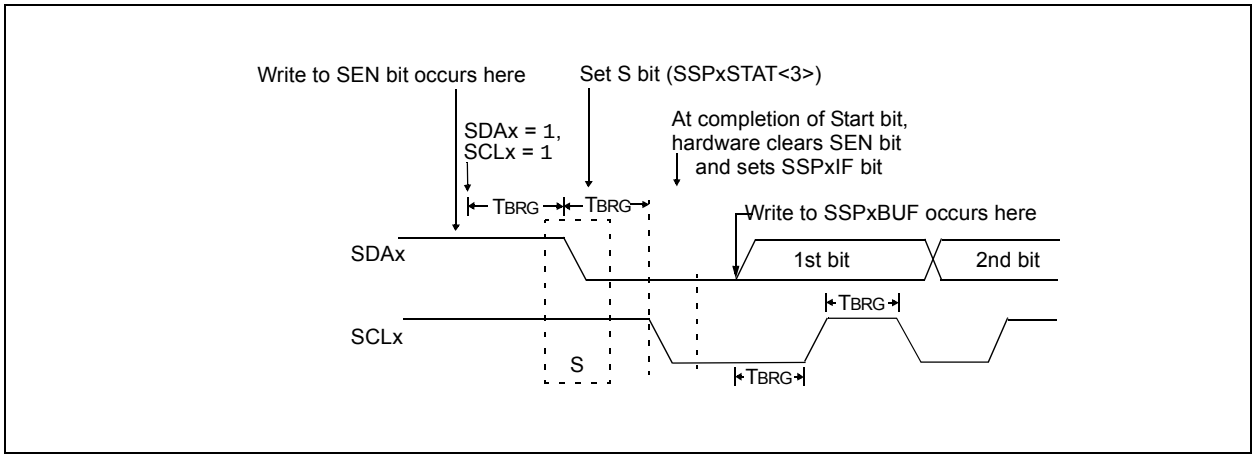
25.6.4 I²C MASTER MODE START CONDITION TIMING

To initiate a Start condition, the user sets the Start Enable bit, SEN bit of the SSPxCON2 register. If the SDAx and SCLx pins are sampled high, the Baud Rate Generator is reloaded with the contents of SSPxADD<7:0> and starts its count. If SCLx and SDAx are both sampled high when the Baud Rate Generator times out (TBRG), the SDAx pin is driven low. The action of the SDAx being driven low while SCLx is high is the Start condition and causes the S bit of the SSPxSTAT1 register to be set. Following this, the Baud Rate Generator is reloaded with the contents of SSPxADD<7:0> and resumes its count. When the Baud Rate Generator times out (TBRG), the SEN bit of the SSPxCON2 register will be automatically cleared by hardware; the Baud Rate Generator is suspended, leaving the SDAx line held low and the Start condition is complete.

Note 1: If at the beginning of the Start condition, the SDAx and SCLx pins are already sampled low, or if during the Start condition, the SCLx line is sampled low before the SDAx line is driven low, a bus collision occurs, the Bus Collision Interrupt Flag, BCLxIF, is set, the Start condition is aborted and the I²C module is reset into its Idle state.

2: The Philips I²C Specification states that a bus collision cannot occur on a Start.

FIGURE 25-26: FIRST START BIT TIMING



25.6.8 ACKNOWLEDGE SEQUENCE TIMING

An Acknowledge sequence is enabled by setting the Acknowledge Sequence Enable bit, ACKEN bit of the SSPxCON2 register. When this bit is set, the SCLx pin is pulled low and the contents of the Acknowledge data bit are presented on the SDAx pin. If the user wishes to generate an Acknowledge, then the ACKDT bit should be cleared. If not, the user should set the ACKDT bit before starting an Acknowledge sequence. The Baud Rate Generator then counts for one rollover period (TBRG) and the SCLx pin is deasserted (pulled high). When the SCLx pin is sampled high (clock arbitration), the Baud Rate Generator counts for TBRG. The SCLx pin is then pulled low. Following this, the ACKEN bit is automatically cleared, the Baud Rate Generator is turned off and the MSSPx module then goes into Idle mode (Figure 25-29).

25.6.8.1 WCOL Status Flag

If the user writes the SSPxBUF when an Acknowledge sequence is in progress, then WCOL is set and the contents of the buffer are unchanged (the write does not occur).

