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Details

Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	40MHz
Connectivity	I ² C, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	21
Program Memory Size	16KB (8K x 16)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	1K x 8
Voltage - Supply (Vcc/Vdd)	2V ~ 3.6V
Data Converters	A/D 10x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Through Hole
Package / Case	28-DIP (0.300", 7.62mm)
Supplier Device Package	28-SPDIP
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic18lf24j10-i-sp

3.6.1 OSCILLATOR CONTROL REGISTER

The OSCCON register (Register 3-2) controls several aspects of the device clock's operation, both in full-power operation and in power-managed modes.

The System Clock Select bits, SCS<1:0>, select the clock source. The available clock sources are the primary clock (defined by the FOSC<2:0> Configuration bits), the secondary clock (Timer1 oscillator) and the internal oscillator. The clock source changes after one or more of the bits are written to, following a brief clock transition interval.

The OSTS (OSCCON<3>) and T1RUN (T1CON<6>) bits indicate which clock source is currently providing the device clock. The OSTS bit indicates that the Oscillator Start-up Timer (OST) has timed out and the primary clock is providing the device clock in primary clock modes. The T1RUN bit indicates when the Timer1 oscillator is providing the device clock in secondary clock modes. In power-managed modes, only one of these bits will be set at any time. If neither of these bits is set, the INTRC is providing the clock, or the internal oscillator has just started and is not yet stable.

The IDLEN bit determines if the device goes into Sleep mode or one of the Idle modes when the SLEEP instruction is executed.

The use of the flag and control bits in the OSCCON register is discussed in more detail in **Section 4.0 "Power-Managed Modes"**.

Note 1: The Timer1 oscillator must be enabled to select the secondary clock source. The Timer1 oscillator is enabled by setting the T1OSCEN bit in the Timer1 Control register (T1CON<3>). If the Timer1 oscillator is not enabled, then any attempt to select a secondary clock source when executing a SLEEP instruction will be ignored.

2: It is recommended that the Timer1 oscillator be operating and stable before executing the SLEEP instruction or a very long delay may occur while the Timer1 oscillator starts.

3.6.1.1 System Clock Selection and the FOSC2 Configuration Bit

The SCS bits are cleared on all forms of Reset. In the device's default configuration, this means the primary oscillator defined by FOSC<1:0> (that is, one of the HC or EC modes) is used as the primary clock source on device Resets.

The default clock configuration on Reset can be changed with the FOSC2 Configuration bit. The effect of this bit is to set the clock source selected when SCS<1:0> = 00. When FOSC2 = 1 (default), the oscillator source defined by FOSC<1:0> is selected whenever SCS<1:0> = 00. When FOSC2 = 0, the INTRC oscillator is selected whenever SCS<1:0> = 00. Because the SCS bits are cleared on Reset, the FOSC2 setting also changes the default oscillator mode on Reset.

Regardless of the setting of FOSC2, INTRC will always be enabled on device power-up. It will serve as the clock source until the device has loaded its configuration values from memory. It is at this point that the FOSC Configuration bits are read and the oscillator selection of operational mode is made.

Note that either the primary clock or the internal oscillator will have two bit setting options, at any given time, depending on the setting of FOSC2.

3.6.2 OSCILLATOR TRANSITIONS

PIC18F45J10 family devices contain circuitry to prevent clock "glitches" when switching between clock sources. A short pause in the device clock occurs during the clock switch. The length of this pause is the sum of two cycles of the old clock source and three to four cycles of the new clock source. This formula assumes that the new clock source is stable.

Clock transitions are discussed in greater detail in **Section 4.1.2 "Entering Power-Managed Modes"**.

PIC18F45J10 FAMILY

NOTES:

PIC18F45J10 FAMILY

4.4.1 PRI_IDLE MODE

This mode is unique among the three low-power Idle modes, in that it does not disable the primary device clock. For timing-sensitive applications, this allows for the fastest resumption of device operation with its more accurate primary clock source, since the clock source does not have to “warm up” or transition from another oscillator.

PRI_IDLE mode is entered from PRI_RUN mode by setting the IDLEN bit and executing a SLEEP instruction. If the device is in another Run mode, set IDLEN first, then set the SCS<1:0> bits to '10' and execute SLEEP. Although the CPU is disabled, the peripherals continue to be clocked from the primary clock source specified by the FOSC0 Configuration bit. The OSTS bit remains set (see Figure 4-6).

When a wake event occurs, the CPU is clocked from the primary clock source. A delay of interval, TCSD, is required between the wake event and when code execution starts. This is required to allow the CPU to become ready to execute instructions. After the wake-up, the OSTS bit remains set. The IDLEN and SCS bits are not affected by the wake-up (see Figure 4-7).

4.4.2 SEC_IDLE MODE

In SEC_IDLE mode, the CPU is disabled but the peripherals continue to be clocked from the Timer1 oscillator. This mode is entered from SEC_RUN by setting the IDLEN bit and executing a SLEEP instruction. If the device is in another Run mode, set IDLEN first, then set SCS<1:0> to '01' and execute SLEEP. When the clock source is switched to the Timer1 oscillator, the primary oscillator is shut-down, the OSTS bit is cleared and the T1RUN bit is set.

When a wake event occurs, the peripherals continue to be clocked from the Timer1 oscillator. After an interval of TCSD following the wake event, the CPU begins executing code being clocked by the Timer1 oscillator. The IDLEN and SCS bits are not affected by the wake-up; the Timer1 oscillator continues to run (see Figure 4-7).

Note: The Timer1 oscillator should already be running prior to entering SEC_IDLE mode. If the T1OSCEN bit is not set when the SLEEP instruction is executed, the SLEEP instruction will be ignored and entry to SEC_IDLE mode will not occur. If the Timer1 oscillator is enabled, but not yet running, peripheral clocks will be delayed until the oscillator has started. In such situations, initial oscillator operation is far from stable and unpredictable operation may result.

FIGURE 4-6: TRANSITION TIMING FOR ENTRY TO IDLE MODE

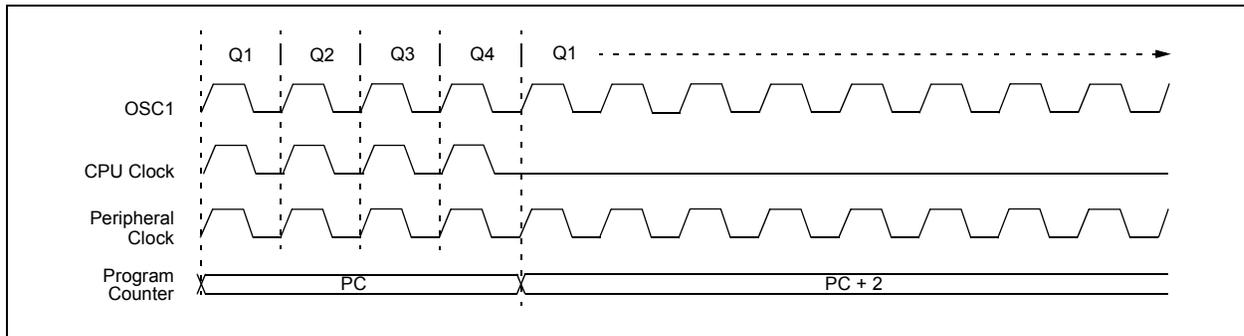
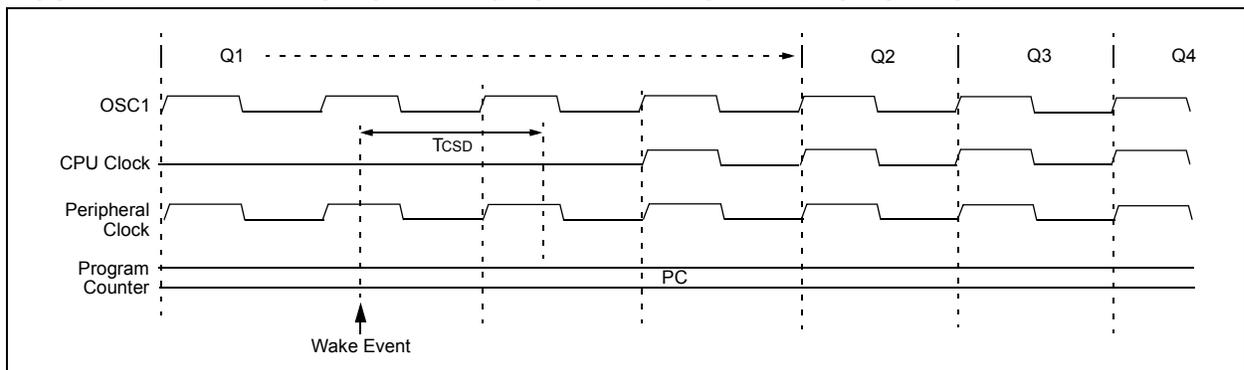


