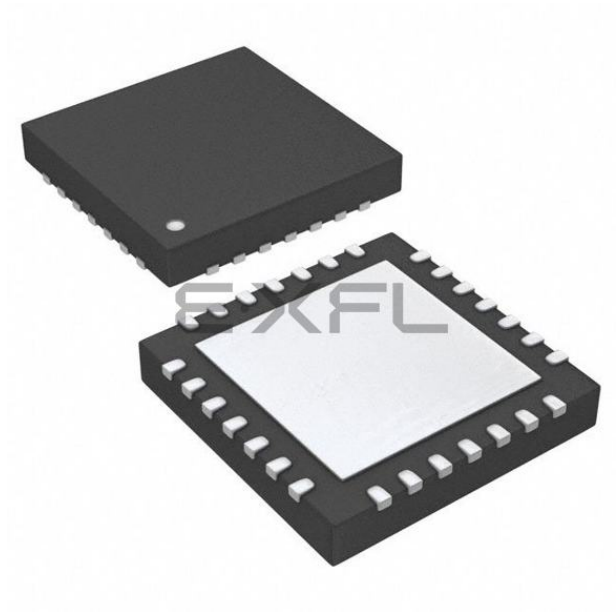

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Program Memory Size	12KB (4K x 24)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	1K x 8
Voltage - Supply (Vcc/Vdd)	2.5V ~ 5.5V
Data Converters	A/D 10x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 125°C (TA)
Mounting Type	Surface Mount
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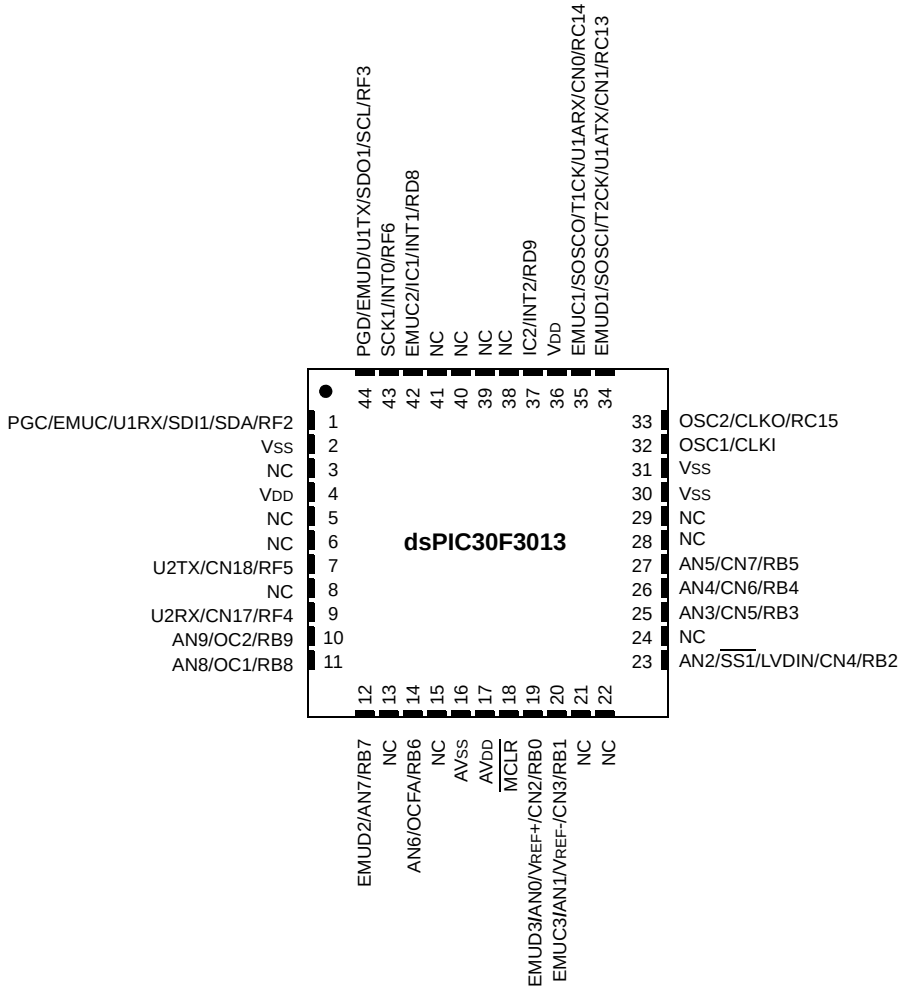
Supplier Device Package	28-QFN (6x6)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/dspic30f2012-20e-ml

Pin Diagrams

44-Pin QFN(1)



Note 1: The metal plane at the bottom of the device is not connected to any pins and is recommended to be connected to VSS externally.

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3.1.1 DATA ACCESS FROM PROGRAM MEMORY USING TABLE INSTRUCTIONS

This architecture fetches 24-bit wide program memory. Consequently, instructions are always aligned. However, as the architecture is modified Harvard, data can also be present in program space.

There are two methods by which program space can be accessed: via special table instructions, or through the remapping of a 16K word program space page into the upper half of data space (see **Section 3.1.2 "Data Access from Program Memory Using Program Space Visibility"**). The TBLRDL and TBLWTL instructions offer a direct method of reading or writing the lsw of any address within program space, without going through data space. The TBLRDH and TBLWTH instructions are the only method whereby the upper 8 bits of a program space word can be accessed as data.

The PC is incremented by two for each successive 24-bit program word. This allows program memory addresses to directly map to data space addresses. Program memory can thus be regarded as two 16-bit word wide address spaces, residing side by side, each with the same address range. TBLRDL and TBLWTL access the space which contains the lsw, and TBLRDH and TBLWTH access the space which contains the MSB.

Figure 3-2 shows how the EA is created for table operations and data space accesses (PSV = 1). Here, P<23:0> refers to a program space word, whereas D<15:0> refers to a data space word.

A set of table instructions are provided to move byte or word-sized data to and from program space. See Figure 3-4 and Figure 3-5.

