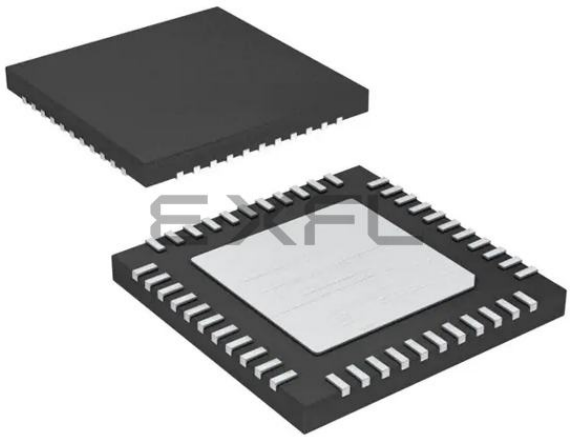

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Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	48MHz
Connectivity	I²C, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	34
Program Memory Size	64KB (32K x 16)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	3.8K x 8
Voltage - Supply (Vcc/Vdd)	2.15V ~ 3.6V
Data Converters	A/D 13x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	44-VQFN Exposed Pad
Supplier Device Package	44-QFN (8x8)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic18f46j11t-i-ml

NOTES:

TABLE 1-4: PIC18F4XJ11 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number		Pin Type	Buffer Type	Description
	44-QFN	44-TQFP			
					PORTE is a bidirectional I/O port.
RE0/AN5/PMRD	25	25			
RE0			I/O	ST	Digital I/O.
AN5			I	Analog	Analog input 5.
PMRD			I/O	DIG	Parallel Master Port input/output.
RE1/AN6/PMWR	26	26			
RE1			I/O	ST	Digital I/O.
AN6			I	Analog	Analog input 6.
PMWR			I/O	DIG	Parallel Master Port write strobe.
RE2/AN7/PMCS	27	27			
RE2			I/O	ST	Digital I/O.
AN7			I	Analog	Analog input 7.
PMCS			O	—	Parallel Master Port byte enable.
VSS1	6	6	P	—	Ground reference for logic and I/O pins.
VSS2	31	29	—	—	
AVSS1	30	—	P	—	Ground reference for analog modules.
VDD1	8	7	P	—	Positive supply for peripheral digital logic and I/O pins.
VDD2	29	28	P	—	
VDDCORE/VCAP	23	23			Core logic power or external filter capacitor connection.
VDDCORE			P	—	Positive supply for microcontroller core logic (regulator disabled).
VCAP			P	—	External filter capacitor connection (regulator enabled).
AVDD1	7	—	P	—	Positive supply for analog modules.
AVDD2	28	—	—	—	Positive supply for analog modules.

Legend: TTL = TTL compatible input; CMOS = CMOS compatible input or output; ST = Schmitt Trigger input with CMOS levels; Analog = Analog input; I = Input; O = Output; P = Power; OD = Open-Drain (no P diode to VDD); DIG = Digital output

Note 1: RA7 and RA6 will be disabled if OSC1 and OSC2 are used for the clock function.

4.6.3 DEEP SLEEP WAKE-UP SOURCES

While in Deep Sleep mode, the device can be awakened by a MCLR, POR, RTCC, INT0 I/O pin interrupt, DSWDT or ULPWU event. After waking, the device performs a POR. When the device is released from Reset, code execution will begin at the device's Reset vector.

The software can determine if the wake-up was caused from an exit from Deep Sleep mode by reading the DS bit (WDTCON<3>). If this bit is set, the POR was caused by a Deep Sleep exit. The DS bit must be manually cleared by the software.

The software can determine the wake event source by reading the DSWAKEH and DSWAKEL registers. When the application firmware is done using the DSWAKEH and DSWAKEL status registers, individual bits do not need to be manually cleared before entering Deep Sleep again. When entering Deep Sleep mode, these registers are automatically cleared.

4.6.3.1 Wake-up Event Considerations

Deep Sleep wake-up events are only monitored while the processor is fully in Deep Sleep mode. If a wake-up event occurs before Deep Sleep mode is entered, the event status will not be reflected in the DSWAKE registers. If the wake-up source asserts prior to entering Deep Sleep, the CPU may go to the interrupt vector (if the wake source has an interrupt bit and the interrupt is fully enabled), and may abort the Deep Sleep entry sequence by executing past the SLEEP instruction. In this case, a wake-up event handler should be placed after the SLEEP instruction to process the event and re-attempt entry into Deep Sleep if desired.

When the device is in Deep Sleep with more than one wake-up source simultaneously enabled, only the first wake-up source to assert will be detected and logged in the DSWAKEH/DSWAKEL status registers.

4.6.4 DEEP SLEEP WATCHDOG TIMER (DSWDT)

Deep Sleep has its own dedicated WDT (DSWDT) with a postscaler for time-outs of 2.1 ms to 25.7 days, configurable through the bits, DSWDTPS<3:0> (CONFIG3L<7:4>).

The DSWDT can be clocked from either the INTRC or the T1OSC/T1CKI input. If the T1OSC/T1CKI source will be used with a crystal, the T1OSCEN bit in the T1CON register needs to be set prior to entering Deep Sleep. The reference clock source is configured through the DSWDTOSC bit (CONFIG3L<0>).

DSWDT is enabled through the DSWDTEN bit (CONFIG3L<3>). Entering Deep Sleep mode automatically clears the DSWDT. See **Section 26.0 "Special Features of the CPU"** for more information.

4.6.5 DEEP SLEEP BROWN OUT RESET (DSBOR)

The Deep Sleep module contains a dedicated Deep Sleep BOR (DSBOR) circuit. This circuit may be optionally enabled through the DSBOREN Configuration bit (CONFIG3L<2>).

The DSBOR circuit monitors the V_{DD} supply rail voltage. The behavior of the DSBOR circuit is described in **Section 5.4 "Brown-out Reset (BOR)"**.

4.6.6 RTCC PERIPHERAL AND DEEP SLEEP

The RTCC can operate uninterrupted during Deep Sleep mode. It can wake the device from Deep Sleep by configuring an alarm.

The RTCC clock source is configured with the RTCOSC bit (CONFIG3L<1>). The available reference clock sources are the INTRC and T1OSC/T1CKI. If the INTRC is used, the RTCC accuracy will directly depend on the INTRC tolerance. For more information on configuring the RTCC peripheral, see **Section 17.0 "Real-Time Clock and Calendar (RTCC)"**.