FIGURE 4-7: TRANSITION TIMING FOR WAKE FROM IDLE TO RUN MODE



PIC18F45J10 FAMILY

FIGURE 5-4: TIME-OUT SEQUENCE ON POWER-UP ($\overline{\text{MCLR}}$ NOT TIED TO V_{DD}): CASE 1

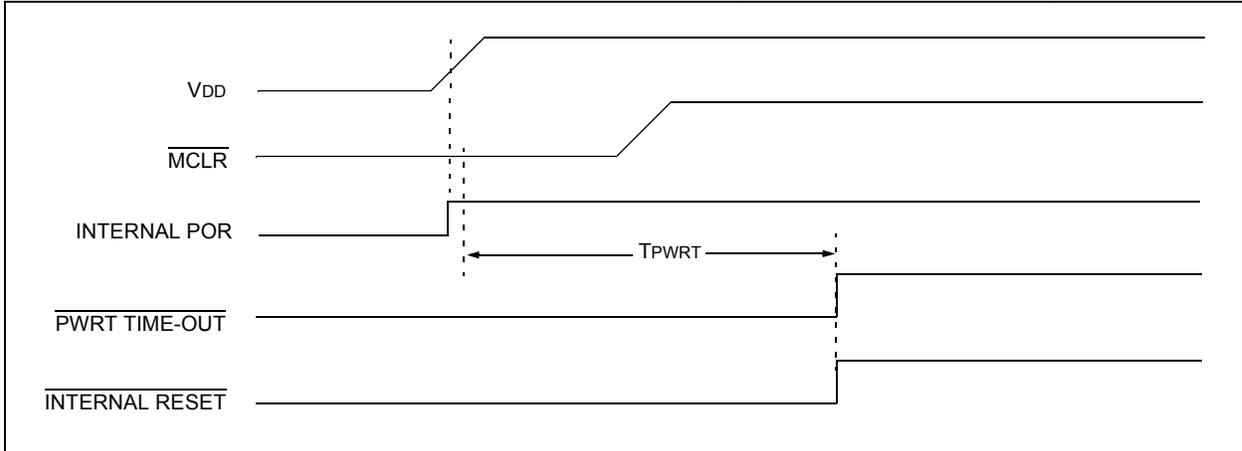


FIGURE 5-5: TIME-OUT SEQUENCE ON POWER-UP ($\overline{\text{MCLR}}$ NOT TIED TO V_{DD}): CASE 2

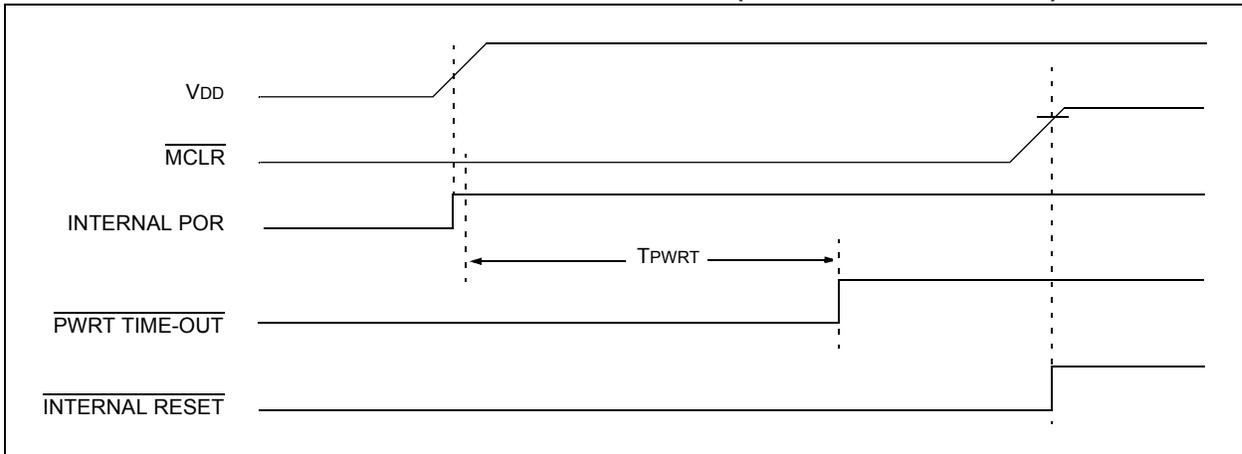
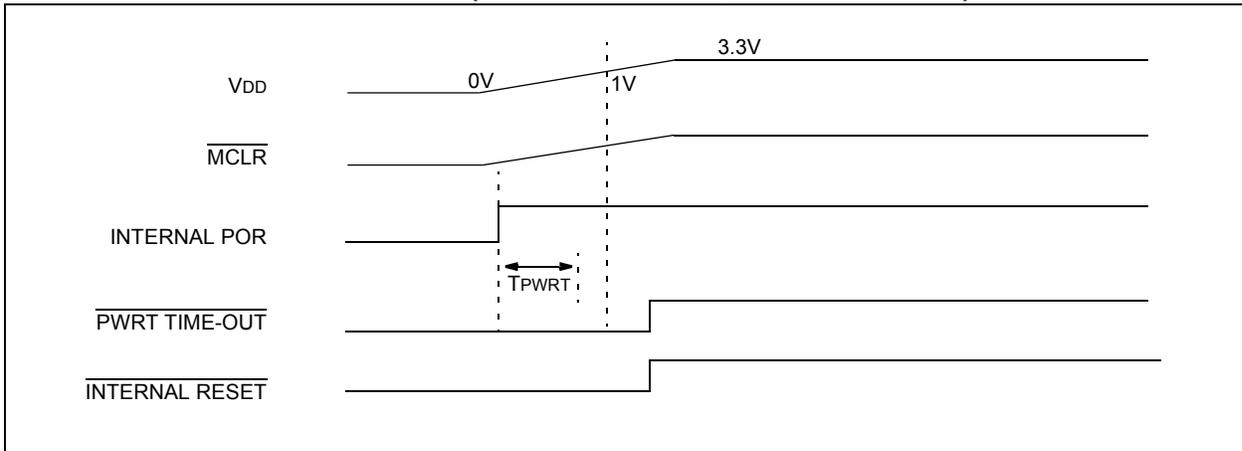


FIGURE 5-6: SLOW RISE TIME ($\overline{\text{MCLR}}$ TIED TO V_{DD} , V_{DD} RISE $>$ T_{PWRT})



PIC18F45J10 FAMILY

6.0 MEMORY ORGANIZATION

There are two types of memory in PIC18 Enhanced microcontroller devices:

- Program Memory
- Data RAM

As Harvard architecture devices, the data and program memories use separate busses; this allows for concurrent access of the two memory spaces.

Additional detailed information on the operation of the Flash program memory is provided in **Section 7.0 “Flash Program Memory”**.

6.1 Program Memory Organization

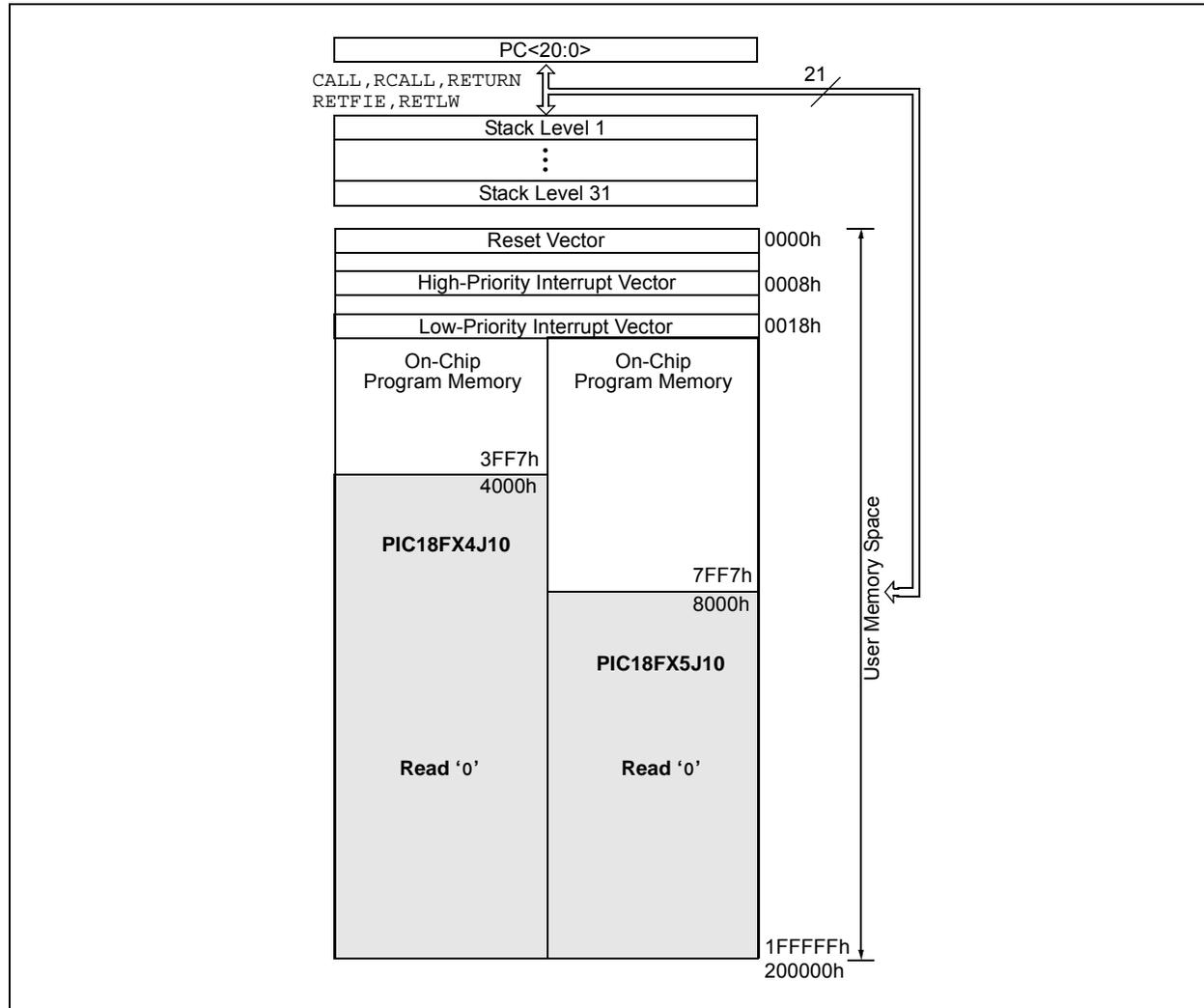
PIC18 microcontrollers implement a 21-bit program counter, which is capable of addressing a 2-Mbyte program memory space. Accessing a location between the upper boundary of the physically implemented memory and the 2-Mbyte address will return all ‘0’s (a NOP instruction).