1. TBLRDL: Table Read Low
   Word: Read the LS Word of the program address; P<15:0> maps to D<15:0>.
   Byte: Read one of the LSB of the program address;
   P<7:0> maps to the destination byte when byte select = 0;
   P<15:8> maps to the destination byte when byte select = 1.
2. TBLWTL: Table Write Low (refer to **Section 5.0 "Flash Program Memory"** for details on Flash Programming)
3. TBLRDH: Table Read High
   Word: Read the MS Word of the program address; P<23:16> maps to D<7:0>; D<15:8> will always be = 0.
   Byte: Read one of the MSB of the program address;
   P<23:16> maps to the destination byte when byte select = 0;
   The destination byte will always be = 0 when byte select = 1.
4. TBLWTH: Table Write High (refer to **Section 5.0 "Flash Program Memory"** for details on Flash Programming)

FIGURE 3-3: PROGRAM DATA TABLE ACCESS (lsw)

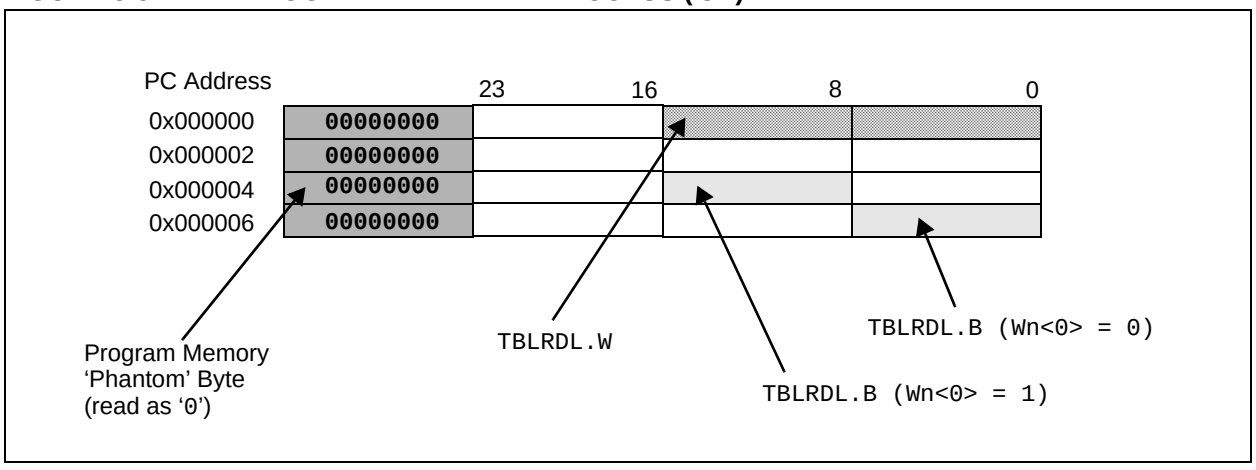


FIGURE 3-7: dsPIC30F3012/3013 DATA SPACE MEMORY MAP

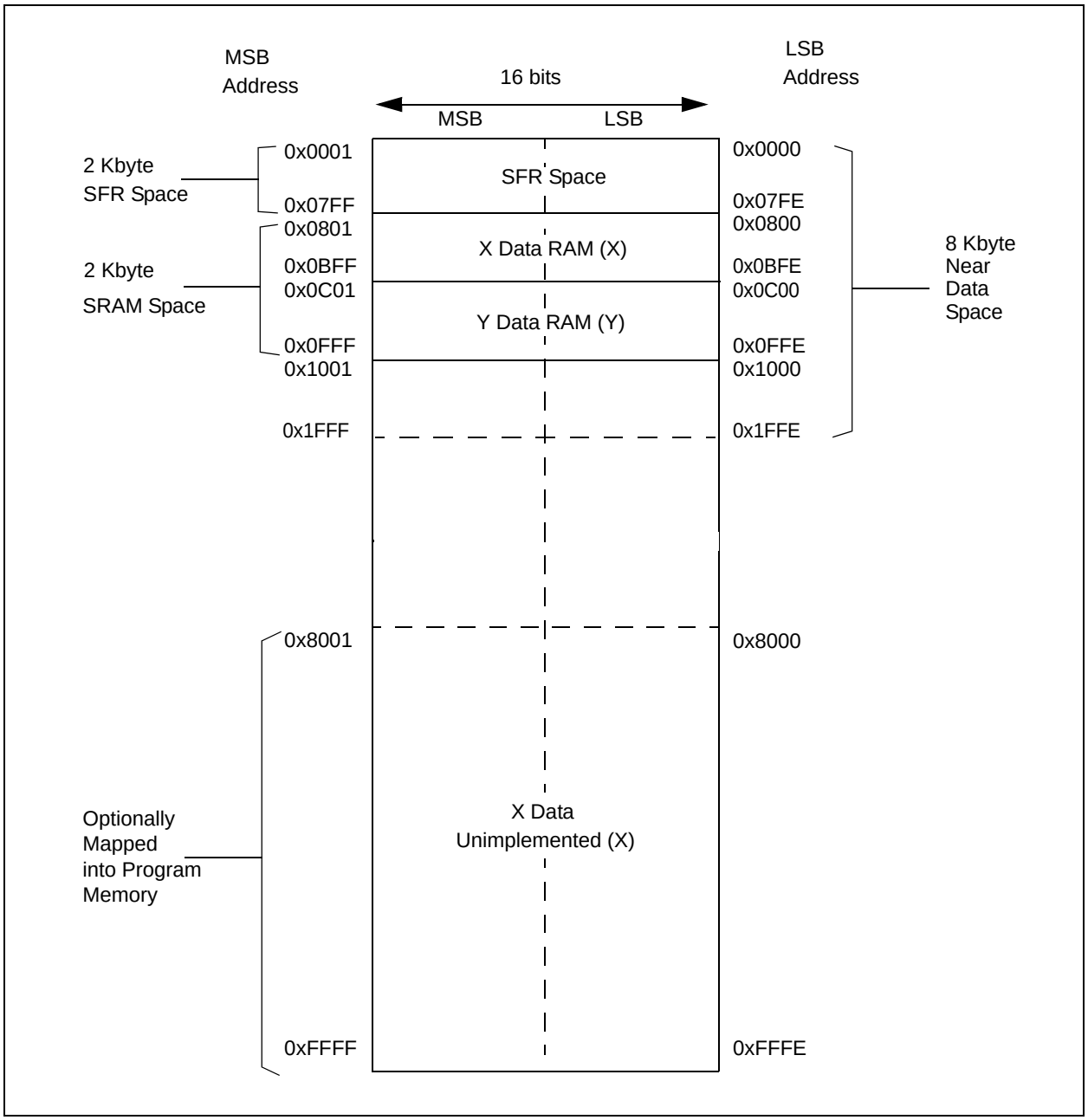
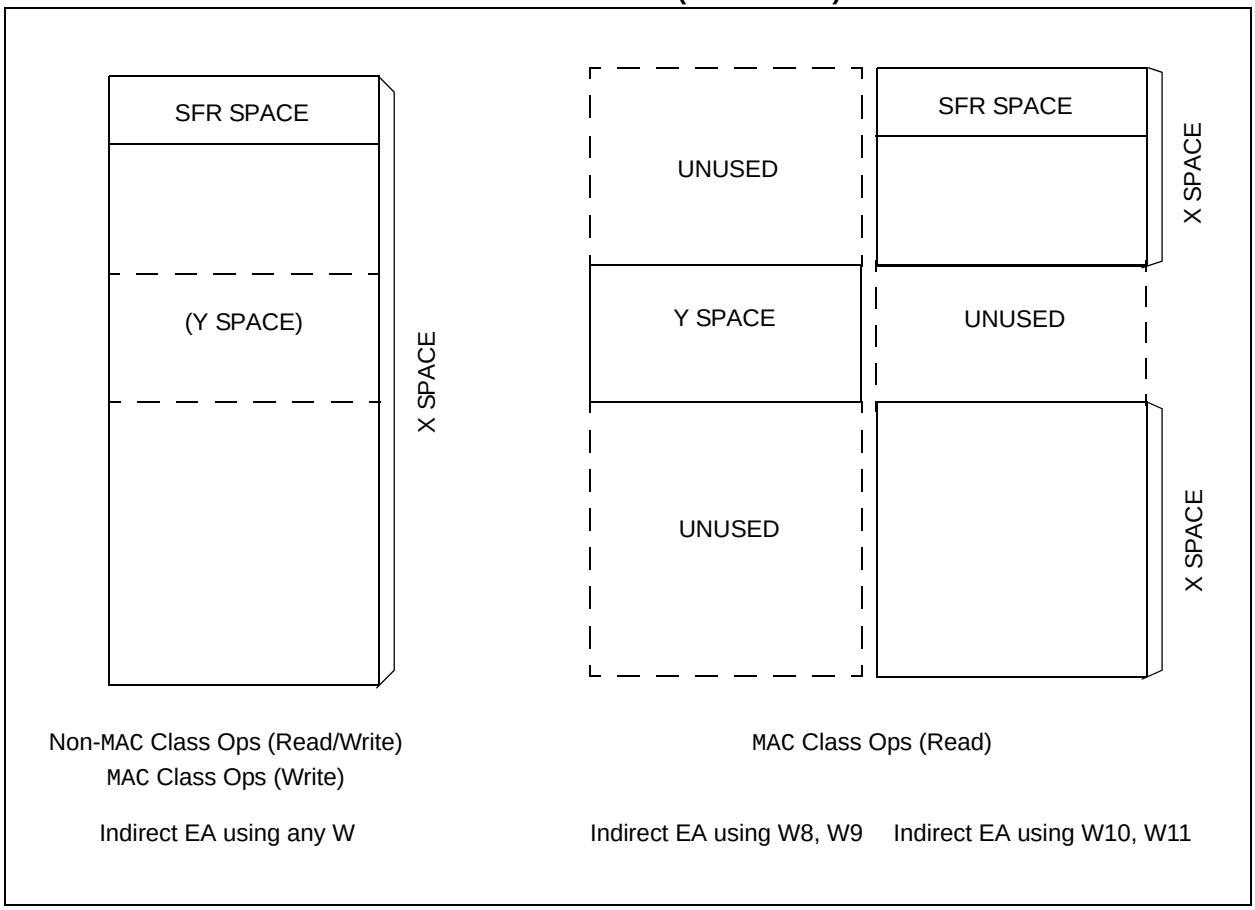