TABLE 6-4: REGISTER FILE SUMMARY (PIC18F46J11 FAMILY)

File Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on POR, BOR	Details on Page:
RPOR23(5)	—	—	—	Remappable Pin RP23 Output Signal Select Bits					---0 0000	74, 169
RPOR22(5)	—	—	—	Remappable Pin RP22 Output Signal Select Bits					---0 0000	74, 168
RPOR21(5)	—	—	—	Remappable Pin RP21 Output Signal Select Bits					---0 0000	74, 168
RPOR20(5)	—	—	—	Remappable Pin RP20 Output Signal Select Bits					---0 0000	74, 168
RPOR19(5)	—	—	—	Remappable Pin RP19 Output Signal Select Bits					---0 0000	74, 167
RPOR18	—	—	—	Remappable Pin RP18 Output Signal Select Bits					---0 0000	74, 167
RPOR17	—	—	—	Remappable Pin RP17 Output Signal Select Bits					---0 0000	75, 167
RPOR16	—	—	—	Remappable Pin RP16 Output Signal Select Bits					---0 0000	75, 166
RPOR15	—	—	—	Remappable Pin RP15 Output Signal Select Bits					---0 0000	75, 166
RPOR14	—	—	—	Remappable Pin RP14 Output Signal Select Bits					---0 0000	75, 166
RPOR13	—	—	—	Remappable Pin RP13 Output Signal Select Bits					---0 0000	75, 165
RPOR12	—	—	—	Remappable Pin RP12 Output Signal Select Bits					---0 0000	75, 165
RPOR11	—	—	—	Remappable Pin RP11 Output Signal Select Bits					---0 0000	75, 165
RPOR10	—	—	—	Remappable Pin RP10 Output Signal Select Bits					---0 0000	75, 164
RPOR9	—	—	—	Remappable Pin RP9 Output Signal Select Bits					---0 0000	75, 164
RPOR8	—	—	—	Remappable Pin RP8 Output Signal Select Bits					---0 0000	75, 163
RPOR7	—	—	—	Remappable Pin RP7 Output Signal Select Bits					---0 0000	75, 163
RPOR6	—	—	—	Remappable Pin RP6 Output Signal Select Bits					---0 0000	75, 163
RPOR5	—	—	—	Remappable Pin RP5 Output Signal Select Bits					---0 0000	75, 162
RPOR4	—	—	—	Remappable Pin RP4 Output Signal Select Bits					---0 0000	75, 162
RPOR3	—	—	—	Remappable Pin RP3 Output Signal Select Bits					---0 0000	75, 162
RPOR2	—	—	—	Remappable Pin RP2 Output Signal Select Bits					---0 0000	75, 161
RPOR1	—	—	—	Remappable Pin RP1 Output Signal Select Bits					---0 0000	75, 161
RPOR0	—	—	—	Remappable Pin RP0 Output Signal Select Bits					---0 0000	75, 161

Legend: x = unknown, u = unchanged, - = unimplemented, q = value depends on condition, r = reserved. **Bold** indicates shared access SFRs.

Note 1: Bit 21 of the PC is only available in Serial Programming (SP) modes.

2: Reset value is '0' when Two-Speed Start-up is enabled and '1' if disabled.

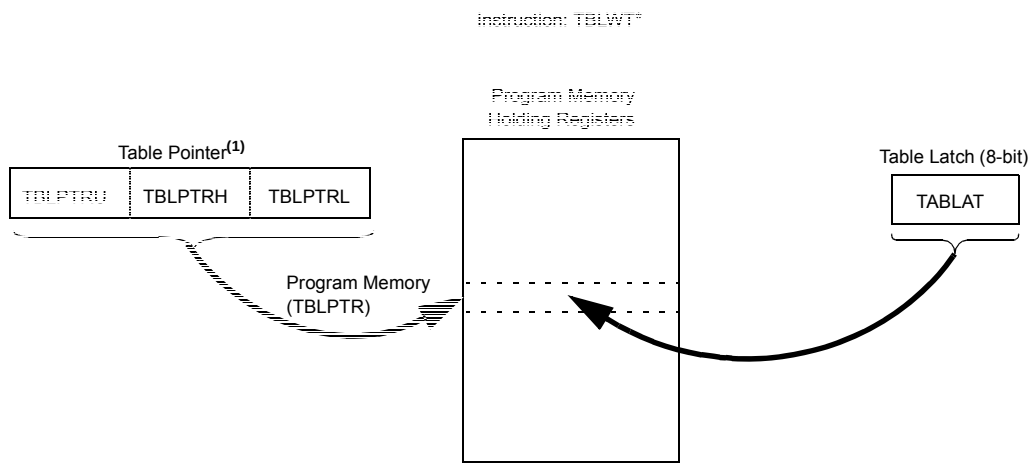
3: The SSPxMSK registers are only accessible when SSPxCON2<3:0> = 1001.

4: Alternate names and definitions for these bits when the MSSP module is operating in I^2C™ Slave mode. See **Section 19.5.3.2 "Address Masking Modes"** for details.

5: These bits and/or registers are only available in 44-pin devices; otherwise, they are unimplemented and read as '0'. Reset values are shown for 44-pin devices.

6: The PMADDRH/PMDOUT1H and PMADDRL/PMDOUT1L register pairs share the same physical registers and addresses, but have different functions determined by the module's operating mode. See **Section 11.1.2 "Data Registers"** for more information.

FIGURE 7-2: TABLE WRITE OPERATION



Note 1: Table Pointer actually points to one of 64 holding registers, the address of which is determined by TBLPTRL<5:0>. The process for physically writing data to the program memory array is discussed in Section 7.5 "Writing to Flash Program Memory".

7.2 Control Registers

Several control registers are used in conjunction with the TBLRD and TBLWT instructions. Those are:

- EECON1 register
- EECON2 register
- TABLAT register
- TBLPTR registers

7.2.1 EECON1 AND EECON2 REGISTERS

The EECON1 register (Register 7-1) is the control register for memory accesses. The EECON2 register is not a physical register; it is used exclusively in the memory write and erase sequences. Reading EECON2 will read all '0's.

The WPROG bit, when set, will allow programming two bytes per word on the execution of the WR command. If this bit is cleared, the WR command will result in programming on a block of 64 bytes.

The FREE bit, when set, will allow a program memory erase operation. When FREE is set, the erase operation is initiated on the next WR command. When FREE is clear, only writes are enabled.

The WREN bit, when set, will allow a write operation. On power-up, the WREN bit is clear. The WRERR bit is set in hardware when the WR bit is set, and cleared when the internal programming timer expires and the write operation is complete.

Note:	During normal operation, the WRERR is read as '1'. This can indicate that a write operation was prematurely terminated by a Reset, or a write operation was attempted improperly.

The WR control bit initiates write operations. The bit cannot be cleared, only set, in software. It is cleared in hardware at the completion of the write operation.

9.2 PIR Registers

The PIR registers contain the individual flag bits for the peripheral interrupts. Due to the number of peripheral interrupt sources, there are three Peripheral Interrupt Request (Flag) registers (PIR1, PIR2, PIR3).

Note 1: Interrupt flag bits are set when an interrupt condition occurs regardless of the state of its corresponding enable bit or the Global Interrupt Enable bit, GIE (INTCON<7>).

2: User software should ensure the appropriate interrupt flag bits are cleared prior to enabling an interrupt and after servicing that interrupt.