The PIC18F24J10 and PIC18F44J10 each have 16 Kbytes of Flash memory and can store up to 8,192 single-word instructions. The PIC18F25J10 and PIC18F45J10 each have 32 Kbytes of Flash memory and can store up to 16,384 single-word instructions.

PIC18 devices have two interrupt vectors. The Reset vector address is at 0000h and the interrupt vector addresses are at 0008h and 0018h.

The program memory map for the PIC18F45J10 family devices is shown in Figure 6-1.

FIGURE 6-1: PROGRAM MEMORY MAP AND STACK FOR PIC18F45J10 FAMILY DEVICES



PIC18F45J10 FAMILY

11.1 Timer0 Operation

Timer0 can operate as either a timer or a counter; the mode is selected with the T0CS bit (T0CON<5>). In Timer mode (T0CS = 0), the module increments on every clock by default unless a different prescaler value is selected (see **Section 11.3 “Prescaler”**). If the TMR0 register is written to, the increment is inhibited for the following two instruction cycles. The user can work around this by writing an adjusted value to the TMR0 register.

The Counter mode is selected by setting the T0CS bit (= 1). In this mode, Timer0 increments either on every rising or falling edge of pin RB5/T0CKI. The incrementing edge is determined by the Timer0 Source Edge Select bit, T0SE (T0CON<4>); clearing this bit selects the rising edge. Restrictions on the external clock input are discussed below.

An external clock source can be used to drive Timer0; however, it must meet certain requirements to ensure that the external clock can be synchronized with the

internal phase clock (Tosc). There is a delay between synchronization and the onset of incrementing the timer/counter.

11.2 Timer0 Reads and Writes in 16-Bit Mode

TMR0H is not the actual high byte of Timer0 in 16-bit mode. It is actually a buffered version of the real high byte of Timer0 which is not directly readable nor writable (refer to Figure 11-2). TMR0H is updated with the contents of the high byte of Timer0 during a read of TMR0L. This provides the ability to read all 16 bits of Timer0 without having to verify that the read of the high and low byte were valid, due to a rollover between successive reads of the high and low byte.

Similarly, a write to the high byte of Timer0 must also take place through the TMR0H Buffer register. The high byte is updated with the contents of TMR0H when a write occurs to TMR0L. This allows all 16 bits of Timer0 to be updated at once.

FIGURE 11-1: TIMER0 BLOCK DIAGRAM (8-BIT MODE)

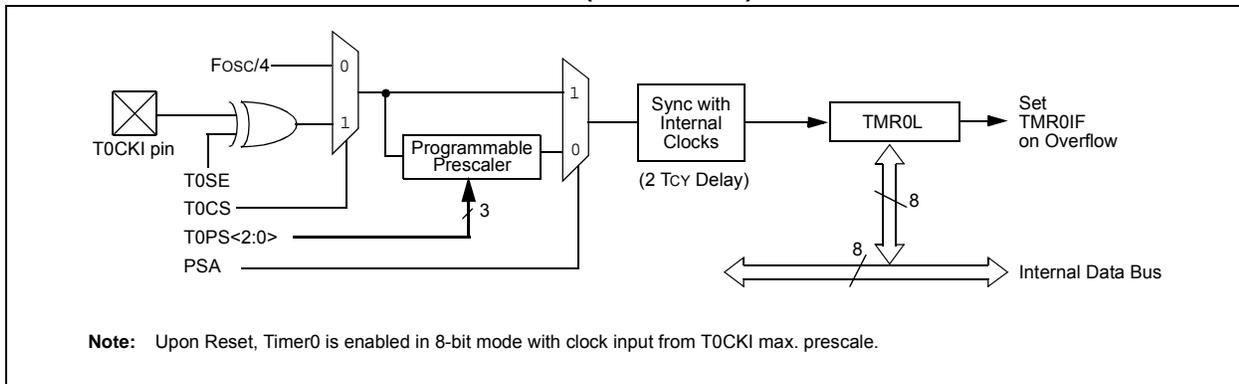
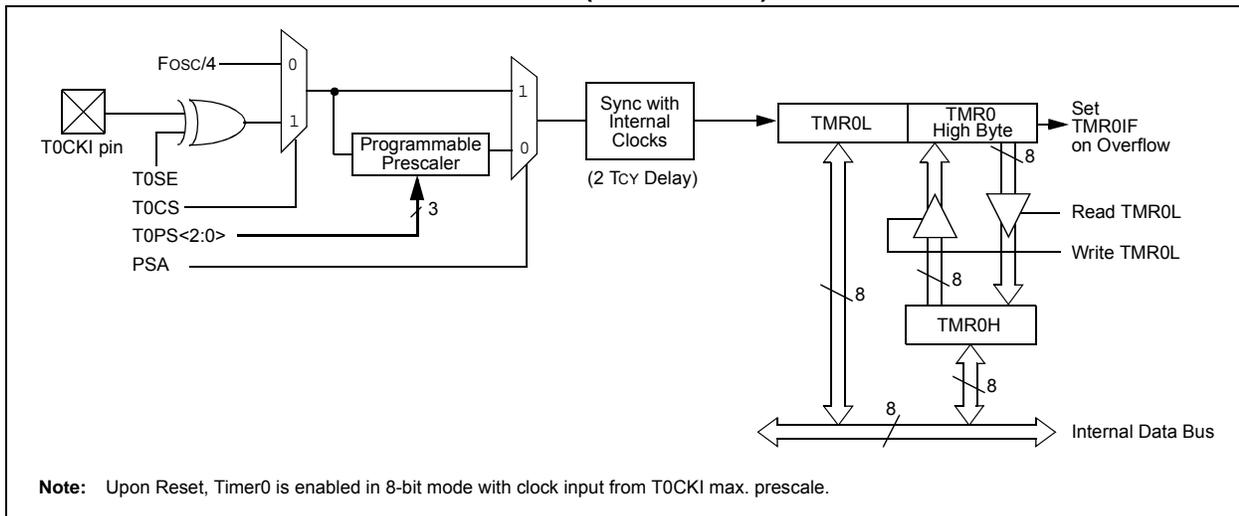


FIGURE 11-2: TIMER0 BLOCK DIAGRAM (16-BIT MODE)



PIC18F45J10 FAMILY

In addition to the expanded range of modes available through the CCP1CON register and ECCP1AS register, the ECCP module has an additional register associated with Enhanced PWM operation and auto-shutdown features. It is:

- ECCP1DEL (PWM Dead-Band Delay)

15.1 ECCP Outputs and Configuration

The Enhanced CCP module may have up to four PWM outputs, depending on the selected operating mode. These outputs, designated P1A through P1D, are multiplexed with I/O pins on PORTC and PORTD. The outputs that are active depend on the ECCP operating mode selected. The pin assignments are summarized in Table 15-1.

To configure the I/O pins as PWM outputs, the proper PWM mode must be selected by setting the P1M<1:0> and CCP1M<3:0> bits. The appropriate TRISC and TRISD direction bits for the port pins must also be set as outputs.

15.1.1 ECCP MODULES AND TIMER RESOURCES

Like the standard CCP modules, the ECCP module can utilize Timers 1 or 2, depending on the mode selected. Timer1 is available for modules in Capture or Compare modes, while Timer2 is available for modules in PWM mode. Interactions between the standard and Enhanced CCP modules are identical to those described for standard CCP modules. Additional details on timer resources are provided in **Section 14.1.1 “CCP Modules and Timer Resources”**.

15.2 Capture and Compare Modes

Except for the operation of the Special Event Trigger discussed below, the Capture and Compare modes of the ECCP module are identical in operation to that of CCP2. These are discussed in detail in **Section 14.2 “Capture Mode”** and **Section 14.3 “Compare Mode”**. No changes are required when moving between 28-pin and 40/44-pin devices.

15.2.1 SPECIAL EVENT TRIGGER

The Special Event Trigger output of ECCP1 resets the TMR1 register pair. This allows the CCPR1 register to effectively be a 16-bit programmable period register for Timer1.

15.3 Standard PWM Mode

When configured in Single Output mode, the ECCP module functions identically to the standard CCP module in PWM mode, as described in **Section 14.4 “PWM Mode”**. This is also sometimes referred to as “Compatible CCP” mode, as in Table 15-1.

Note: When setting up single output PWM operations, users are free to use either of the processes described in **Section 14.4.4 “Setup for PWM Operation”** or **Section 15.4.9 “Setup for PWM Operation”**. The latter is more generic and will work for either single or multi-output PWM.

TABLE 15-1: PIN ASSIGNMENTS FOR VARIOUS ECCP1 MODES

ECCP Mode	CCP1CON Configuration	RC2	RD5	RD6	RD7
All 40/44-pin Devices:					
Compatible CCP	00xx 11xx	CCP1	RD5/PSP5	RD6/PSP6	RD7/PSP7
Dual PWM	10xx 11xx	P1A	P1B	RD6/PSP6	RD7/PSP7
Quad PWM	x1xx 11xx	P1A	P1B	P1C	P1D

Legend: x = Don't care. Shaded cells indicate pin assignments not used by ECCP1 in a given mode.