FIGURE 3-8: DATA SPACE FOR MCU AND DSP (MAC CLASS) INSTRUCTIONS EXAMPLE



8.1 Interrupt Priority

The user-assignable interrupt priority bits (IP<2:0>) for each individual interrupt source are located in the LS 3 bits of each nibble within the IPCx register(s). Bit 3 of each nibble is not used and is read as a '0'. These bits define the priority level assigned to a particular interrupt by the user.

Note: The user-assignable priority levels start at 0 as the lowest priority and level 7 as the highest priority.

Natural Order Priority is determined by the position of an interrupt in the vector table, and only affects interrupt operation when multiple interrupts with the same user-assigned priority become pending at the same time.

Table 8-1 lists the interrupt numbers and interrupt sources for the dsPIC30F2011/2012/3012/3013 devices and their associated vector numbers.

Note 1: The natural order priority scheme has 0 as the highest priority and 53 as the lowest priority.

2: The natural order priority number is the same as the INT number.

The ability for the user to assign every interrupt to one of seven priority levels means that the user can assign a very high overall priority level to an interrupt with a low natural order priority. For example, the PLVD (Low Voltage Detect) can be given a priority of 7. The INT0 (External Interrupt 0) may be assigned to priority level 1, thus giving it a very low effective priority.

TABLE 8-1: INTERRUPT VECTOR TABLE

Interrupt Number	Vector Number	Interrupt Source
Highest Natural Order Priority		
0	8	INT0 – External Interrupt 0
1	9	IC1 – Input Capture 1
2	10	OC1 – Output Compare 1
3	11	T1 – Timer 1
4	12	IC2 – Input Capture 2
5	13	OC2 – Output Compare 2
6	14	T2 – Timer2
7	15	T3 – Timer3
8	16	SPI1
9	17	U1RX – UART1 Receiver
10	18	U1TX – UART1 Transmitter
11	19	ADC – ADC Convert Done
12	20	NVM – NVM Write Complete
13	21	SI2C – I^2C™ Slave Interrupt
14	22	MI2C – I^2C Master Interrupt
15	23	Input Change Interrupt
16	24	INT1 – External Interrupt 1
17-22	25-30	Reserved
23	31	INT2 – External Interrupt 2
24	32	U2RX(1) – UART2 Receiver
25	33	U2TX(1) – UART2 Transmitter
26-41	34-49	Reserved
42	50	LVD – Low-Voltage Detect
43-53	51-61	Reserved
Lowest Natural Order Priority		

Note 1: Only the dsPIC30F3013 has UART2 and the U2RX, U2TX interrupts. These locations are reserved for the dsPIC30F2011/2012/3012.

8.2 Reset Sequence

A Reset is not a true exception because the interrupt controller is not involved in the Reset process. The processor initializes its registers in response to a Reset which forces the PC to zero. The processor then begins program execution at location 0x000000. A GOTO instruction is stored in the first program memory location immediately followed by the address target for the GOTO instruction. The processor executes the GOTO to the specified address and then begins operation at the specified target (start) address.

8.2.1 RESET SOURCES

In addition to external Reset and Power-on Reset (POR), there are six sources of error conditions which 'trap' to the Reset vector.

- Watchdog Time-out:
  The watchdog has timed out, indicating that the processor is no longer executing the correct flow of code.
- Uninitialized W Register Trap:
  An attempt to use an uninitialized W register as an Address Pointer causes a Reset.
- Illegal Instruction Trap:
  Attempted execution of any unused opcodes results in an illegal instruction trap. Note that a fetch of an illegal instruction does not result in an illegal instruction trap if that instruction is flushed prior to execution due to a flow change.
- Brown-out Reset (BOR):
  A momentary dip in the power supply to the device has been detected which may result in malfunction.
- Trap Lockout:
  Occurrence of multiple trap conditions simultaneously causes a Reset.