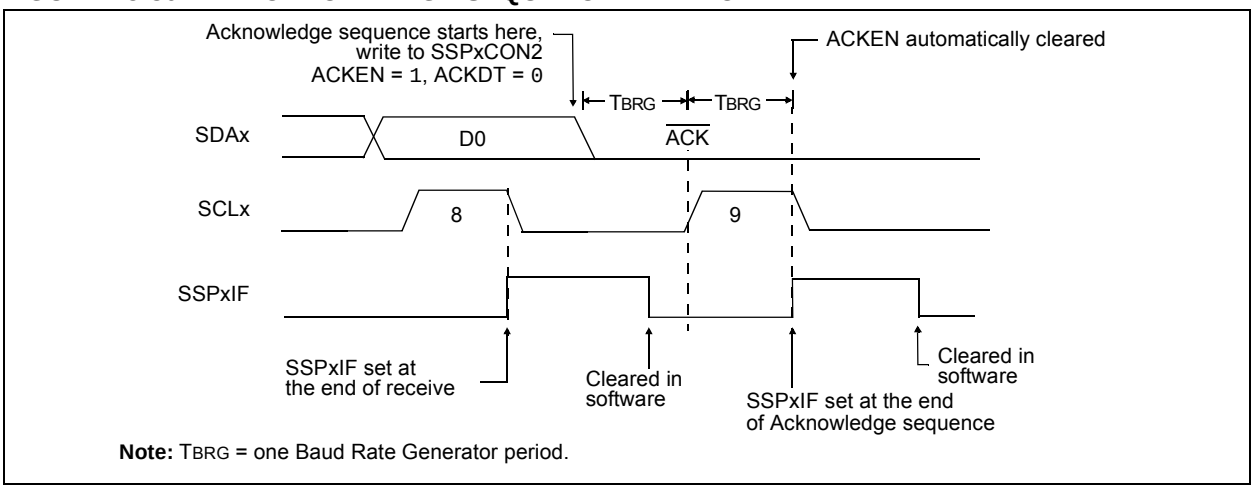
25.6.9 STOP CONDITION TIMING

A Stop bit is asserted on the SDAx pin at the end of a receive/transmit by setting the Stop Sequence Enable bit, PEN bit of the SSPxCON2 register. At the end of a receive/transmit, the SCLx line is held low after the falling edge of the ninth clock. When the PEN bit is set, the master will assert the SDAx line low. When the SDAx line is sampled low, the Baud Rate Generator is reloaded and counts down to '0'. When the Baud Rate Generator times out, the SCLx pin will be brought high and one TBRG (Baud Rate Generator rollover count) later, the SDAx pin will be deasserted. When the SDAx pin is sampled high while SCLx is high, the P bit of the SSPxSTAT register is set. A TBRG later, the PEN bit is cleared and the SSPxIF bit is set (Figure 25-30).

25.6.9.1 WCOL Status Flag

If the user writes the SSPxBUF when a Stop sequence is in progress, then the WCOL bit is set and the contents of the buffer are unchanged (the write does not occur).

FIGURE 25-30: ACKNOWLEDGE SEQUENCE WAVEFORM



Note: TBRG = one Baud Rate Generator period.

25.7 BAUD RATE GENERATOR

The MSSPx module has a Baud Rate Generator available for clock generation in both I^2C and SPI Master modes. The Baud Rate Generator (BRG) reload value is placed in the SSPxADD register (Register 25-6). When a write occurs to SSPxBUF, the Baud Rate Generator will automatically begin counting down.

Once the given operation is complete, the internal clock will automatically stop counting and the clock pin will remain in its last state.

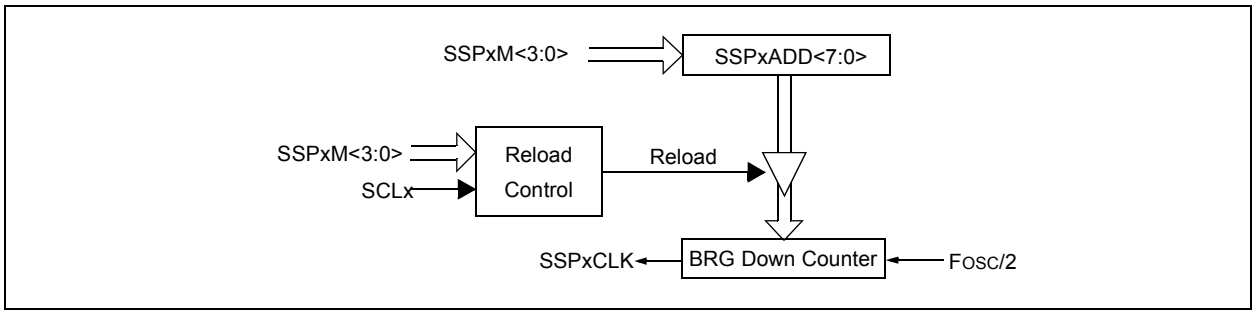
An internal signal "Reload" in Figure 25-39 triggers the value from SSPxADD to be loaded into the BRG counter. This occurs twice for each oscillation of the module clock line. The logic dictating when the reload signal is asserted depends on the mode the MSSPx is being operated in.