PIC18F45J10 FAMILY

15.4.4 HALF-BRIDGE MODE

In the Half-Bridge Output mode, two pins are used as outputs to drive push-pull loads. The PWM output signal is output on the P1A pin, while the complementary PWM output signal is output on the P1B pin (Figure 15-4). This mode can be used for half-bridge applications, as shown in Figure 15-5, or for full-bridge applications where four power switches are being modulated with two PWM signals.

In Half-Bridge Output mode, the programmable dead-band delay can be used to prevent shoot-through current in half-bridge power devices. The value of bits, PDC<6:0>, sets the number of instruction cycles before the output is driven active. If the value is greater than the duty cycle, the corresponding output remains inactive during the entire cycle. See **Section 15.4.6 “Programmable Dead-Band Delay”** for more details of the dead-band delay operations.

Since the P1A and P1B outputs are multiplexed with the PORTC<2> and PORTD<5> data latches, the TRISC<2> and TRISD<5> bits must be cleared to configure P1A and P1B as outputs.

FIGURE 15-4: HALF-BRIDGE PWM OUTPUT

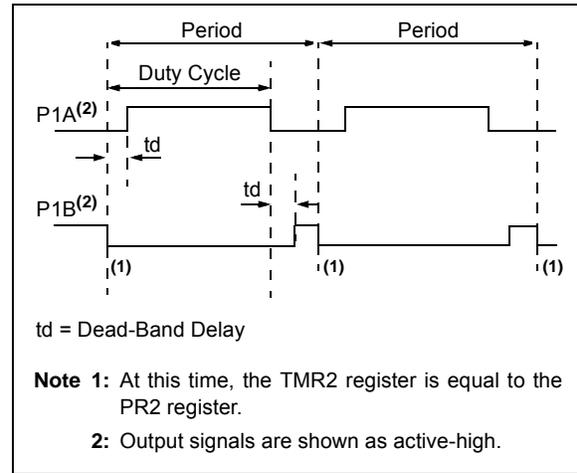
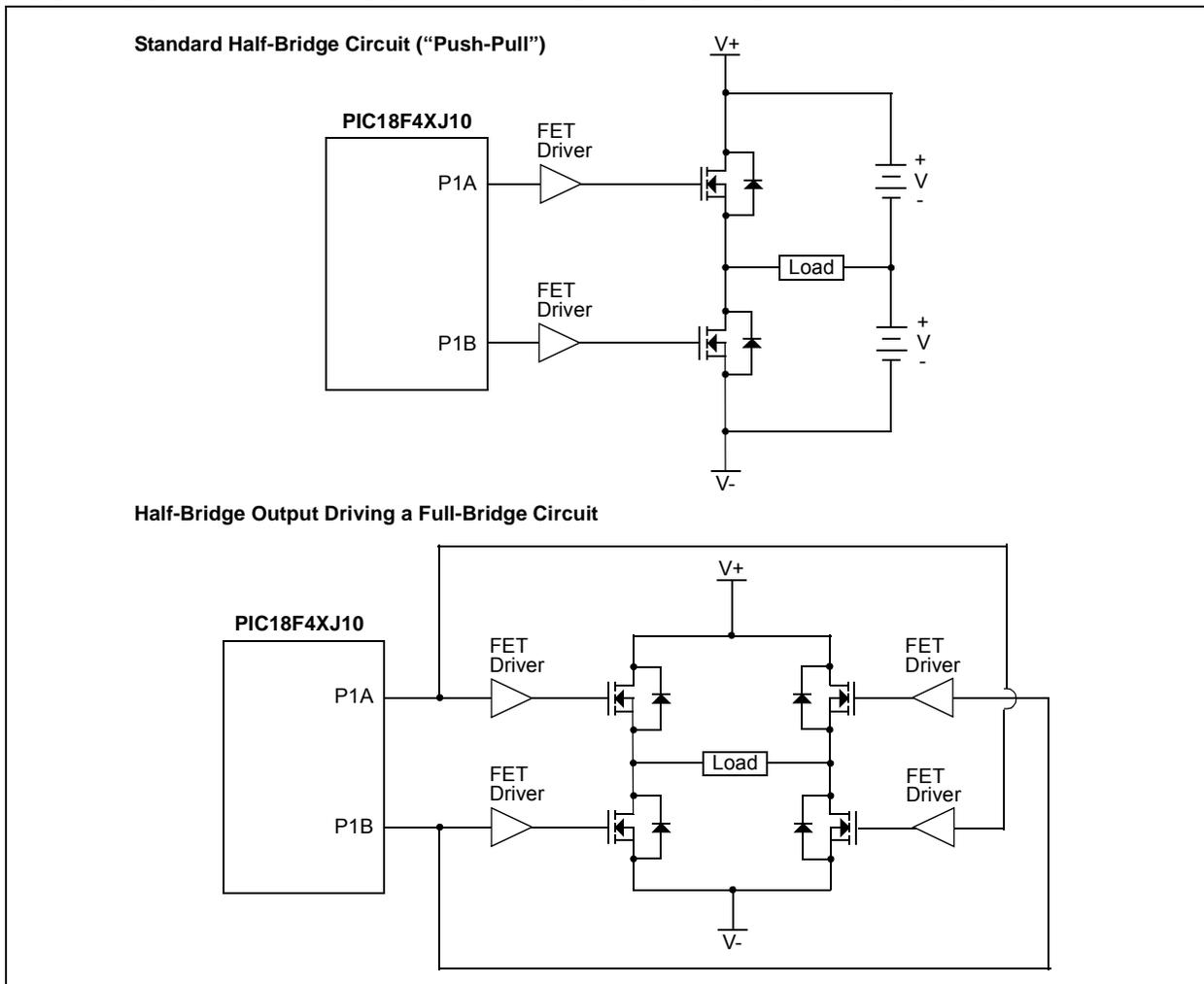


FIGURE 15-5: EXAMPLES OF HALF-BRIDGE OUTPUT MODE APPLICATIONS



PIC18F45J10 FAMILY

FIGURE 15-8: PWM DIRECTION CHANGE

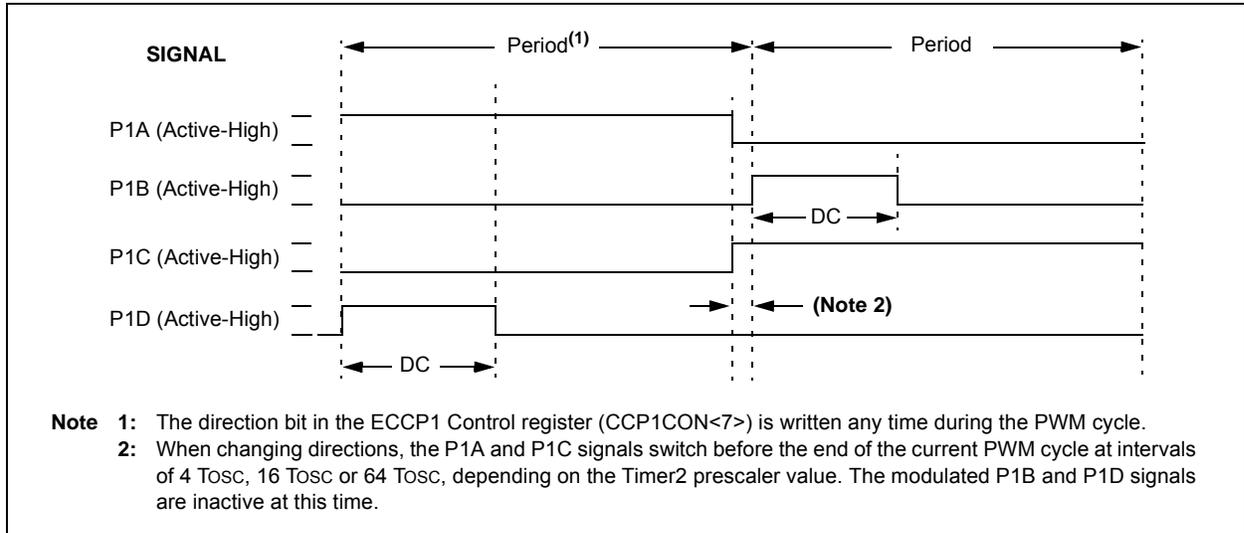
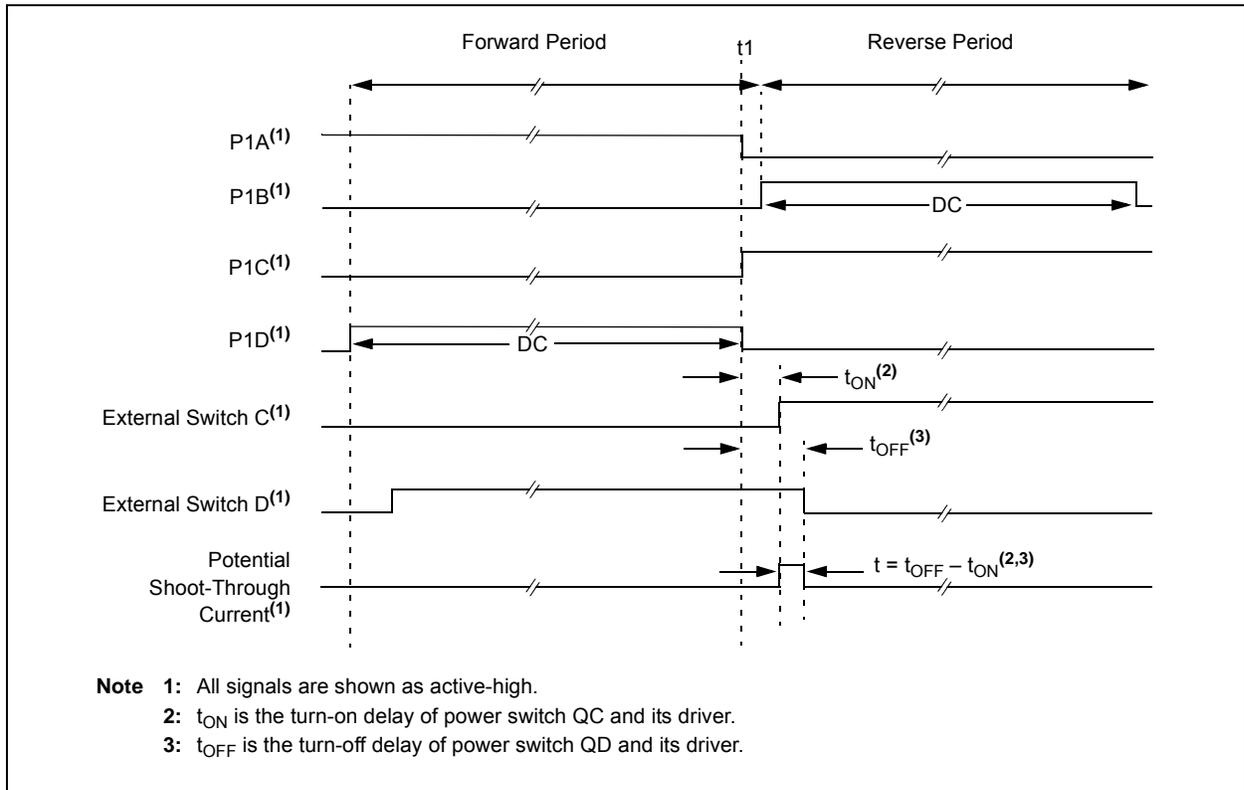