8.3 Traps

Traps can be considered as non-maskable interrupts indicating a software or hardware error, which adhere to a predefined priority as shown in Figure 8-1. They are intended to provide the user a means to correct erroneous operation during debug and when operating within the application.

Note:	If the user does not intend to take corrective action in the event of a trap error condition, these vectors must be loaded with the address of a default handler that contains the RESET instruction. If, on the other hand, one of the vectors containing an invalid address is called, an address error trap is generated.

Note that many of these trap conditions can only be detected when they occur. Consequently, the questionable instruction is allowed to complete prior to trap exception processing. If the user chooses to recover from the error, the result of the erroneous action that caused the trap may have to be corrected.

There are eight fixed priority levels for traps: Level 8 through Level 15, which implies that the IPL3 is always set during processing of a trap.

If the user is not currently executing a trap, and he sets the IPL<3:0> bits to a value of '0111' (Level 7), then all interrupts are disabled, but traps can still be processed.

8.3.1 TRAP SOURCES

The following traps are provided with increasing priority. However, since all traps can be nested, priority has little effect.

Math Error Trap:

The math error trap executes under the following four circumstances:

1. If an attempt is made to divide by zero, the divide operation is aborted on a cycle boundary and the trap is taken.
2. If enabled, a math error trap is taken when an arithmetic operation on either accumulator A or B causes an overflow from bit 31 and the accumulator guard bits are not utilized.
3. If enabled, a math error trap is taken when an arithmetic operation on either accumulator A or B causes a catastrophic overflow from bit 39 and all saturation is disabled.
4. If the shift amount specified in a shift instruction is greater than the maximum allowed shift amount, a trap occurs.

TABLE 8-2: dsPIC30F2011/2012/3012 INTERRUPT CONTROLLER REGISTER MAP

SFR Name	ADR	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Reset State
INTCON1	0080	NSTDIS	—	—	—	—	OVATE	OVBTE	COVTE	—	—	—	MATHERR	ADDRERR	STKERR	OSCFAIL	—	0000 0000 0000 0000
INTCON2	0082	ALTIVT	DISI	—	—	—	—	—	—	—	—	—	—	—	INT2EP	INT1EP	INT0EP	0000 0000 0000 0000
IFS0	0084	CNIF	MI2CIF	SI2CIF	NVMIF	ADIF	U1TXIF	U1RXIF	SPI1IF	T3IF	T2IF	OC2IF	IC2IF	T1IF	OC1IF	IC1IF	INT0IF	0000 0000 0000 0000
IFS1	0086	—	—	—	—	—	—	—	—	INT2IF	—	—	—	—	—	—	INT1IF	0000 0000 0000 0000
IFS2	0088	—	—	—	—	—	LVDIF		—	—	—	—	—	—	—	—	—	0000 0000 0000 0000
IEC0	008C	CNIE	MI2CIE	SI2CIE	NVMIE	ADIE	U1TXIE	U1RXIE	SPI1IE	T3IE	T2IE	OC2IE	IC2IE	T1IE	OC1IE	IC1IE	INT0IE	0000 0000 0000 0000
IEC1	008E	—	—	—	—	—	—	—	—	INT2IE	—	—	—	—	—	—	INT1IE	0000 0000 0000 0000
IEC2	0090	—	—	—	—	—	LVDIE	—	—	—	—	—	—	—	—	—	—	0000 0000 0000 0000
IPC0	0094	—	T1IP<2:0>			—	OC1IP<2:0>			—	IC1IP<2:0>			—	INT0IP<2:0>			0100 0100 0100 0100
IPC1	0096	—	T31P<2:0>			—	T2IP<2:0>			—	OC2IP<2:0>			—	IC2IP<2:0>			0100 0100 0100 0100
IPC2	0098	—	ADIP<2:0>			—	U1TXIP<2:0>			—	U1RXIP<2:0>			—	SPI1IP<2:0>			0100 0100 0100 0100
IPC3	009A	—	CNIP<2:0>			—	MI2CIP<2:0>			—	SI2CIP<2:0>			—	NVMIP<2:0>			0100 0100 0100 0100
IPC4	009C	—	—	—	—	—	—	—	—	—	—	—	—	—	INT1IP<2:0>			0000 0000 0000 0100
IPC5	009E	—	INT2IP<2:0>			—	—	—	—	—	—	—	—	—	—	—	—	0100 0000 0000 0000
IPC6	00A0	—	—	—	—	—	—	—	—	—	1	0	0	—	1	0	0	0000 0000 0100 0100
IPC7	00A2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0000 0000 0000 0000
IPC8	00A4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0000 0000 0000 0000
IPC9	00A6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0000 0000 0000 0000
IPC10	00A8	—	—	—	—	—	LVDIP<2:0>			—	—	—	—	—	—	—	—	0000 0100 0000 0000

Legend: u = uninitialized bit; — = unimplemented bit, read as '0'

Note: Refer to the "*dsPIC30F Family Reference Manual*" (DS70046) for descriptions of register bit fields.

10.1 Timer Gate Operation

The 32-bit timer can be placed in the Gated Time Accumulation mode. This mode allows the internal TCY to increment the respective timer when the gate input signal (T2CK pin) is asserted high. Control bit, TGATE (T2CON<6>), must be set to enable this mode. When in this mode, Timer2 is the originating clock source. The TGATE setting is ignored for Timer3. The timer must be enabled (TON = 1) and the timer clock source set to internal (TCS = 0).

The falling edge of the external signal terminates the count operation but does not reset the timer. The user must reset the timer in order to start counting from zero.

10.2 ADC Event Trigger

When a match occurs between the 32-bit timer (TMR3/TMR2) and the 32-bit combined period register (PR3/PR2), or between the 16-bit timer TMR3 and the 16-bit period register PR3, a special ADC trigger event signal is generated by Timer3.

10.3 Timer Prescaler

The input clock (FOSC/4 or external clock) to the timer has a prescale option of 1:1, 1:8, 1:64, and 1:256, selected by control bits, TCKPS<1:0> (T2CON<5:4> and T3CON<5:4>). For the 32-bit timer operation, the originating clock source is Timer2. The prescaler operation for Timer3 is not applicable in this mode. The prescaler counter is cleared when any of the following occurs:

- A write to the TMR2/TMR3 register
- A write to the T2CON/T3CON register
- A device Reset, such as a POR and BOR

However, if the timer is disabled (TON = 0), the Timer 2 prescaler cannot be reset since the prescaler clock is halted.