REGISTER 9-4: PIR1: PERIPHERAL INTERRUPT REQUEST (FLAG) REGISTER 1 (ACCESS F9Eh)

R/W-0	R/W-0	R-0	R-0	R/W-0	R/W-0	R/W-0	R/W-0
PMPIF(1)	ADIF	RC1IF	TX1IF	SSP1IF	CCP1IF	TMR2IF	TMR1IF
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 **PMPIF:** Parallel Master Port Read/Write Interrupt Flag bit(1)
1 = A read or a write operation has taken place (must be cleared in software)
0 = No read or write has occurred

bit 6 **ADIF:** A/D Converter Interrupt Flag bit
1 = An A/D conversion completed (must be cleared in software)
0 = The A/D conversion is not complete

bit 5 **RC1IF:** EUSART1 Receive Interrupt Flag bit
1 = The EUSART1 receive buffer, RCREG1, is full (cleared when RCREG1 is read)
0 = The EUSART1 receive buffer is empty

bit 4 **TX1IF:** EUSART1 Transmit Interrupt Flag bit
1 = The EUSART1 transmit buffer, TXREG1, is empty (cleared when TXREG1 is written)
0 = The EUSART1 transmit buffer is full

bit 3 **SSP1IF:** Master Synchronous Serial Port 1 Interrupt Flag bit
1 = The transmission/reception is complete (must be cleared in software)
0 = Waiting to transmit/receive

bit 2 **CCP1IF:** ECCP1 Interrupt Flag bit
Capture mode:
1 = A TMR1/TMR3 register capture occurred (must be cleared in software)
0 = No TMR1/TMR3 register capture occurred
Compare mode:
1 = A TMR1/TMR3 register compare match occurred (must be cleared in software)
0 = No TMR1/TMR3 register compare match occurred
PWM mode:
Unused in this mode.

bit 1 **TMR2IF:** TMR2 to PR2 Match Interrupt Flag bit
1 = TMR2 to PR2 match occurred (must be cleared in software)
0 = No TMR2 to PR2 match occurred

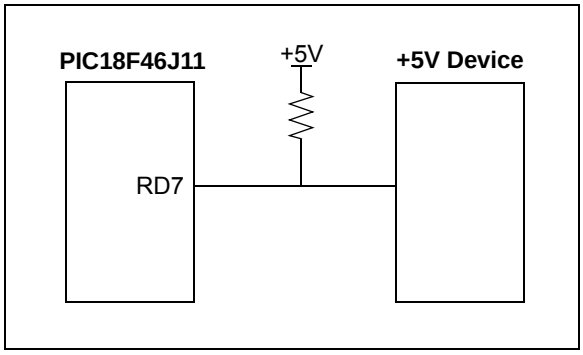
bit 0 **TMR1IF:** TMR1 Overflow Interrupt Flag bit
1 = TMR1 register overflowed (must be cleared in software)
0 = TMR1 register did not overflow

Note 1: These bits are unimplemented on 28-pin devices.

10.1.3 INTERFACING TO A 5V SYSTEM

Though the V_{DDMAX} of the PIC18F46J11 family is 3.6V, these devices are still capable of interfacing with 5V systems, even if the V_{IH} of the target system is above 3.6V. This is accomplished by adding a pull-up resistor to the port pin (Figure 10-2), clearing the LAT bit for that pin and manipulating the corresponding TRIS bit (Figure 10-1) to either allow the line to be pulled high or to drive the pin low. Only port pins that are tolerant of voltages up to 5.5V can be used for this type of interface (refer to **Section 10.1.2 "Input Pins and Voltage Considerations"**).

FIGURE 10-2: +5V SYSTEM HARDWARE INTERFACE



EXAMPLE 10-1: COMMUNICATING WITH THE +5V SYSTEM

```
BCF   LATD, 7   ; set up LAT register so
                ; changing TRIS bit will
                ; drive line low
BCF   TRISD, 7  ; send a 0 to the 5V system
BSF   TRISD, 7  ; send a 1 to the 5V system
```

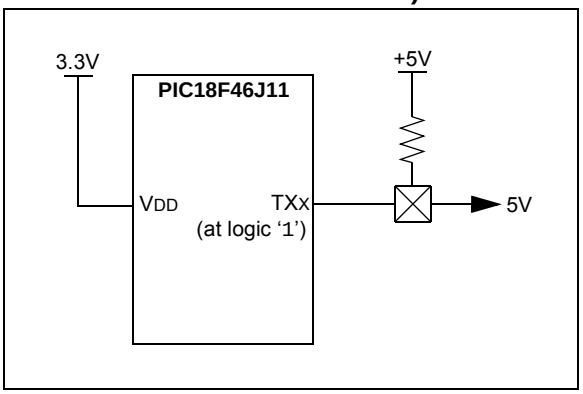
10.1.4 OPEN-DRAIN OUTPUTS

The output pins for several peripherals are also equipped with a configurable open-drain output option. This allows the peripherals to communicate with external digital logic operating at a higher voltage level, without the use of level translators.

The open-drain option is implemented on port pins specifically associated with the data and clock outputs of the EUSARTs, the MSSP modules (in SPI mode) and the ECCP modules. It is selectively enabled by setting the open-drain control bit for the corresponding module in the ODCON registers (Register 10-1, Register 10-2 and Register 10-3). Their configuration is discussed in more detail with the individual port where these peripherals are multiplexed.

When the open-drain option is required, the output pin must also be tied through an external pull-up resistor provided by the user to a higher voltage level, up to 5.5V (Figure 10-3). When a digital logic high signal is output, it is pulled up to the higher voltage level.

FIGURE 10-3: USING THE OPEN-DRAIN OUTPUT (USART SHOWN AS EXAMPLE)



10.1.5 TTL INPUT BUFFER OPTION

Many of the digital I/O ports use Schmitt Trigger (ST) input buffers. While this form of buffering works well with many types of input, some applications may require TTL level signals to interface with external logic devices. This is particularly true for the Parallel Master Port (PMP), which is likely to be interfaced to TTL level logic or memory devices.

The inputs for the PMP can be optionally configured for TTL buffers with the PMPTTL bit in the PADCFG1 register (Register 10-4). Setting this bit configures all data and control input pins for the PMP to use TTL buffers. By default, these PMP inputs use the port's ST buffers.

TABLE 10-6: SUMMARY OF REGISTERS ASSOCIATED WITH PORTB

Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Reset Values on page
PORTB	RB7	RB6	RB5	RB4	RB3	RB2	RB1	RB0	87
LATB	LATB7	LATB6	LATB5	LATB4	LATB3	LATB2	LATB1	LATB0	87
TRISB	TRISB7	TRISB6	TRISB5	TRISB4	TRISB3	TRISB2	TRISB1	TRISB0	87
INTCON	GIE/GIEH	PEIE/GIEL	TMR0IE	INT0IE	RBIE	TMR0IF	INT0IF	RBIF	87
INTCON2	$\overline{\text{RBPU}}$	INTEDG0	INTEDG1	INTEDG2	INTEDG3	TMR0IP	INT3IP	RBIP	87
INTCON3	INT2IP	INT1IP	INT3IE	INT2IE	INT1IE	INT3IF	INT2IF	INT1IF	87
ANCON0	PCFG7	PCFG6	PCFG5	PCFG4	PCFG3	PCFG2	PCFG1	PCFG0	87

Legend: — = unimplemented, read as '0'. Shaded cells are not used by PORTB.