FIGURE 15-9: PWM DIRECTION CHANGE AT NEAR 100% DUTY CYCLE



PIC18F45J10 FAMILY

15.4.7.1 Auto-Shutdown and Automatic Restart

The auto-shutdown feature can be configured to allow automatic restarts of the module following a shutdown event. This is enabled by setting the PRSEN bit of the ECCP1DEL register (ECCP1DEL<7>).

In Shutdown mode with PRSEN = 1 (Figure 15-10), the ECCPASE bit will remain set for as long as the cause of the shutdown continues. When the shutdown condition clears, the ECCPASE bit is cleared. If PRSEN = 0 (Figure 15-11), once a shutdown condition occurs, the ECCPASE bit will remain set until it is cleared by firmware. Once ECCPASE is cleared, the Enhanced PWM will resume at the beginning of the next PWM period.

Note: Writing to the ECCPASE bit is disabled while a shutdown condition is active.

Independent of the PRSEN bit setting, if the auto-shutdown source is one of the comparators, the shutdown condition is a level. The ECCPASE bit cannot be cleared as long as the cause of the shutdown persists.

The Auto-Shutdown mode can be forced by writing a '1' to the ECCPASE bit.

15.4.8 START-UP CONSIDERATIONS

When the ECCP module is used in the PWM mode, the application hardware must use the proper external pull-up and/or pull-down resistors on the PWM output pins. When the microcontroller is released from Reset, all of the I/O pins are in the high-impedance state. The external circuits must keep the power switch devices in the OFF state until the microcontroller drives the I/O pins with the proper signal levels, or activates the PWM output(s).

The CCP1M<1:0> bits (CCP1CON<1:0>) allow the user to choose whether the PWM output signals are active-high or active-low for each pair of PWM output pins (P1A/P1C and P1B/P1D). The PWM output polarities must be selected before the PWM pins are configured as outputs. Changing the polarity configuration while the PWM pins are configured as outputs is not recommended, since it may result in damage to the application circuits.

The P1A, P1B, P1C and P1D output latches may not be in the proper states when the PWM module is initialized. Enabling the PWM pins for output at the same time as the ECCP module may cause damage to the application circuit. The ECCP module must be enabled in the proper output mode and complete a full PWM cycle before configuring the PWM pins as outputs. The completion of a full PWM cycle is indicated by the TMR2IF bit being set as the second PWM period begins.

FIGURE 15-10: PWM AUTO-SHUTDOWN (PRSEN = 1, AUTO-RESTART ENABLED)

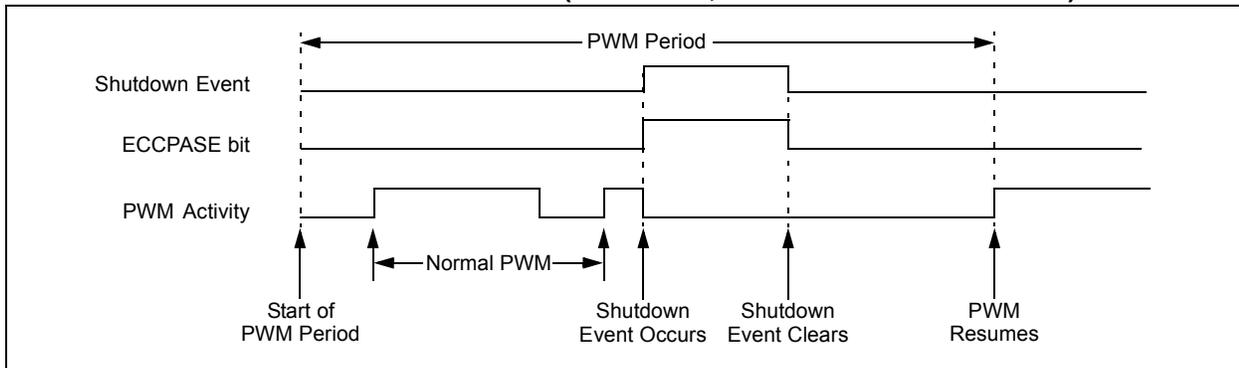


FIGURE 15-11: PWM AUTO-SHUTDOWN (PRSEN = 0, AUTO-RESTART DISABLED)

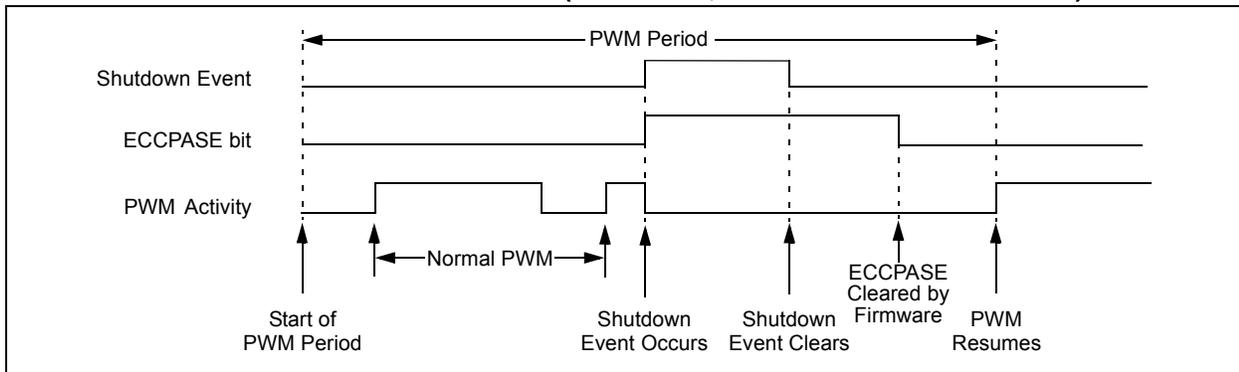
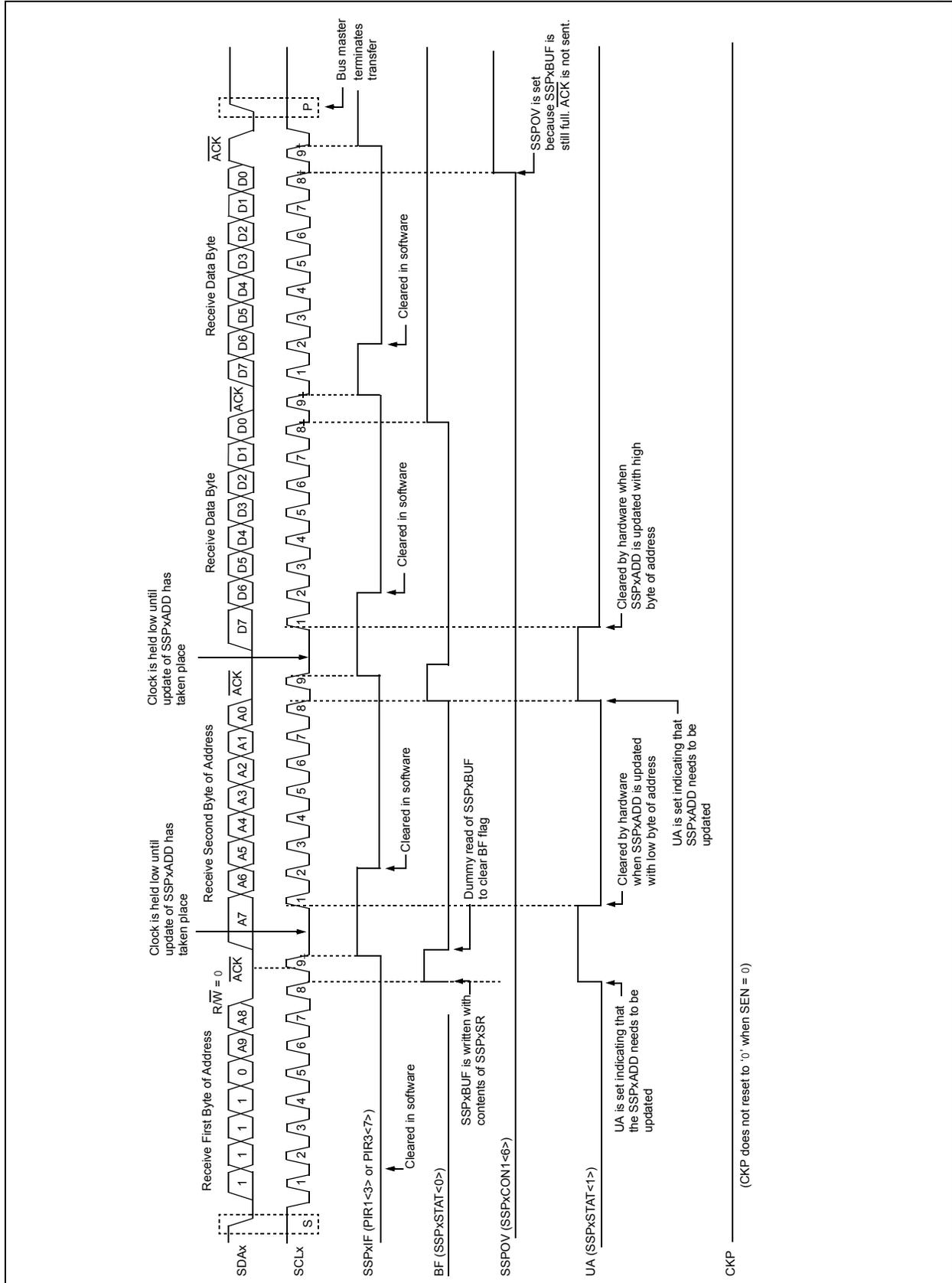