Table 25-4 demonstrates clock rates based on instruction cycles and the BRG value loaded into SSPxADD.

EQUATION 25-1:

$$F_{CLOCK} = \frac{F_{OSC}}{(SSPxADD + 1)(4)}$$

FIGURE 25-40: BAUD RATE GENERATOR BLOCK DIAGRAM



Note: Values of 0x00, 0x01 and 0x02 are not valid for SSPxADD when used as a Baud Rate Generator for I^2C. This is an implementation limitation.

TABLE 25-4: MSSPX CLOCK RATE W/BRG

FOSC	FCY	BRG Value	FCLOCK (2 Rollovers of BRG)
32 MHz	8 MHz	13h	400 kHz(1)
32 MHz	8 MHz	19h	308 kHz
32 MHz	8 MHz	4Fh	100 kHz
16 MHz	4 MHz	09h	400 kHz(1)
16 MHz	4 MHz	0Ch	308 kHz
16 MHz	4 MHz	27h	100 kHz
4 MHz	1 MHz	09h	100 kHz

Note 1: The I^2C interface does not conform to the 400 kHz I^2C specification (which applies to rates greater than 100 kHz) in all details, but may be used with care where higher rates are required by the application.

TABLE 26-5: BAUD RATES FOR ASYNCHRONOUS MODES

BAUD RATE	SYNC = 0, BRGH = 0, BRG16 = 0											
	Fosc = 32.000 MHz			Fosc = 20.000 MHz			Fosc = 18.432 MHz			Fosc = 11.0592 MHz		
	Actual Rate	% Error	SPBRG value (decimal)	Actual Rate	% Error	SPBRG value (decimal)	Actual Rate	% Error	SPBRG value (decimal)	Actual Rate	% Error	SPBRG value (decimal)
300	—	—	—	—	—	—	—	—	—	—	—	—
1200	—	—	—	1221	1.73	255	1200	0.00	239	1200	0.00	143
2400	2404	0.16	207	2404	0.16	129	2400	0.00	119	2400	0.00	71
9600	9615	0.16	51	9470	-1.36	32	9600	0.00	29	9600	0.00	17
10417	10417	0.00	47	10417	0.00	29	10286	-1.26	27	10165	-2.42	16
19.2k	19.23k	0.16	25	19.53k	1.73	15	19.20k	0.00	14	19.20k	0.00	8
57.6k	55.55k	-3.55	3	—	—	—	57.60k	0.00	7	57.60k	0.00	2
115.2k	—	—	—	—	—	—	—	—	—	—	—	—

BAUD RATE	SYNC = 0, BRGH = 0, BRG16 = 0											
	Fosc = 8.000 MHz			Fosc = 4.000 MHz			Fosc = 3.6864 MHz			Fosc = 1.000 MHz		
	Actual Rate	% Error	SPBRG value (decimal)	Actual Rate	% Error	SPBRG value (decimal)	Actual Rate	% Error	SPBRG value (decimal)	Actual Rate	% Error	SPBRG value (decimal)
300	—	—	—	300	0.16	207	300	0.00	191	300	0.16	51
1200	1202	0.16	103	1202	0.16	51	1200	0.00	47	1202	0.16	12
2400	2404	0.16	51	2404	0.16	25	2400	0.00	23	—	—	—
9600	9615	0.16	12	—	—	—	9600	0.00	5	—	—	—
10417	10417	0.00	11	10417	0.00	5	—	—	—	—	—	—
19.2k	—	—	—	—	—	—	19.20k	0.00	2	—	—	—
57.6k	—	—	—	—	—	—	57.60k	0.00	0	—	—	—
115.2k	—	—	—	—	—	—	—	—	—	—	—	—