10.4 PORTC, TRISC and LATC Registers

PORTC is an 8-bit wide, bidirectional port. The corresponding Data Direction register is TRISC. Setting a TRISC bit (= 1) will make the corresponding PORTC pin an input (i.e., put the corresponding output driver in a high-impedance mode). Clearing a TRISC bit (= 0) will make the corresponding PORTC pin an output (i.e., put the contents of the output latch on the selected pin).

The Data Latch register (LATC) is also memory mapped. Read-modify-write operations on the LATC register read and write the latched output value for PORTC.

PORTC is multiplexed with several peripheral functions (see Table 10-7). The pins have Schmitt Trigger input buffers.

When enabling peripheral functions, care should be taken in defining TRIS bits for each PORTC pin. Some peripherals override the TRIS bit to make a pin an output, while other peripherals override the TRIS bit to make a pin an input. The user should refer to the corresponding peripheral section for additional information.

Note: On a Power-on Reset, PORTC pins (except RC2) are configured as digital inputs. RC2 will default as an analog input (controlled by the ANCON1 register).

The contents of the TRISC register are affected by peripheral overrides. Reading TRISC always returns the current contents, even though a peripheral device may be overriding one or more of the pins.

EXAMPLE 10-4: INITIALIZING PORTC

```
CLRF   LATC     ; Initialize PORTC by
                ; clearing output
                ; data latches
MOVLW  0x3F     ; Value used to
                ; initialize data
                ; direction
MOVWF  TRISC    ; Set RC<5:0> as inputs
                ;  RC<7:6> as outputs
MOVLB 0x0F      ; ANCON register is not in
                  Access Bank
BSF    ANCON1,PCFG11
               ;Configure RC2/AN11 as
                digital input
```

TABLE 10-9: PORTD I/O SUMMARY (CONTINUED)

Pin	Function	TRIS Setting	I/O	I/O Type	Description
RD6/PMD6/ RP23	RD6	1	I	ST	PORTD<6> data input.
		0	O	DIG	LATD<6> data output.
	PMD6	1	I	ST/TTL	Parallel Master Port data in.
		0	O	DIG	Parallel Master Port data out.
	RP23	1	I	ST	Remappable peripheral pin 23 input.
		0	O	DIG	Remappable peripheral pin 23 output.
RD7/PMD7/ RP24	RD7	1	I	ST	PORTD<7> data input.
		0	O	DIG	LATD<7> data output.
	PMD7	1	I	ST/TTL	Parallel Master Port data in.
		0	O	DIG	Parallel Master Port data out.
	RP24	1	I	ST	Remappable peripheral pin 24 input.
		0	O	DIG	Remappable peripheral pin 24 output.

Legend: DIG = Digital level output; TTL = TTL input buffer; ST = Schmitt Trigger input buffer; I^2C/SMB = I^2C/SMBus input buffer; x = Don't care (TRIS bit does not affect port direction or is overridden for this option).

TABLE 10-10: SUMMARY OF REGISTERS ASSOCIATED WITH PORTD

Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Reset Values on page
PORTD(1)	RD7	RD6	RD5	RD4	RD3	RD2	RD1	RD0	93
LATD(1)	LATD7	LATD6	LATD5	LATD4	LATD3	LATD2	LATD1	LATD0	92
TRISD(1)	TRISD7	TRISD6	TRISD5	TRISD4	TRISD3	TRISD2	TRISD1	TRISD0	92

Legend: — = unimplemented, read as '0'. Shaded cells are not used by PORTD.

Note 1: These registers are not available in 28-pin devices.

REGISTER 10-6: RPINR1: PERIPHERAL PIN SELECT INPUT REGISTER 1 (BANKED EE7h)

U-0	U-0	U-0	R/$\overline{W}$-1	R/$\overline{W}$-1	R/$\overline{W}$-1	R/$\overline{W}$-1	R/$\overline{W}$-1
—	—	—	INTR1R4	INTR1R3	INTR1R2	INTR1R1	INTR1R0
bit 7							bit 0

Legend:	R/$\overline{W}$ = Readable, Writable if IOLOCK = 0		
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 7-5 **Unimplemented:** Read as '0'

bit 4-0 **INTR1R<4:0>:** Assign External Interrupt 1 (INT1) to the Corresponding RPn Pin bits

REGISTER 10-7: RPINR2: PERIPHERAL PIN SELECT INPUT REGISTER 2 (BANKED EE8h)

U-0	U-0	U-0	R/$\overline{W}$-1	R/$\overline{W}$-1	R/$\overline{W}$-1	R/$\overline{W}$-1	R/$\overline{W}$-1
—	—	—	INTR2R4	INTR2R3	INTR2R2	INTR2R1	INTR2R0
bit 7							bit 0

Legend:	R/$\overline{W}$ = Readable, Writable if IOLOCK = 0		
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 7-5 **Unimplemented:** Read as '0'

bit 4-0 **INTR2R<4:0>:** Assign External Interrupt 2 (INT2) to the Corresponding RPn pin bits

REGISTER 10-8: RPINR3: PERIPHERAL PIN SELECT INPUT REGISTER 3 (BANKED EE9h)

U-0	U-0	U-0	R/$\overline{W}$-1	R/$\overline{W}$-1	R/$\overline{W}$-1	R/$\overline{W}$-1	R/$\overline{W}$-1
—	—	—	INTR3R4	INTR3R3	INTR3R2	INTR3R1	INTR3R0
bit 7							bit 0

Legend:	R/$\overline{W}$ = Readable, Writable if IOLOCK = 0		
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 7-5 **Unimplemented:** Read as '0'

bit 4-0 **INTR3R<4:0>:** Assign External Interrupt 3 (INT3) to the Corresponding RPn Pin bits

17.1.4 RTCEN BIT WRITE

An attempt to write to the RTCEN bit while RTCWREN = 0 will be ignored. RTCWREN must be set before a write to RTCEN can take place.

Like the RTCEN bit, the RTCVALH<15:8> and RTCVALL<7:0> registers can only be written to when RTCWREN = 1. A write to these registers, while RTCWREN = 0, will be ignored.

17.2 Operation

17.2.1 REGISTER INTERFACE

The register interface for the RTCC and alarm values is implemented using the Binary Coded Decimal (BCD) format. This simplifies the firmware, when using the module, as each of the digits is contained within its own 4-bit value (see Figure 17-2 and Figure 17-3).