FIGURE 16-10: I²C™ SLAVE MODE TIMING WITH SEN = 0 (RECEPTION, 10-BIT ADDRESSING)



17.1.3 AUTO-BAUD RATE DETECT

The Enhanced USART module supports the automatic detection and calibration of baud rate. This feature is active only in Asynchronous mode and while the WUE bit is clear.

The automatic baud rate measurement sequence (Figure 17-1) begins whenever a Start bit is received and the ABDEN bit is set. The calculation is self-averaging.

In the Auto-Baud Rate Detect (ABD) mode, the clock to the BRG is reversed. Rather than the BRG clocking the incoming RX signal, the RX signal is timing the BRG. In ABD mode, the internal Baud Rate Generator is used as a counter to time the bit period of the incoming serial byte stream.

Once the ABDEN bit is set, the state machine will clear the BRG and look for a Start bit. The Auto-Baud Rate Detect must receive a byte with the value 55h (ASCII “U”, which is also the LIN/J2602 bus Sync character) in order to calculate the proper bit rate. The measurement is taken over both a low and a high bit time in order to minimize any effects caused by asymmetry of the incoming signal. After a Start bit, the SPBRG begins counting up, using the preselected clock source on the first rising edge of RX. After eight bits on the RX pin or the fifth rising edge, an accumulated value totalling the proper BRG period is left in the SPBRGH:SPBRG register pair. Once the 5th edge is seen (this should correspond to the Stop bit), the ABDEN bit is automatically cleared.

If a rollover of the BRG occurs (an overflow from FFFFh to 0000h), the event is trapped by the ABDOVF status bit (BAUDCON<7>). It is set in hardware by BRG rollovers and can be set or cleared by the user in software. ABD mode remains active after rollover events and the ABDEN bit remains set (Figure 17-2).

While calibrating the baud rate period, the BRG registers are clocked at 1/8th the preconfigured clock rate. Note that the BRG clock will be configured by the BRG16 and BRGH bits. Independent of the BRG16 bit setting, both the SPBRG and SPBRGH will be used as a 16-bit counter. This allows the user to verify that no carry occurred for 8-bit modes by checking for 00h in the SPBRGH register. Refer to Table 17-4 for counter clock rates to the BRG.

While the ABD sequence takes place, the EUSART state machine is held in Idle. The RCIF interrupt is set once the fifth rising edge on RX is detected. The value in the RCREG needs to be read to clear the RCIF interrupt. The contents of RCREG should be discarded.

Note 1: If the WUE bit is set with the ABDEN bit, Auto-Baud Rate Detection will occur on the byte *following* the Break character.

2: It is up to the user to determine that the incoming character baud rate is within the range of the selected BRG clock source. Some combinations of oscillator frequency and EUSART baud rates are not possible due to bit error rates. Overall system timing and communication baud rates must be taken into consideration when using the Auto-Baud Rate Detection feature.

TABLE 17-4: BRG COUNTER CLOCK RATES

BRG16	BRGH	BRG Counter Clock
0	0	Fosc/512
0	1	Fosc/128
1	0	Fosc/128
1	1	Fosc/32

Note: During the ABD sequence, SPBRG and SPBRGH are both used as a 16-bit counter, independent of BRG16 setting.

17.1.3.1 ABD and EUSART Transmission

Since the BRG clock is reversed during ABD acquisition, the EUSART transmitter cannot be used during ABD. This means that whenever the ABDEN bit is set, TXREG cannot be written to. Users should also ensure that ABDEN does not become set during a transmit sequence. Failing to do this may result in unpredictable EUSART operation.

PIC18F45J10 FAMILY

18.7 A/D Converter Calibration

The A/D converter in the PIC18F45J10 family of devices includes a self-calibration feature which compensates for any offset generated within the module. The calibration process is automated and is initiated by setting the ADCAL bit (ADCON0<7>). The next time the GO/DONE bit is set, the module will perform a “dummy” conversion (that is, with reading none of the input channels) and store the resulting value internally to compensate for offset. Thus, subsequent offsets will be compensated.

The calibration process assumes that the device is in a relatively steady-state operating condition. If A/D calibration is used, it should be performed after each device Reset or if there are other major changes in operating conditions.

18.8 Operation in Power-Managed Modes

The selection of the automatic acquisition time and A/D conversion clock is determined in part by the clock source and frequency while in a power-managed mode.

If the A/D is expected to operate while the device is in a power-managed mode, the ACQT<2:0> and ADCS<2:0> bits in ADCON2 should be updated in accordance with the power-managed mode clock that will be used. After the power-managed mode is entered (either of the power-managed Run modes), an A/D acquisition or conversion may be started. Once an acquisition or conversion is started, the device should continue to be clocked by the same power-managed mode clock source until the conversion has been completed. If desired, the device may be placed into the corresponding power-managed Idle mode during the conversion.

If the power-managed mode clock frequency is less than 1 MHz, the A/D RC clock source should be selected.

Operation in the Sleep mode requires the A/D RC clock to be selected. If bits, ACQT<2:0>, are set to ‘000’ and a conversion is started, the conversion will be delayed one instruction cycle to allow execution of the SLEEP instruction and entry to Sleep mode. The IDLEN and SCS bits in the OSCCON register must have already been cleared prior to starting the conversion.

TABLE 18-2: REGISTERS ASSOCIATED WITH A/D OPERATION

Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Reset Values on page
INTCON	GIE/GIEH	PEIE/GIEL	TMR0IE	INT0IE	RBIE	TMR0IF	INT0IF	RBIF	47
PIR1	PSPIF ⁽¹⁾	ADIF	RCIF	TXIF	SSP1IF	CCP1IF	TMR2IF	TMR1IF	49
PIE1	PSPIE ⁽¹⁾	ADIE	RCIE	TXIE	SSP1IE	CCP1IE	TMR2IE	TMR1IE	49
IPR1	PSPIP ⁽¹⁾	ADIP	RCIP	TXIP	SSP1IP	CCP1IP	TMR2IP	TMR1IP	49
PIR2	OSCFIF	CMIF	—	—	BCL1IF	—	—	CCP2IF	49
PIE2	OSCFIE	CMIE	—	—	BCL1IE	—	—	CCP2IE	49
IPR2	OSCFIP	CMIP	—	—	BCL1IP	—	—	CCP2IP	49
ADRESH	A/D Result Register High Byte								48
ADRESL	A/D Result Register Low Byte								48
ADCON0	ADCAL	—	CHS3	CHS2	CHS1	CHS0	GO/DONE	ADON	48
ADCON1	—	—	VCFG1	VCFG0	PCFG3	PCFG2	PCFG1	PCFG0	48
ADCON2	ADFM	—	ACQT2	ACQT1	ACQT0	ADCS2	ADCS1	ADCS0	48
PORTA	—	—	RA5	—	RA3	RA2	RA1	RA0	50
TRISA	—	—	TRISA5	—	TRISA3	TRISA2	TRISA1	TRISA0	50
PORTB	RB7	RB6	RB5	RB4	RB3	RB2	RB1	RB0	50
TRISB	PORTB Data Direction Control Register								50
LATB	PORTB Data Latch Register (Read and Write to Data Latch)								50
PORTE ⁽¹⁾	—	—	—	—	—	RE2	RE1	RE0	50
TRISE ⁽¹⁾	IBF	OBF	IBOV	PSPMODE	—	TRISE2	TRISE1	TRISE0	50
LATE ⁽¹⁾	—	—	—	—	—	PORTE Data Latch Register (Read and Write to Data Latch)			50

Legend: — = unimplemented, read as ‘0’. Shaded cells are not used for A/D conversion.

Note 1: These registers and/or bits are not implemented on 28-pin devices and should be read as ‘0’.

20.0 COMPARATOR VOLTAGE REFERENCE MODULE

The comparator voltage reference is a 16-tap resistor ladder network that provides a selectable reference voltage. Although its primary purpose is to provide a reference for the analog comparators, it may also be used independently of them.