TMR2/TMR3 is not cleared when T2CON/T3CON is written.

10.4 Timer Operation During Sleep Mode

The timer does not operate during CPU Sleep mode because the internal clocks are disabled.

10.5 Timer Interrupt

The 32-bit timer module can generate an interrupt-on-period match or on the falling edge of the external gate signal. When the 32-bit timer count matches the respective 32-bit period register, or the falling edge of the external “gate” signal is detected, the T3IF bit (IFS0<7>) is asserted and an interrupt is generated if enabled. In this mode, the T3IF interrupt flag is used as the source of the interrupt. The T3IF bit must be cleared in software.

Enabling an interrupt is accomplished via the respective timer interrupt enable bit, T3IE (IEC0<7>).

NOTES:

15.10 UART Operation During CPU Sleep and Idle Modes

15.10.1 UART OPERATION DURING CPU SLEEP MODE

When the device enters Sleep mode, all clock sources to the module are shut down and stay at logic ‘0’. If entry into Sleep mode occurs while a transmission is in progress, then the transmission is aborted. The UxTX pin is driven to logic ‘1’. Similarly, if entry into Sleep mode occurs while a reception is in progress, then the reception is aborted. The UxSTA, UxMODE, transmit and receive registers and buffers, and the UxBRG register are not affected by Sleep mode.

If the WAKE bit (UxMODE<7>) is set before the device enters Sleep mode, then a falling edge on the UxRX pin will generate a receive interrupt. The Receive Interrupt Select mode bit (URXISEL) has no effect for this function. If the receive interrupt is enabled, then this will wake-up the device from Sleep. The UARTEN bit must be set in order to generate a wake-up interrupt.

15.10.2 UART OPERATION DURING CPU IDLE MODE

For the UART, the USIDL bit selects if the module will stop operation when the device enters Idle mode or whether the module will continue on Idle. If USIDL = 0, the module will continue to operate during Idle mode. If USIDL = 1, the module will stop on Idle.

16.0 12-BIT ANALOG-TO-DIGITAL CONVERTER (ADC) MODULE

Note: This data sheet summarizes features of this group of dsPIC30F devices and is not intended to be a complete reference source. For more information on the CPU, peripherals, register descriptions and general device functionality, refer to the "*dsPIC30F Family Reference Manual*" (DS70046).

The 12-bit Analog-to-Digital Converter allows conversion of an analog input signal to a 12-bit digital number. This module is based on a Successive Approximation Register (SAR) architecture and provides a maximum sampling rate of 200 ksps. The ADC module has up to 10 analog inputs which are multiplexed into a sample and hold amplifier. The output of the sample and hold is the input into the converter which generates the result. The analog reference voltage is software selectable to either the device supply voltage (AVDD/AVSS) or the voltage level on the (VREF+/VREF-) pin. The ADC has a unique feature of being able to operate while the device is in Sleep mode with RC oscillator selection.

The ADC module has six 16-bit registers:

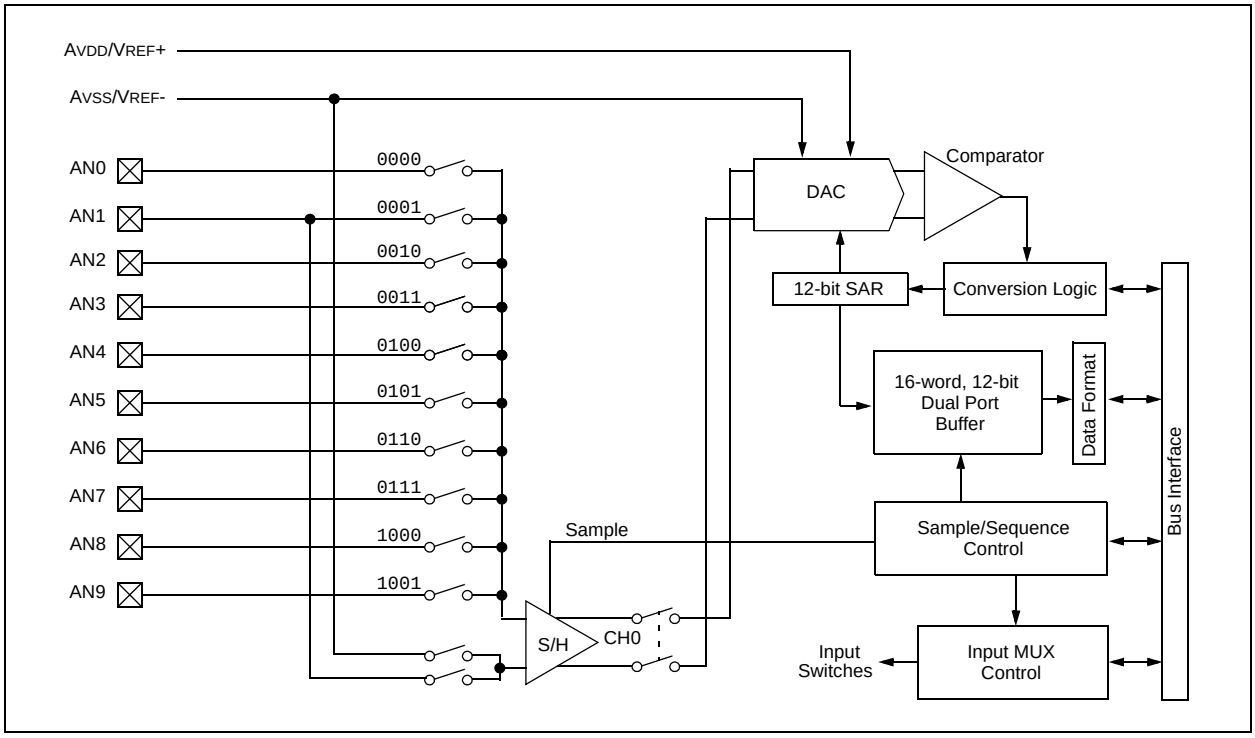
- A/D Control Register 1 (ADCON1)
- A/D Control Register 2 (ADCON2)
- A/D Control Register 3 (ADCON3)
- A/D Input Select Register (ADCHS)
- A/D Port Configuration Register (ADPCFG)
- A/D Input Scan Selection Register (ADCSSL)

The ADCON1, ADCON2 and ADCON3 registers control the operation of the ADC module. The ADCHS register selects the input channels to be converted. The ADPCFG register configures the port pins as analog inputs or as digital I/O. The ADCSSL register selects inputs for scanning.

Note: The SSRC<2:0>, ASAM, SMPI<3:0>, BUFM and ALTS bits, as well as the ADCON3 and ADCSSL registers, must not be written to while ADON = 1. This would lead to indeterminate results.