FIGURE 17-2: TIMER DIGIT FORMAT

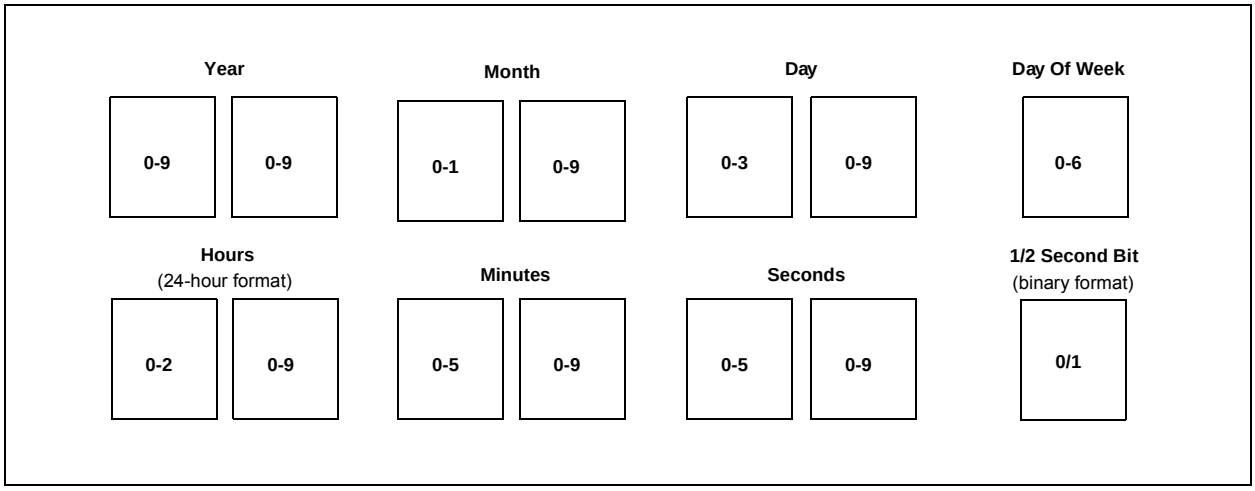
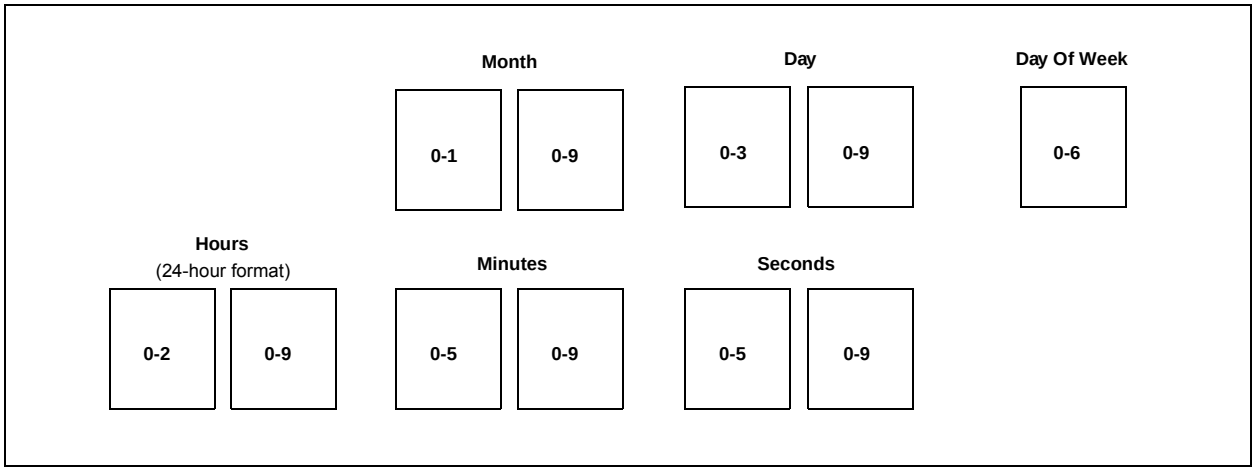


FIGURE 17-3: ALARM DIGIT FORMAT



19.3.9 OPERATION IN POWER-MANAGED MODES

In SPI Master mode, module clocks may be operating at a different speed than when in full-power mode. In the case of Sleep mode, all clocks are halted.

In Idle modes, a clock is provided to the peripherals. That clock can be from the primary clock source, the secondary clock (Timer1 oscillator) or the INTOSC source. See **Section 3.3 "Clock Sources and Oscillator Switching"** for additional information.

In most cases, the speed that the master clocks SPI data is not important; however, this should be evaluated for each system.

If MSSP interrupts are enabled, they can wake the controller from Sleep mode, or one of the Idle modes, when the master completes sending data. If an exit from Sleep or Idle mode is not desired, MSSP interrupts should be disabled.

If the Sleep mode is selected, all module clocks are halted and the transmission/reception will remain in that state until the device wakes. After the device returns to Run mode, the module will resume transmitting and receiving data.

In SPI Slave mode, the SPI Transmit/Receive Shift register operates asynchronously to the device. This allows the device to be placed in any power-managed mode and data to be shifted into the SPI Transmit/Receive Shift register. When all 8 bits have been received, the MSSP interrupt flag bit will be set, and if enabled, will wake the device.

19.3.10 EFFECTS OF A RESET

A Reset disables the MSSP module and terminates the current transfer.

19.3.11 BUS MODE COMPATIBILITY

Table 19-1 provides the compatibility between the standard SPI modes and the states of the CKP and CKE control bits.

TABLE 19-1: SPI BUS MODES

Standard SPI Mode Terminology	Control Bits State	
	CKP	CKE
0, 0	0	1
0, 1	0	0
1, 0	1	1
1, 1	1	0