A block diagram of the module is shown in Figure 20-1. The resistor ladder is segmented to provide two ranges of CVREF values and has a power-down function to conserve power when the reference is not being used. The module's supply reference can be provided from either device VDD/VSS or an external voltage reference.

20.1 Configuring the Comparator Voltage Reference

The voltage reference module is controlled through the CVRCON register (Register 20-1). The comparator voltage reference provides two ranges of output voltage, each with 16 distinct levels. The range to be

used is selected by the CVRR bit (CVRCON<5>). The primary difference between the ranges is the size of the steps selected by the CVREF Selection bits (CVR<3:0>), with one range offering finer resolution. The equations used to calculate the output of the comparator voltage reference are as follows:

$$\text{If CVRR} = 1: \\ \text{CVREF} = ((\text{CVR}\langle 3:0 \rangle) / 24) \times \text{CVRSRC}$$

$$\text{If CVRR} = 0: \\ \text{CVREF} = (\text{CVRSRC} \times 1/4) + (((\text{CVR}\langle 3:0 \rangle) / 32) \times \text{CVRSRC})$$

The comparator reference supply voltage can come from either VDD and VSS, or the external VREF+ and VREF- that are multiplexed with RA2 and RA3. The voltage source is selected by the CVRSS bit (CVRCON<4>).

The settling time of the comparator voltage reference must be considered when changing the CVREF output (see Table 24-3 in **Section 24.0 "Electrical Characteristics"**).

REGISTER 20-1: CVRCON: COMPARATOR VOLTAGE REFERENCE CONTROL REGISTER

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
CVREN	CVROE ⁽¹⁾	CVRR	CVRSS	CVR3	CVR2	CVR1	CVR0
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 **CVREN:** Comparator Voltage Reference Enable bit
1 = CVREF circuit powered on
0 = CVREF circuit powered down
- bit 6 **CVROE:** Comparator VREF Output Enable bit⁽¹⁾
1 = CVREF voltage level is also output on the RA2/AN2/VREF-/CVREF pin
0 = CVREF voltage is disconnected from the RA2/AN2/VREF-/CVREF pin
- bit 5 **CVRR:** Comparator VREF Range Selection bit
1 = 0 to 0.667 CVRSRC, with CVRSRC/24 step size (low range)
0 = 0.25 CVRSRC to 0.75 CVRSRC, with CVRSRC/32 step size (high range)
- bit 4 **CVRSS:** Comparator VREF Source Selection bit
1 = Comparator reference source, CVRSRC = (VREF+) – (VREF-)
0 = Comparator reference source, CVRSRC = VDD – VSS
- bit 3-0 **CVR<3:0>:** Comparator VREF Value Selection bits (0 ≤ (CVR<3:0>) ≤ 15)
When CVRR = 1:
CVREF = ((CVR<3:0>)/24) • (CVRSRC)
When CVRR = 0:
CVREF = (CVRSRC/4) + ((CVR<3:0>)/32) • (CVRSRC)

Note 1: CVROE overrides the TRISA<2> bit setting.

PIC18F45J10 FAMILY

BNOV Branch if Not Overflow

Syntax: BNOV n

Operands: $-128 \leq n \leq 127$

Operation: if Overflow bit is '0',
(PC) + 2 + 2n → PC

Status Affected: None

Encoding:

1110	0101	nnnn	nnnn
------	------	------	------

Description: If the Overflow bit is '0', then the program will branch. The 2's complement number, '2n', is added to the PC. Since the PC will have incremented to fetch the next instruction, the new address will be PC + 2 + 2n. This instruction is then a two-cycle instruction.

Words: 1

Cycles: 1(2)

Q Cycle Activity:

If Jump:

Q1	Q2	Q3	Q4
Decode	Read literal 'n'	Process Data	Write to PC
No operation	No operation	No operation	No operation

If No Jump:

Q1	Q2	Q3	Q4
Decode	Read literal 'n'	Process Data	No operation

Example: HERE BNOV Jump

Before Instruction
PC = address (HERE)

After Instruction
If Overflow = 0;
PC = address (Jump)
If Overflow = 1;
PC = address (HERE + 2)

BNZ Branch if Not Zero

Syntax: BNZ n

Operands: $-128 \leq n \leq 127$

Operation: if Zero bit is '0',
(PC) + 2 + 2n → PC

Status Affected: None

Encoding:

1110	0001	nnnn	nnnn
------	------	------	------

Description: If the Zero bit is '0', then the program will branch. The 2's complement number, '2n', is added to the PC. Since the PC will have incremented to fetch the next instruction, the new address will be PC + 2 + 2n. This instruction is then a two-cycle instruction.

Words: 1

Cycles: 1(2)

Q Cycle Activity:

If Jump:

Q1	Q2	Q3	Q4
Decode	Read literal 'n'	Process Data	Write to PC
No operation	No operation	No operation	No operation

If No Jump:

Q1	Q2	Q3	Q4
Decode	Read literal 'n'	Process Data	No operation

Example: HERE BNZ Jump

Before Instruction
PC = address (HERE)

After Instruction
If Zero = 0;
PC = address (Jump)
If Zero = 1;
PC = address (HERE + 2)

PIC18F45J10 FAMILY

RETURN **Return from Subroutine**

Syntax: RETURN {s}

Operands: s ∈ [0, 1]

Operation: (TOS) → PC;
 if s = 1,
 (WR) → W,
 (STATUS) → STATUS,
 (BSR) → BSR,
 PCLATH, PCLATH are unchanged

Status Affected: None

Encoding:

0000	0000	0001	001s
------	------	------	------

Description: Return from subroutine. The stack is popped and the top of the stack (TOS) is loaded into the program counter. If 's' = 1, the contents of the shadow registers, WS, STATUS and BSR, are loaded into their corresponding registers, W, STATUS and BSR. If 's' = 0, no update of these registers occurs (default).

Words: 1

Cycles: 2

Q Cycle Activity:

	Q1	Q2	Q3	Q4
Decode	No operation	Process Data	POP PC from stack	
No operation	No operation	No operation	No operation	No operation

Example: RETURN

After Instruction:
 PC = TOS

RLCF **Rotate Left f through Carry**

Syntax: RLCF f {,d {,a}}

Operands: 0 ≤ f ≤ 255
 d ∈ [0, 1]
 a ∈ [0, 1]

Operation: (f<n>) → dest<n + 1>,
 (f<7>) → C,
 (C) → dest<0>

Status Affected: C, N, Z

Encoding:

0011	01da	ffff	ffff
------	------	------	------

Description: The contents of register 'f' are rotated one bit to the left through the Carry flag. If 'd' is '0', the result is placed in W. If 'd' is '1', the result is stored back in register 'f' (default).
 If 'a' is '0', the Access Bank is selected. If 'a' is '1', the BSR is used to select the GPR bank (default).
 If 'a' is '0' and the extended instruction set is enabled, this instruction operates in Indexed Literal Offset Addressing mode whenever f ≤ 95 (5Fh). See **Section 22.2.3 "Byte-Oriented and Bit-Oriented Instructions in Indexed Literal Offset Mode"** for details.



Words: 1

Cycles: 1

Q Cycle Activity:

	Q1	Q2	Q3	Q4
Decode	Read register 'f'	Process Data	Write to destination	

Example: RLCF REG, 0, 0

Before Instruction

REG = 1110 0110
 C = 0

After Instruction

REG = 1110 0110
 W = 1100 1100
 C = 1

PIC18F45J10 FAMILY

22.2.3 BYTE-ORIENTED AND BIT-ORIENTED INSTRUCTIONS IN INDEXED LITERAL OFFSET MODE

Note: Enabling the PIC18 instruction set extension may cause legacy applications to behave erratically or fail entirely.

In addition to eight new commands in the extended set, enabling the extended instruction set also enables Indexed Literal Offset Addressing mode (**Section 6.5.1 “Indexed Addressing with Literal Offset”**). This has a significant impact on the way that many commands of the standard PIC18 instruction set are interpreted.

When the extended set is disabled, addresses embedded in opcodes are treated as literal memory locations: either as a location in the Access Bank ('a' = 0), or in a GPR bank designated by the BSR ('a' = 1). When the extended instruction set is enabled and 'a' = 0, however, a file register argument of 5Fh or less is interpreted as an offset from the pointer value in FSR2 and not as a literal address. For practical purposes, this means that all instructions that use the Access RAM bit as an argument – that is, all byte-oriented and bit-oriented instructions, or almost half of the core PIC18 instructions – may behave differently when the extended instruction set is enabled.

When the content of FSR2 is 00h, the boundaries of the Access RAM are essentially remapped to their original values. This may be useful in creating backward compatible code. If this technique is used, it may be necessary to save the value of FSR2 and restore it when moving back and forth between C and assembly routines in order to preserve the Stack Pointer. Users must also keep in mind the syntax requirements of the extended instruction set (see **Section 22.2.3.1 “Extended Instruction Syntax with Standard PIC18 Commands”**).

Although the Indexed Literal Offset Addressing mode can be very useful for dynamic stack and pointer manipulation, it can also be very annoying if a simple arithmetic operation is carried out on the wrong register. Users who are accustomed to the PIC18 programming must keep in mind that, when the extended instruction set is enabled, register addresses of 5Fh or less are used for Indexed Literal Offset Addressing.

Representative examples of typical byte-oriented and bit-oriented instructions in the Indexed Literal Offset Addressing mode are provided on the following page to show how execution is affected. The operand conditions shown in the examples are applicable to all instructions of these types.