The block diagram of the 12-bit ADC module is shown in Figure 16-1.

FIGURE 16-1: 12-BIT ADC FUNCTIONAL BLOCK DIAGRAM



The configuration procedures in the next section provide the required setup values for the conversion speeds above 100 ksps.

16.7.1 200 KSPS CONFIGURATION GUIDELINE

The following configuration items are required to achieve a 200 ksps conversion rate.

- Comply with conditions provided in Table 16-1.
- Connect external VREF+ and VREF- pins following the recommended circuit shown in Figure 16-2.
- Set SSRC<2.0> = 111 in the ADCON1 register to enable the auto convert option.
- Enable automatic sampling by setting the ASAM control bit in the ADCON1 register.
- Write the SMPI<3.0> control bits in the ADCON2 register for the desired number of conversions between interrupts.
- Configure the ADC clock period to be:

$$\frac{1}{(14 + 1) \times 200{,}000} = 334 \text{ ns}$$

  by writing to the ADCS<5:0> control bits in the ADCON3 register.
- Configure the sampling time to be 1 TAD by writing: SAMC<4:0> = 00001.

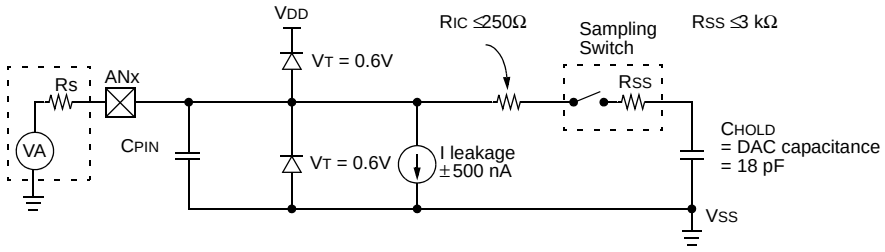
The following figure shows the timing diagram of the ADC running at 200 ksps. The TAD selection in conjunction with the guidelines described above allows a conversion speed of 200 ksps. See Example 16-1 for code example.

16.8 A/D Acquisition Requirements

The analog input model of the 12-bit ADC is shown in Figure 16-3. The total sampling time for the A/D is a function of the internal amplifier settling time and the holding capacitor charge time.

For the ADC to meet its specified accuracy, the charge holding capacitor (CHOLD) must be allowed to fully charge to the voltage level on the analog input pin. The source impedance (RS), the interconnect impedance (RIC) and the internal sampling switch (RSS) impedance combine to directly affect the time required to charge the capacitor CHOLD. The combined impedance of the analog sources must therefore be small enough to fully charge the holding capacitor within the chosen sample time. To minimize the effects of pin leakage currents on the accuracy of the ADC, the maximum recommended source impedance, RS, is 2.5 kΩ. After the analog input channel is selected (changed), this sampling function must be completed prior to starting the conversion. The internal holding capacitor will be in a discharged state prior to each sample operation.

FIGURE 16-3: 12-BIT A/D CONVERTER ANALOG INPUT MODEL



Legend: CPIN = input capacitance; VT = threshold voltage; I leakage = leakage current at the pin due to various junctions; RIC = interconnect resistance; RSS = sampling switch resistance; CHOLD = sample/hold capacitance (from DAC)

Note: CPIN value depends on device package and is not tested. Effect of CPIN negligible if Rs ≤2.5 kΩ

TABLE 16-2: A/D CONVERTER REGISTER MAP FOR dsPIC30F2011/3012

SFR Name	Addr.	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Reset State
ADCBUF0	0280	—	—	—	—	ADC Data Buffer 0												0000 uuuu uuuu uuuu
ADCBUF1	0282	—	—	—	—	ADC Data Buffer 1												0000 uuuu uuuu uuuu
ADCBUF2	0284	—	—	—	—	ADC Data Buffer 2												0000 uuuu uuuu uuuu
ADCBUF3	0286	—	—	—	—	ADC Data Buffer 3												0000 uuuu uuuu uuuu
ADCBUF4	0288	—	—	—	—	ADC Data Buffer 4												0000 uuuu uuuu uuuu
ADCBUF5	028A	—	—	—	—	ADC Data Buffer 5												0000 uuuu uuuu uuuu
ADCBUF6	028C	—	—	—	—	ADC Data Buffer 6												0000 uuuu uuuu uuuu
ADCBUF7	028E	—	—	—	—	ADC Data Buffer 7												0000 uuuu uuuu uuuu
ADCBUF8	0290	—	—	—	—	ADC Data Buffer 8												0000 uuuu uuuu uuuu
ADCBUF9	0292	—	—	—	—	ADC Data Buffer 9												0000 uuuu uuuu uuuu
ADCBUFA	0294	—	—	—	—	ADC Data Buffer 10												0000 uuuu uuuu uuuu
ADCBUFB	0296	—	—	—	—	ADC Data Buffer 11												0000 uuuu uuuu uuuu
ADCBUFC	0298	—	—	—	—	ADC Data Buffer 12												0000 uuuu uuuu uuuu
ADCBUFD	029A	—	—	—	—	ADC Data Buffer 13												0000 uuuu uuuu uuuu
ADCBUFE	029C	—	—	—	—	ADC Data Buffer 14												0000 uuuu uuuu uuuu
ADCBUFF	029E	—	—	—	—	ADC Data Buffer 15												0000 uuuu uuuu uuuu
ADCON1	02A0	ADON	—	ADSIDL	—	—	—	FORM<1:0>		SSRC<2:0>			—	—	ASAM	SAMP	DONE	0000 0000 0000 0000
ADCON2	02A2	VCFG<2:0>			—	—	CSCNA	—	—	BUFS	—	SMPI<3:0>				BUFM	ALTS	0000 0000 0000 0000
ADCON3	02A4	—	—	—	SAMC<4:0>					ADRC	—	ADCS<5:0>						0000 0000 0000 0000
ADCHS	02A6	—	—	—	CH0NB	CH0SB<3:0>				—	—	—	CH0NA	CH0SA<3:0>				0000 0000 0000 0000
ADPCFG	02A8	—	—	—	—	—	—	—	—	PCFG7	PCFG6	PCFG5	PCFG4	PCFG3	PCFG2	PCFG1	PCFG0	0000 0000 0000 0000
ADCSSL	02AA	—	—	—	—	—	—	—	—	CSSL7	CSSL6	CSSL5	CSSL4	CSSL3	CSSL2	CSSL1	CSSL0	0000 0000 0000 0000

Legend: u = uninitialized bit; — = unimplemented bit, read as '0'

Note: Refer to the "*dsPIC30F Family Reference Manual*" (DS70046) for descriptions of register bit fields.