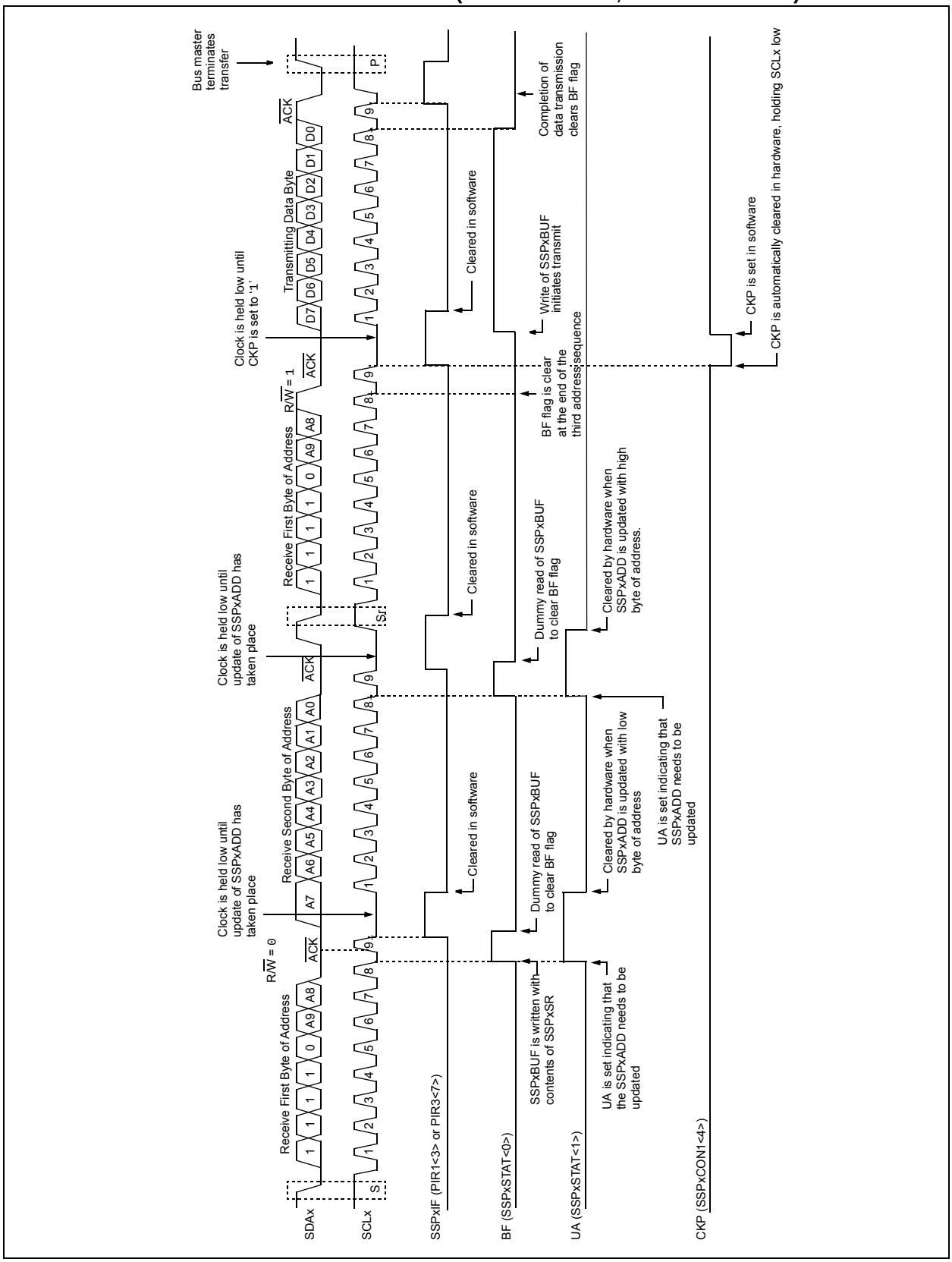
There is also an SMP bit, which controls when the data is sampled.

19.3.12 SPI CLOCK SPEED AND MODULE INTERACTIONS

Because MSSP1 and MSSP2 are independent modules, they can operate simultaneously at different data rates. Setting the SSPM<3:0> bits of the SSPxCON1 register determines the rate for the corresponding module.

An exception is when both modules use Timer2 as a time base in Master mode. In this instance, any changes to the Timer2 module's operation will affect both MSSP modules equally. If different bit rates are required for each module, the user should select one of the other three time base options for one of the modules.

FIGURE 19-13: I²C™ SLAVE MODE TIMING (TRANSMISSION, 10-BIT ADDRESS)



REGISTER 26-8: CONFIG4H: CONFIGURATION REGISTER 4 HIGH (BYTE ADDRESS 300007h)

U-1	U-1	U-1	U-1	U-0	U-0	U-0	R/WO-1
—	—	—	—	—	—	—	WPDIS
bit 7							bit 0

Legend:			
R = Readable bit	WO = Write-Once bit	U = Unimplemented bit, read as ‘0’	
-n = Value at Reset	‘1’ = Bit is set	‘0’ = Bit is cleared	x = Bit is unknown

bit 7-4 **Unimplemented:** Program the corresponding Flash Configuration bit to ‘1’

bit 3-1 **Unimplemented:** Read as ‘0’

bit 0 **WPDIS:** Write-Protect Disable bit

1 = WPFP<5:0>/WPEND region ignored
0 = WPFP<5:0>/WPEND region erase/write-protected

REGISTER 26-9: DEVID1: DEVICE ID REGISTER 1 FOR PIC18F46J11 FAMILY DEVICES (BYTE ADDRESS 3FFFFEh)

R	R	R	R	R	R	R	R
DEV2	DEV1	DEV0	REV4	REV3	REV2	REV1	REV0
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’	
-n = Value at Reset	‘1’ = Bit is set	‘0’ = Bit is cleared	x = Bit is unknown

bit 7-5 **DEV<2:0>:** Device ID bits

These bits are used with DEV<10:3> bits in Device ID Register 2 to identify the part number. See Register 26-10.

bit 4-0 **REV<4:0>:** Revision ID bits

These bits are used to indicate the device revision.

26.2 Watchdog Timer (WDT)

PIC18F46J11 family devices have both a conventional WDT circuit and a dedicated, Deep Sleep capable Watchdog Timer. When enabled, the conventional WDT operates in normal Run, Idle and Sleep modes. This data sheet section describes the conventional WDT circuit.

The dedicated, Deep Sleep capable WDT can only be enabled in Deep Sleep mode. This timer is described in **Section 4.6.4 "Deep Sleep Watchdog Timer (DSWDT)"**.

The conventional WDT is driven by the INTRC oscillator. When the WDT is enabled, the clock source is also enabled. The nominal WDT period is 4 ms and has the same stability as the INTRC oscillator.

The 4 ms period of the WDT is multiplied by a 16-bit postscaler. Any output of the WDT postscaler is selected by a multiplexer, controlled by the WDTPS bits in Configuration Register 2H. Available periods range from about 4 ms to 135 seconds (2.25 minutes depending on voltage, temperature and WDT postscaler). The WDT and postscaler are cleared whenever a SLEEP or CLRWDT instruction is executed, or a clock failure (primary or Timer1 oscillator) has occurred.

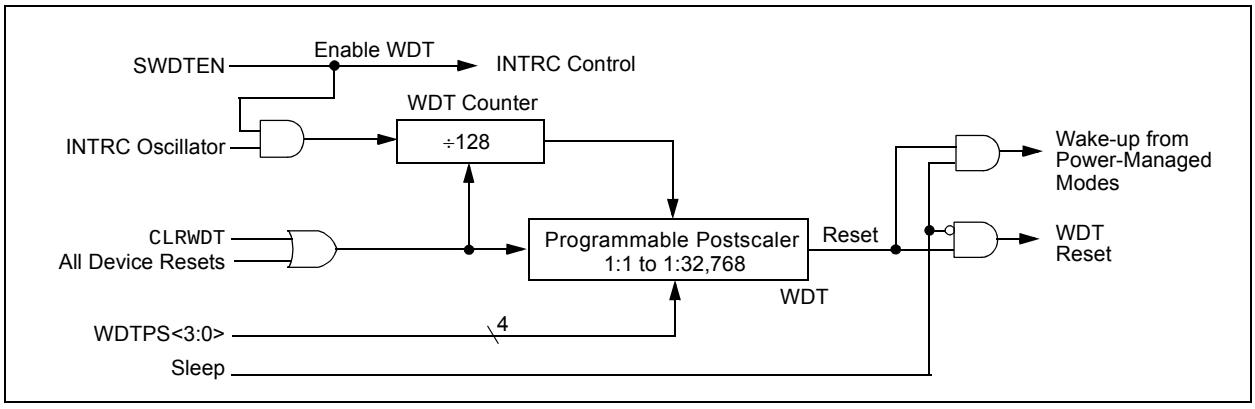
Note 1:	The CLRWDT and SLEEP instructions clear the WDT and postscaler counts when executed.
2:	When a CLRWDT instruction is executed, the postscaler count will be cleared.