22.2.3.1 Extended Instruction Syntax with Standard PIC18 Commands

When the extended instruction set is enabled, the file register argument, 'f', in the standard byte-oriented and bit-oriented commands is replaced with the literal offset value, 'k'. As already noted, this occurs only when 'f' is less than or equal to 5Fh. When an offset value is used, it must be indicated by square brackets (“[]”). As with the extended instructions, the use of brackets indicates to the compiler that the value is to be interpreted as an index or an offset. Omitting the brackets, or using a value greater than 5Fh within brackets, will generate an error in the MPASM Assembler.

If the index argument is properly bracketed for Indexed Literal Offset Addressing, the Access RAM argument is never specified; it will automatically be assumed to be '0'. This is in contrast to standard operation (extended instruction set disabled) when 'a' is set on the basis of the target address. Declaring the Access RAM bit in this mode will also generate an error in the MPASM Assembler.

The destination argument, 'd', functions as before.

Refer to the MPLAB® IDE, MPASM™ or MPLAB C18 documentation for information on enabling Extended Instruction set support

22.2.4 CONSIDERATIONS WHEN ENABLING THE EXTENDED INSTRUCTION SET

It is important to note that the extensions to the instruction set may not be beneficial to all users. In particular, users who are not writing code that uses a software stack may not benefit from using the extensions to the instruction set.

Additionally, the Indexed Literal Offset Addressing mode may create issues with legacy applications written to the PIC18 assembler. This is because instructions in the legacy code may attempt to address registers in the Access Bank below 5Fh. Since these addresses are interpreted as literal offsets to FSR2 when the instruction set extension is enabled, the application may read or write to the wrong data addresses.

When porting an application to the PIC18F45J10 family, it is very important to consider the type of code. A large, re-entrant application that is written in 'C' and would benefit from efficient compilation will do well when using the instruction set extensions. Legacy applications that heavily use the Access Bank will most likely not benefit from using the extended instruction set.

PIC18F45J10 FAMILY

FIGURE 24-6: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER TIMING

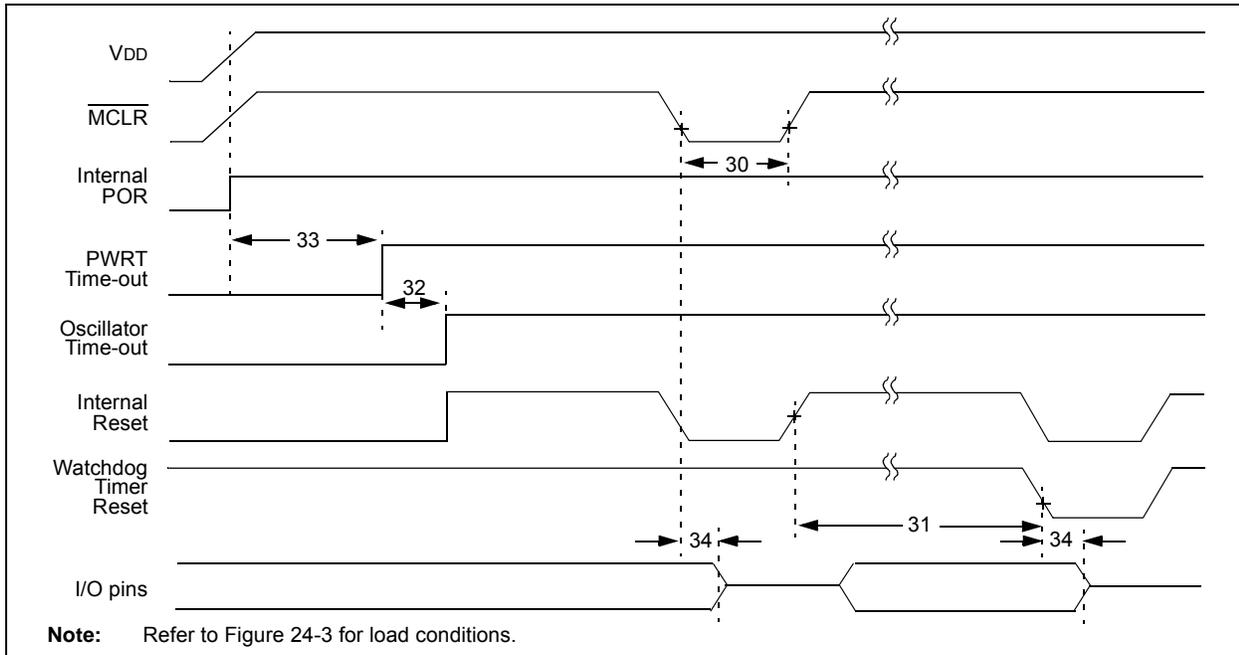


FIGURE 24-7: BROWN-OUT RESET TIMING

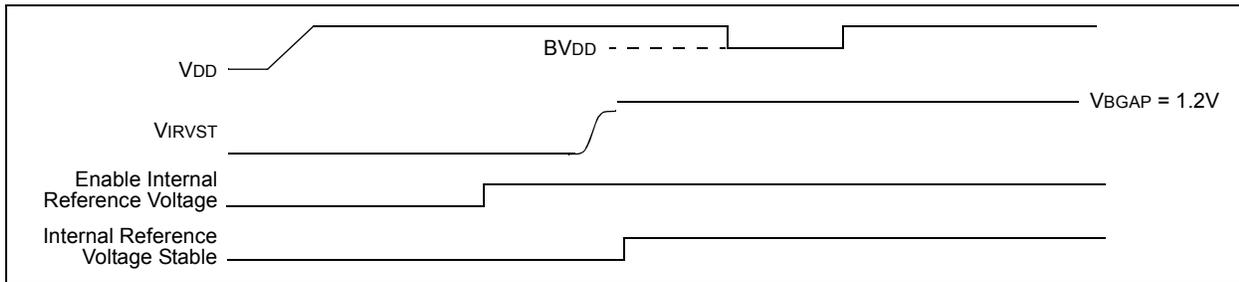


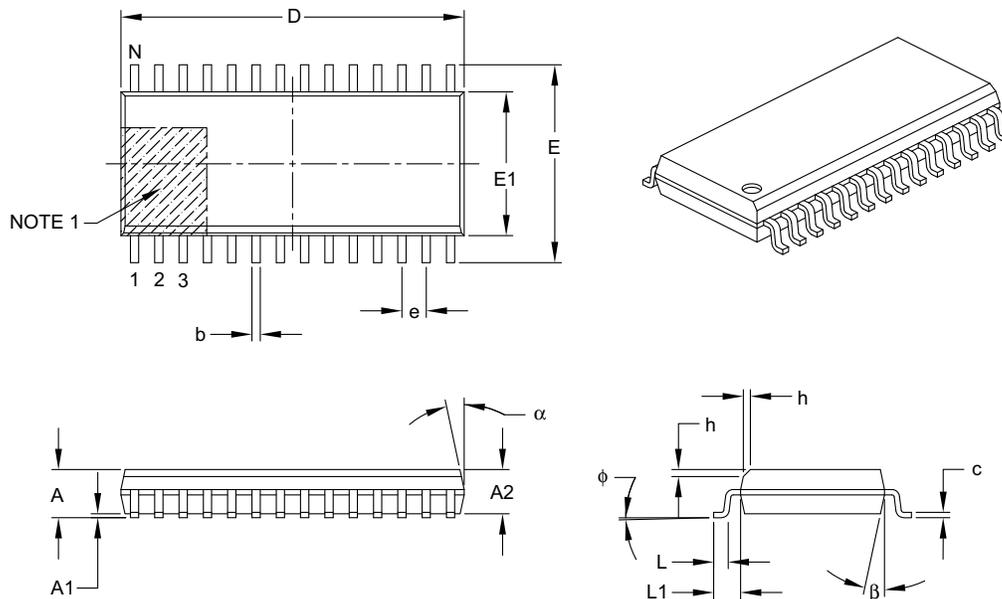
TABLE 24-10: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER, POWER-UP TIMER AND BROWN-OUT RESET REQUIREMENTS

Param. No.	Symbol	Characteristic	Min	Typ	Max	Units	Conditions
30	TMCL	MCLR Pulse Width (low)	2	—	—	μs	
31	TWDT	Watchdog Timer Time-out Period (no postscaler)	2.8	4.1	5.4	ms	
32	TOST	Oscillation Start-up Timer Period	1024 T _{osc}	—	1024 T _{osc}	—	T _{osc} = OSC1 period
33	TPWRT	Power-up Timer Period	46.2	66	85.8	ms	
34	TIOZ	I/O High-Impedance from MCLR Low or Watchdog Timer Reset	—	2	—	μs	
38	TcSD	CPU Start-up Time	—	200	—	μs	

PIC18F45J10 FAMILY

28-Lead Plastic Small Outline (SO) – Wide, 7.50 mm Body [SOIC]

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



Dimension Limits	Units	MILLIMETERS		
		MIN	NOM	MAX
Number of Pins	N	28		
Pitch	e	1.27 BSC		
Overall Height	A	–	–	2.65
Molded Package Thickness	A2	2.05	–	–
Standoff §	A1	0.10	–	0.30
Overall Width	E	10.30 BSC		
Molded Package Width	E1	7.50 BSC		
Overall Length	D	17.90 BSC		
Chamfer (optional)	h	0.25	–	0.75
Foot Length	L	0.40	–	1.27
Footprint	L1	1.40 REF		
Foot Angle Top	ϕ	0°	–	8°
Lead Thickness	c	0.18	–	0.33
Lead Width	b	0.31	–	0.51
Mold Draft Angle Top	α	5°	–	15°
Mold Draft Angle Bottom	β	5°	–	15°

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 0.15 mm per side.
- Dimensioning and tolerancing per ASME Y14.5M.

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

REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-052B