TABLE 17-1: OSCILLATOR OPERATING MODES

Oscillator Mode	Description
XTL	200 kHz-4 MHz crystal on OSC1:OSC2.
XT	4 MHz-10 MHz crystal on OSC1:OSC2.
XT w/PLL 4x	4 MHz-10 MHz crystal on OSC1:OSC2, 4x PLL enabled.
XT w/PLL 8x	4 MHz-10 MHz crystal on OSC1:OSC2, 8x PLL enabled.
XT w/PLL 16x	4 MHz-7.5 MHz crystal on OSC1:OSC2, 16x PLL enabled(1).
LP	32 kHz crystal on SOSCO:SOSCI(2).
HS	10 MHz-25 MHz crystal.
HS/2 w/PLL 4x	10 MHz-20 MHz crystal, divide by 2, 4x PLL enabled.
HS/2 w/PLL 8x	10 MHz-20 MHz crystal, divide by 2, 8x PLL enabled.
HS/2 w/PLL 16x	10 MHz-15 MHz crystal, divide by 2, 16x PLL enabled(1).
HS/3 w/PLL 4x	12 MHz-25 MHz crystal, divide by 3, 4x PLL enabled.
HS/3 w/PLL 8x	12 MHz-25 MHz crystal, divide by 3, 8x PLL enabled.
HS/3 w/PLL 16x	12 MHz-22.5 MHz crystal, divide by 3, 16x PLL enabled(1).
EC	External clock input (0-40 MHz).
ECIO	External clock input (0-40 MHz), OSC2 pin is I/O.
EC w/PLL 4x	External clock input (4-10 MHz), OSC2 pin is I/O, 4x PLL enabled.
EC w/PLL 8x	External clock input (4-10 MHz), OSC2 pin is I/O, 8x PLL enabled.
EC w/PLL 16x	External clock input (4-7.5 MHz), OSC2 pin is I/O, 16x PLL enabled(1).
ERC	External RC oscillator, OSC2 pin is FOSC/4 output(3).
ERCIO	External RC oscillator, OSC2 pin is I/O(3).
FRC	7.37 MHz internal RC oscillator.
FRC w/PLL 4x	7.37 MHz Internal RC oscillator, 4x PLL enabled.
FRC w/PLL 8x	7.37 MHz Internal RC oscillator, 8x PLL enabled.
FRC w/PLL 16x	7.37 MHz Internal RC oscillator, 16x PLL enabled.
LPRC	512 kHz internal RC oscillator.

Note 1: dsPIC30F maximum operating frequency of 120 MHz must be met.

2: LP oscillator can be conveniently shared as system clock, as well as real-time clock for Timer1.

3: Requires external R and C. Frequency operation up to 4 MHz.

17.3.1.1 POR with Long Crystal Start-up Time (with FSCM Enabled)

The oscillator start-up circuitry is not linked to the POR circuitry. Some crystal circuits (especially low frequency crystals) will have a relatively long start-up time. Therefore, one or more of the following conditions is possible after the POR timer and the PWRT have expired:

- The oscillator circuit has not begun to oscillate.
- The Oscillator Start-up Timer has not expired (if a crystal oscillator is used).
- The PLL has not achieved a LOCK (if PLL is used).

If the FSCM is enabled and one of the above conditions is true, then a clock failure trap will occur. The device will automatically switch to the FRC oscillator and the user can switch to the desired crystal oscillator in the trap ISR.

17.3.1.2 Operating without FSCM and PWRT

If the FSCM is disabled and the Power-up Timer (PWRT) is also disabled, then the device will exit rapidly from Reset on power-up. If the clock source is FRC, LPRC, ERC or EC, it will be active immediately.

If the FSCM is disabled and the system clock has not started, the device will be in a frozen state at the Reset vector until the system clock starts. From the user's perspective, the device will appear to be in Reset until a system clock is available.

17.3.2 BOR: PROGRAMMABLE BROWN-OUT RESET

The BOR (Brown-out Reset) module is based on an internal voltage reference circuit. The main purpose of the BOR module is to generate a device Reset when a brown-out condition occurs. Brown-out conditions are generally caused by glitches on the AC mains (i.e., missing portions of the AC cycle waveform due to bad power transmission lines, or voltage sags due to excessive current draw when a large inductive load is turned on).

The BOR module allows selection of one of the following voltage trip points (see Table 20-11):

- 2.6V-2.71V
- 4.1V-4.4V
- 4.58V-4.73V

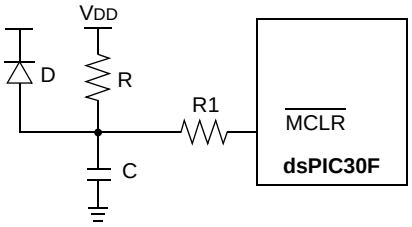
Note:	The BOR voltage trip points indicated here are nominal values provided for design guidance only. Refer to the Electrical Specifications in the specific device data sheet for BOR voltage limit specifications.

A BOR will generate a Reset pulse which will reset the device. The BOR will select the clock source based on the device Configuration bit values (FOS<2:0> and FPR<4:0>). Furthermore, if an Oscillator mode is selected, the BOR will activate the Oscillator Start-up Timer (OST). The system clock is held until OST expires. If the PLL is used, then the clock will be held until the LOCK bit (OSCCON<5>) is '1'.

Concurrently, the POR time-out (T_{POR}) and the PWRT time-out (T_{PWRT}) will be applied before the internal Reset is released. If T_{PWRT} = 0 and a crystal oscillator is being used, then a nominal delay of T_{FSCM} = 100 µs is applied. The total delay in this case is (T_{POR} + T_{FSCM}).

The BOR Status bit (RCON<1>) will be set to indicate that a BOR has occurred. The BOR circuit, if enabled, will continue to operate while in Sleep or Idle modes and will reset the device should V_{DD} fall below the BOR threshold voltage.

FIGURE 17-6: EXTERNAL POWER-ON RESET CIRCUIT (FOR SLOW V_{DD} POWER-UP)



Note 1: External Power-on Reset circuit is required only if the V_{DD} power-up slope is too slow. The diode D helps discharge the capacitor quickly when V_{DD} powers down.

2: R should be suitably chosen so as to make sure that the voltage drop across R does not violate the device's electrical specifications.