26.2.1 CONTROL REGISTER

The WDTCON register (Register 26-11) is a readable and writable register. The SWDTEN bit enables or disables WDT operation. This allows software to override the WDTEN Configuration bit and enable the WDT only if it has been disabled by the Configuration bit.

LVDSTAT is a read-only status bit that is continuously updated and provides information about the current level of V_{DDCORE}. This bit is only valid when the on-chip voltage regulator is enabled.

FIGURE 26-1: WDT BLOCK DIAGRAM



REGISTER 26-11: WDTCON: WATCHDOG TIMER CONTROL REGISTER (ACCESS FC0h)

R/W-1	R-x	R-x	U-0	R-0	R/W-0	R/W-0	R/W-0
REGSLP(2)	LVDSTAT(2)	ULPLVL	—	DS(2)	ULPEN	ULPSINK	SWDTEN(1)
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 **REGSLP:** Voltage Regulator Low-Power Operation Enable bit(2)
1 = On-chip regulator enters low-power operation when device enters Sleep mode
0 = On-chip regulator is active even in Sleep mode

bit 6 **LVDSTAT:** Low-Voltage Detect Status bit(2)
1 = V_{DDCORE} > 2.45V nominal
0 = V_{DDCORE} < 2.45V nominal

bit 5 **ULPLVL:** Ultra Low-Power Wake-up Output bit (not valid unless ULPEN = 1)
1 = Voltage on RA0 > ~0.5V
0 = Voltage on RA0 < ~0.5V

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

bit 3 **DS:** Deep Sleep Wake-up Status bit (used in conjunction with RCON, POR and BOR bits to determine Reset source)(2)
1 = If the last exit from POR was caused by a normal wake-up from Deep Sleep
0 = If the last exit from POR was a result of hard cycling V_{DD}, or if the Deep Sleep BOR was enabled and detected, a (V_{DD} < V_{DSBOR}) and (V_{DD} < V_{POR}) condition

bit 2 **ULPEN:** Ultra Low-Power Wake-up Module Enable bit
1 = Ultra Low-Power Wake-up module is enabled; ULPLVL bit indicates comparator output
0 = Ultra Low-Power Wake-up module is disabled

bit 1 **ULPSINK:** Ultra Low-Power Wake-up Current Sink Enable bit
1 = Ultra Low-Power Wake-up current sink is enabled (if ULPEN = 1)
0 = Ultra Low-Power Wake-up current sink is disabled

bit 0 **SWDTEN:** Software Controlled Watchdog Timer Enable bit(1)
1 = Watchdog Timer is on
0 = Watchdog Timer is off

Note 1: This bit has no effect if the Configuration bit, WDTEN, is enabled.
2: Not available on devices where the on-chip voltage regulator is disabled ("LF" devices).

TABLE 26-3: SUMMARY OF WATCHDOG TIMER REGISTERS

Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Reset Values on Page:
RCON	IPEN	—	$\overline{CM}$	$\overline{RI}$	$\overline{TO}$	$\overline{PD}$	$\overline{POR}$	$\overline{BOR}$	70
WDTCON	REGSLP	LVDSTAT	ULPLVL	—	DS	ULPEN	ULPSINK	SWDTEN	70

Legend: — = unimplemented, read as '0'. Shaded cells are not used by the Watchdog Timer.

27.2 Extended Instruction Set

In addition to the standard 75 instructions of the PIC18 instruction set, the PIC18F46J11 family of devices also provides an optional extension to the core CPU functionality. The added features include eight additional instructions that augment Indirect and Indexed Addressing operations and the implementation of Indexed Literal Offset Addressing for many of the standard PIC18 instructions.

The additional features of the extended instruction set are enabled by default on unprogrammed devices. Users must properly set or clear the XINST Configuration bit during programming to enable or disable these features.

The instructions in the extended set can all be classified as literal operations, which either manipulate the File Select Registers (FSR), or use them for Indexed Addressing. Two of the instructions, ADDFSR and SUBFSR, each have an additional special instantiation for using FSR2. These versions (ADDULNK and SUBULNK) allow for automatic return after execution.

The extended instructions are specifically implemented to optimize re-entrant program code (that is, code that is recursive or that uses a software stack) written in high-level languages, particularly C. Among other things, they allow users working in high-level languages to perform certain operations on data structures more efficiently. These include:

- Dynamic allocation and deallocation of software stack space when entering and leaving subroutines
- Function Pointer invocation
- Software Stack Pointer manipulation
- Manipulation of variables located in a software stack

A summary of the instructions in the extended instruction set is provided in Table 27-3. Detailed descriptions are provided in **Section 27.2.2 "Extended Instruction Set"**. The opcode field descriptions in Table 27-1 (page 414) apply to both the standard and extended PIC18 instruction sets.

Note:	The instruction set extension and the Indexed Literal Offset Addressing mode were designed for optimizing applications written in C; the user may likely never use these instructions directly in assembler. The syntax for these commands is provided as a reference for users who may be reviewing code that has been generated by a compiler.

27.2.1 EXTENDED INSTRUCTION SYNTAX

Most of the extended instructions use indexed arguments, using one of the FSRs and some offset to specify a source or destination register. When an argument for an instruction serves as part of Indexed Addressing, it is enclosed in square brackets ("[ ]"). This is done to indicate that the argument is used as an index or offset. The MPASM™ Assembler will flag an error if it determines that an index or offset value is not bracketed.

When the extended instruction set is enabled, brackets are also used to indicate index arguments in byte-oriented and bit-oriented instructions. This is in addition to other changes in their syntax. For more details, see **Section 27.2.3.1 "Extended Instruction Syntax with Standard PIC18 Commands"**.

Note:	In the past, square brackets have been used to denote optional arguments in the PIC18 and earlier instruction sets. In this text and going forward, optional arguments are denoted by braces ("{ }").