BAUD RATE	SYNC = 0, BRGH = 1, BRG16 = 0											
	Fosc = 32.000 MHz			Fosc = 20.000 MHz			Fosc = 18.432 MHz			Fosc = 11.0592 MHz		
	Actual Rate	% Error	SPBRG value (decimal)	Actual Rate	% Error	SPBRG value (decimal)	Actual Rate	% Error	SPBRG value (decimal)	Actual Rate	% Error	SPBRG value (decimal)
300	—	—	—	—	—	—	—	—	—	—	—	—
1200	—	—	—	—	—	—	—	—	—	—	—	—
2400	—	—	—	—	—	—	—	—	—	—	—	—
9600	9615	0.16	207	9615	0.16	129	9600	0.00	119	9600	0.00	71
10417	10417	0.00	191	10417	0.00	119	10378	-0.37	110	10473	0.53	65
19.2k	19.23k	0.16	103	19.23k	0.16	64	19.20k	0.00	59	19.20k	0.00	35
57.6k	57.14k	-0.79	34	56.82k	-1.36	21	57.60k	0.00	19	57.60k	0.00	11
115.2k	117.64k	2.12	16	113.64k	-1.36	10	115.2k	0.00	9	115.2k	0.00	5

FIGURE 26-7: AUTO-WAKE-UP BIT (WUE) TIMING DURING NORMAL OPERATION

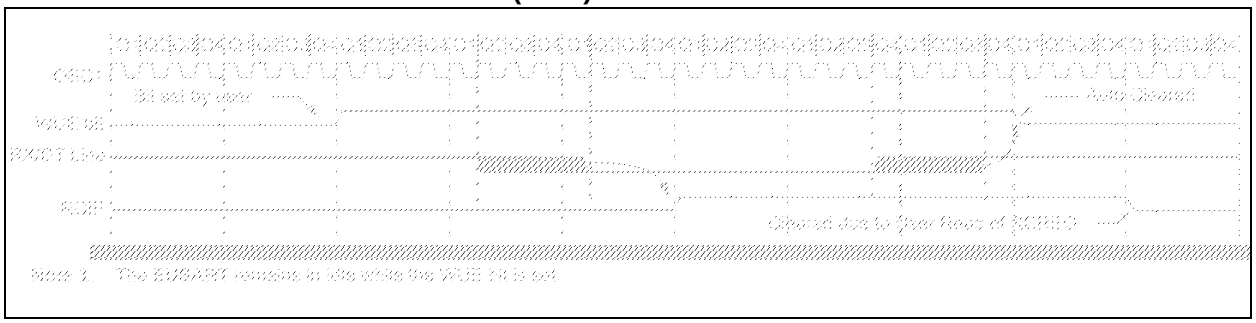
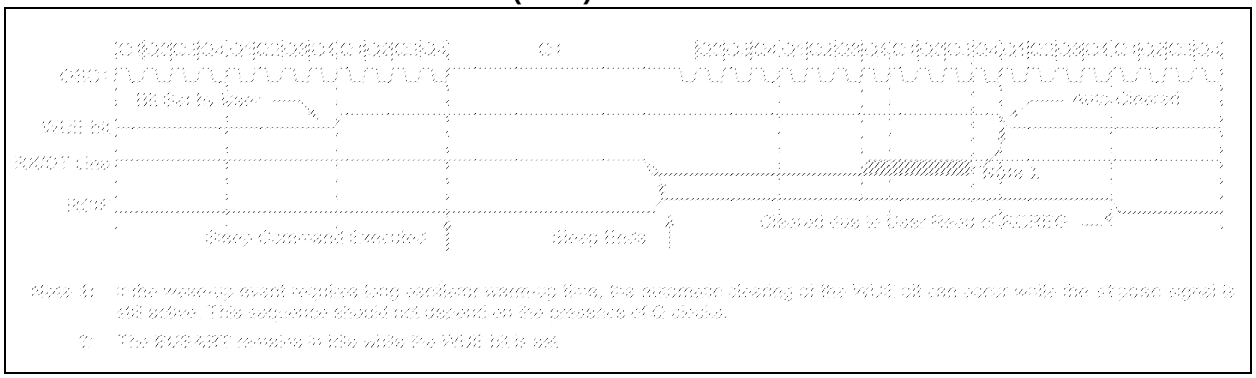


FIGURE 26-8: AUTO-WAKE-UP BIT (WUE) TIMINGS DURING SLEEP



26.5 EUSART Operation During Sleep

The EUSART will remain active during Sleep only in the Synchronous Slave mode. All other modes require the system clock and therefore cannot generate the necessary signals to run the Transmit or Receive Shift registers during Sleep.

Synchronous Slave mode uses an externally generated clock to run the Transmit and Receive Shift registers.

26.5.1 SYNCHRONOUS RECEIVE DURING SLEEP

To receive during Sleep, all the following conditions must be met before entering Sleep mode:

- RCSTA and TXSTA Control registers must be configured for Synchronous Slave Reception (see **Section 26.4.2.4 "Synchronous Slave Reception Set-up:"**).
- If interrupts are desired, set the RCIE bit of the PIE1 register and the GIE and PEIE bits of the INTCON register.
- The RCIF interrupt flag must be cleared by reading RCREG to unload any pending characters in the receive buffer.

Upon entering Sleep mode, the device will be ready to accept data and clocks on the RX/DT and TX/CK pins, respectively. When the data word has been completely clocked in by the external device, the RCIF interrupt flag bit of the PIR1 register will be set. Thereby, waking the processor from Sleep.

Upon waking from Sleep, the instruction following the SLEEP instruction will be executed. If the GIE global interrupt enable bit of the INTCON register is also set, then the Interrupt Service Routine at address 004h will be called.

26.5.2 SYNCHRONOUS TRANSMIT DURING SLEEP

To transmit during Sleep, all the following conditions must be met before entering Sleep mode:

- RCSTA and TXSTA Control registers must be configured for Synchronous Slave Transmission (see **Section 26.4.2.2 "Synchronous Slave Transmission Set-up:"**).
- The TXIF interrupt flag must be cleared by writing the output data to the TXREG, thereby filling the TSR and transmit buffer.
- If interrupts are desired, set the TXIE bit of the PIE1 register and the PEIE bit of the INTCON register.
- Interrupt enable bits TXIE of the PIE1 register and PEIE of the INTCON register must set.

Upon entering Sleep mode, the device will be ready to accept clocks on TX/CK pin and transmit data on the RX/DT pin. When the data word in the TSR has been completely clocked out by the external device, the pending byte in the TXREG will transfer to the TSR and the TXIF flag will be set. Thereby, waking the processor from Sleep. At this point, the TXREG is available to accept another character for transmission, which will clear the TXIF flag.

Upon waking from Sleep, the instruction following the SLEEP instruction will be executed. If the Global Interrupt Enable (GIE) bit is also set then the Interrupt Service Routine at address 0004h will be called.

26.5.3 ALTERNATE PIN LOCATIONS

This module incorporates I/O pins that can be moved to other locations with the use of the alternate pin function registers, APFCON0 and APFCON1. To determine which pins can be moved and what their default locations are upon a reset, see **Section 12.1 "Alternate Pin Function"** for more information.

30.5 Memory Programming Requirements

DC CHARACTERISTICS			Standard Operating Conditions (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +125°C				
Param No.	Sym.	Characteristic	Min.	Typ†	Max.	Units	Conditions
		Program Memory Programming Specifications					
D110	VIHH	Voltage on $\overline{MCLR}$/VPP/RA5 pin	8.0	—	9.0	V	**(Note 3, Note 4)**
D111	IDDP	Supply Current during Programming	—	—	10	mA	
D112		VDD for Bulk Erase	2.7	—	VDD max.	V	
D113	VPEW	VDD for Write or Row Erase	VDD min.	—	VDD max.	V	
D114	IPPPGM	Current on $\overline{MCLR}$/VPP during Erase/ Write	—	—	1.0	mA	
D115	IDDPGM	Current on VDD during Erase/Write	—		5.0	mA	
		Data EEPROM Memory					
D116	ED	Byte Endurance	100K	—	—	E/W	-40°C to +85°C
D117	VDRW	VDD for Read/Write	VDD min.	—	VDD max.	V	
D118	TDEW	Erase/Write Cycle Time	—	4.0	5.0	ms	
D119	TRETD	Characteristic Retention	—	40	—	Year	Provided no other specifications are violated
D120	TREF	Number of Total Erase/Write Cycles before Refresh(2)	1M	10M	—	E/W	-40°C to +85°C
		Program Flash Memory					
D121	EP	Cell Endurance	10K	—	—	E/W	-40°C to +85°C (**Note 1**)
D122	VPR	VDD for Read	VDD min.	—	VDD max.	V	
D123	TIW	Self-timed Write Cycle Time	—	2	2.5	ms	
D124	TRETD	Characteristic Retention	—	40	—	Year	Provided no other specifications are violated

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

Note 1: Self-write and Block Erase.

2: Refer to **Section 11.2 "Using the Data EEPROM"** for a more detailed discussion on data EEPROM endurance.

3: Required only if single-supply programming is disabled.