TABLE 27-3: EXTENSIONS TO THE PIC18 INSTRUCTION SET

Mnemonic, Operands		Description	Cycles	16-Bit Instruction Word				Status Affected
				MSb			LSb	
ADDFSR	f, k	Add Literal to FSR	1	1110	1000	ffkk	kkkk	None
ADDULNK	k	Add Literal to FSR2 and Return	2	1110	1000	11kk	kkkk	None
CALLW		Call Subroutine using WREG	2	0000	0000	0001	0100	None
MOVSF	z_s, f_d	Move z_s (source) to 1st word	2	1110	1011	0zzz	zzzz	None
		f_d (destination) 2nd word		1111	ffff	ffff	ffff	—
MOVSS	z_s, z_d	Move z_s (source) to 1st word	2	1110	1011	1zzz	zzzz	None
		z_d (destination) 2nd word		1111	xxxx	xzzz	zzzz	—
PUSHL	k	Store Literal at FSR2, Decrement FSR2	1	1110	1010	kkkk	kkkk	None —
SUBFSR	f, k	Subtract Literal from FSR	1	1110	1001	ffkk	kkkk	None
SUBULNK	k	Subtract Literal from FSR2 and Return	2	1110	1001	11kk	kkkk	None

FIGURE 29-3: HIGH/LOW-VOLTAGE DETECT CHARACTERISTICS

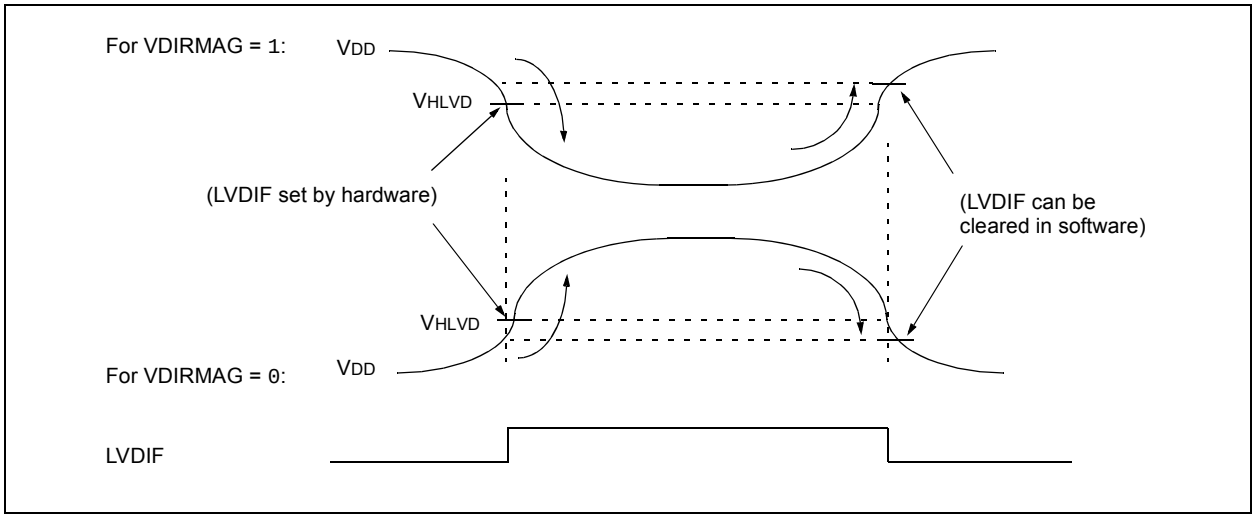
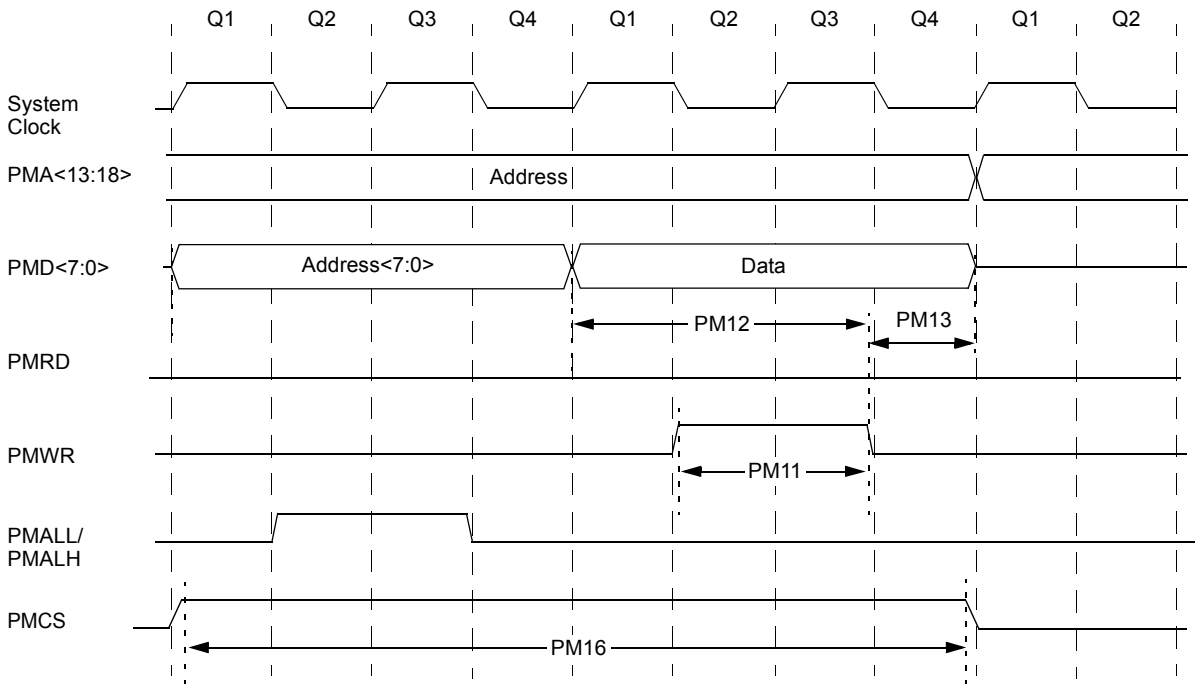


TABLE 29-7: HIGH/LOW-VOLTAGE DETECT CHARACTERISTICS

Standard Operating Conditions (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for industrial								
Param No.	**Symbol**	**Characteristic**		**Min**	**Typ**	**Max**	**Units**	**Conditions**
D420		HLVD Voltage on VDD Transition High-to-Low	HLVDL<3:0> = 1000	2.33	2.45	2.57	V	
			HLVDL<3:0> = 1001	2.47	2.60	2.73	V	
			HLVDL<3:0> = 1010	2.66	2.80	2.94	V	
			HLVDL<3:0> = 1011	2.76	2.90	3.05	V	
			HLVDL<3:0> = 1100	2.85	3.00	3.15	V	
			HLVDL<3:0> = 1101	2.97	3.13	3.29	V	
			HLVDL<3:0> = 1110	3.23	3.40	3.57	V	
D421	TIRVST	Time for Internal Reference Voltage to become Stable		—	20	—	μs	
D422	TLVD	High/Low-Voltage Detect Pulse Width		200	—	—	μs	

FIGURE 29-11: PARALLEL MASTER PORT WRITE TIMING DIAGRAM



Note: Operating Conditions: 2.0V < V_{DD} < 3.6V, -40°C < T_A < +85°C unless otherwise stated.

TABLE 29-18: PARALLEL MASTER PORT WRITE TIMING REQUIREMENTS

Param. No	Symbol	Characteristics	Min	Typ	Max	Units
PM11		PMWR Pulse Width	—	0.5 T_{CY}	—	ns
PM12		Data Out Valid before PMWR or PMENB goes Inactive (data setup time)	—	—	—	ns
PM13		PMWR or PMEMB Invalid to Data Out Invalid (data hold time)	—	—	—	ns
PM16		PMCS Pulse Width	T_{CY} – 5	—	—	ns