4: The MPLAB ICD 2 does not support variable VPP output. Circuitry to limit the ICD 2 VPP voltage must be placed between the ICD 2 and target system when programming or debugging with the ICD 2.

30.8 AC Characteristics: PIC16(L)F1826/27-I/E

FIGURE 30-6: CLOCK TIMING

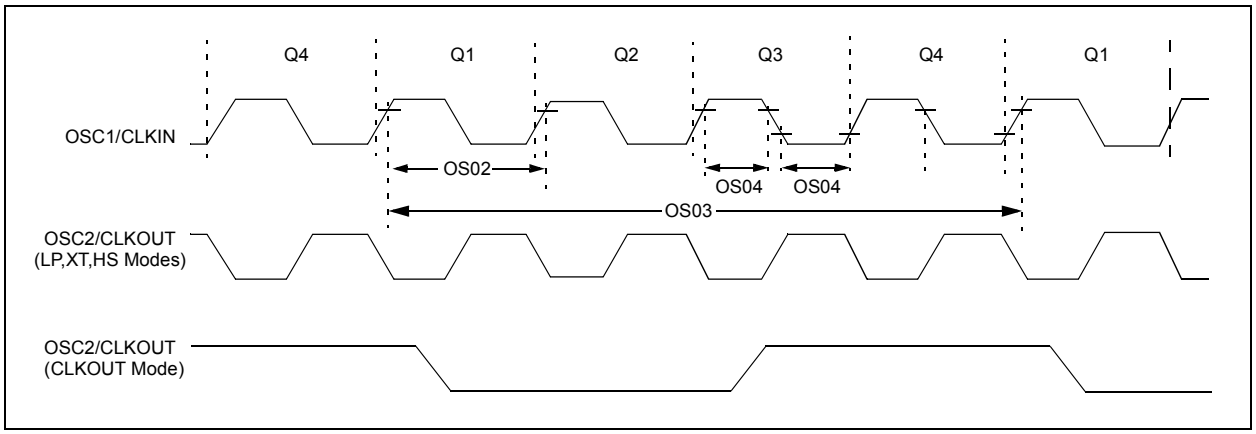


TABLE 30-1: CLOCK OSCILLATOR TIMING REQUIREMENTS

Standard Operating Conditions (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +125°C							
Param No.	**Sym.**	**Characteristic**	**Min.**	**Typ†**	**Max.**	**Units**	**Conditions**
OS01	FOSC	External CLKIN Frequency(1)	DC	—	0.5	MHz	EC Oscillator mode (low)
			DC	—	4	MHz	EC Oscillator mode (medium)
			DC	—	20	MHz	EC Oscillator mode (high)
		Oscillator Frequency(1)	—	32.768	—	kHz	LP Oscillator mode
			0.1	—	4	MHz	XT Oscillator mode
			1	—	4	MHz	HS Oscillator mode
			1	—	20	MHz	HS Oscillator mode, VDD > 2.7V
			DC	—	4	MHz	RC Oscillator mode, VDD > 2.0V
OS02	TOSC	External CLKIN Period(1)	27	—	∞	μs	LP Oscillator mode
			250	—	∞	ns	XT Oscillator mode
			50	—	∞	ns	HS Oscillator mode
			50	—	∞	ns	EC Oscillator mode
		Oscillator Period(1)	—	30.5	—	μs	LP Oscillator mode
			250	—	10,000	ns	XT Oscillator mode
			50	—	1,000	ns	HS Oscillator mode
			250	—	—	ns	RC Oscillator mode
OS03	TCY	Instruction Cycle Time(1)	200 TCY	—	DC	ns	TCY = FOSC/4
OS04*	TosH, TosL	External CLKIN High, External CLKIN Low	2	—	—	μs	LP oscillator
			100	—	—	ns	XT oscillator
			20	—	—	ns	HS oscillator
OS05*	TosR, TosF	External CLKIN Rise, External CLKIN Fall	0	—	∞	ns	LP oscillator
			0	—	∞	ns	XT oscillator
			0	—	∞	ns	HS oscillator

* 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.

Note 1: Instruction cycle period (TCY) equals four times the input oscillator time base period. All specified values are based on characterization data for that particular oscillator type under standard operating conditions with the device executing code. Exceeding these specified limits may result in an unstable oscillator operation and/or higher than expected current consumption. All devices are tested to operate at "min" values with an external clock applied to OSC1 pin. When an external clock input is used, the "max" cycle time limit is "DC" (no clock) for all devices.

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