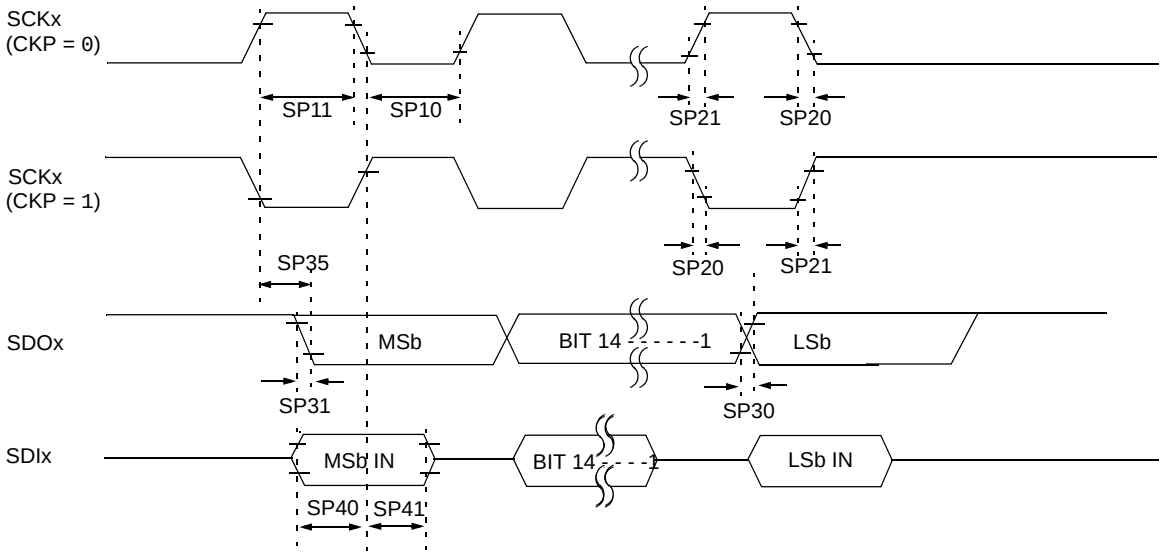
3: R1 should be suitably chosen so as to limit any current flowing into $\overline{MCLR}$ from external capacitor C, in the event of $\overline{MCLR}/V_{PP}$ pin breakdown due to Electrostatic Discharge (ESD) or Electrical Overstress (EOS).

Note:	Dedicated supervisory devices, such as the MCP1XX and MCP8XX, may also be used as an external Power-on Reset circuit.

TABLE 18-2: INSTRUCTION SET OVERVIEW (CONTINUED)

Base Instr #	Assembly Mnemonic	Assembly Syntax		Description	# of Words	# of Cycles	Status Flags Affected
66	RRNC	RRNC	f	f = Rotate Right (No Carry) f	1	1	N,Z
		RRNC	f,WREG	WREG = Rotate Right (No Carry) f	1	1	N,Z
		RRNC	Ws,Wd	Wd = Rotate Right (No Carry) Ws	1	1	N,Z
67	SAC	SAC	Acc,#Slit4,Wdo	Store Accumulator	1	1	None
		SAC.R	Acc,#Slit4,Wdo	Store Rounded Accumulator	1	1	None
68	SE	SE	Ws,Wnd	Wnd = sign-extended Ws	1	1	C,N,Z
69	SETM	SETM	f	f = 0xFFFF	1	1	None
		SETM	WREG	WREG = 0xFFFF	1	1	None
		SETM	Ws	Ws = 0xFFFF	1	1	None
70	SFTAC	SFTAC	Acc,Wn	Arithmetic Shift Accumulator by (Wn)	1	1	OA,OB,OAB, SA,SB,SAB
		SFTAC	Acc,#Slit6	Arithmetic Shift Accumulator by Slit6	1	1	OA,OB,OAB, SA,SB,SAB
71	SL	SL	f	f = Left Shift f	1	1	C,N,OV,Z
		SL	f,WREG	WREG = Left Shift f	1	1	C,N,OV,Z
		SL	Ws,Wd	Wd = Left Shift Ws	1	1	C,N,OV,Z
		SL	Wb,Wns,Wnd	Wnd = Left Shift Wb by Wns	1	1	N,Z
		SL	Wb,#lit5,Wnd	Wnd = Left Shift Wb by lit5	1	1	N,Z
72	SUB	SUB	Acc	Subtract Accumulators	1	1	OA,OB,OAB, SA,SB,SAB
		SUB	f	f = f - WREG	1	1	C,DC,N,OV,Z
		SUB	f,WREG	WREG = f - WREG	1	1	C,DC,N,OV,Z
		SUB	#lit10,Wn	Wn = Wn - lit10	1	1	C,DC,N,OV,Z
		SUB	Wb,Ws,Wd	Wd = Wb - Ws	1	1	C,DC,N,OV,Z
		SUB	Wb,#lit5,Wd	Wd = Wb - lit5	1	1	C,DC,N,OV,Z
73	SUBB	SUBB	f	f = f - WREG - ($\overline{C}$)	1	1	C,DC,N,OV,Z
		SUBB	f,WREG	WREG = f - WREG - ($\overline{C}$)	1	1	C,DC,N,OV,Z
		SUBB	#lit10,Wn	Wn = Wn - lit10 - ($\overline{C}$)	1	1	C,DC,N,OV,Z
		SUBB	Wb,Ws,Wd	Wd = Wb - Ws - ($\overline{C}$)	1	1	C,DC,N,OV,Z
		SUBB	Wb,#lit5,Wd	Wd = Wb - lit5 - ($\overline{C}$)	1	1	C,DC,N,OV,Z
74	SUBR	SUBR	f	f = WREG - f	1	1	C,DC,N,OV,Z
		SUBR	f,WREG	WREG = WREG - f	1	1	C,DC,N,OV,Z
		SUBR	Wb,Ws,Wd	Wd = Ws - Wb	1	1	C,DC,N,OV,Z
		SUBR	Wb,#lit5,Wd	Wd = lit5 - Wb	1	1	C,DC,N,OV,Z
75	SUBBR	SUBBR	f	f = WREG - f - ($\overline{C}$)	1	1	C,DC,N,OV,Z
		SUBBR	f,WREG	WREG = WREG -f - ($\overline{C}$)	1	1	C,DC,N,OV,Z
		SUBBR	Wb,Ws,Wd	Wd = Ws - Wb - ($\overline{C}$)	1	1	C,DC,N,OV,Z
		SUBBR	Wb,#lit5,Wd	Wd = lit5 - Wb - ($\overline{C}$)	1	1	C,DC,N,OV,Z
76	SWAP	SWAP.b	Wn	Wn = nibble swap Wn	1	1	None
		SWAP	Wn	Wn = byte swap Wn	1	1	None
77	TBLRDH	TBLRDH	Ws,Wd	Read Prog<23:16> to Wd<7:0>	1	2	None
78	TBLRDL	TBLRDL	Ws,Wd	Read Prog<15:0> to Wd	1	2	None
79	TBLWTH	TBLWTH	Ws,Wd	Write Ws<7:0> to Prog<23:16>	1	2	None
80	TBLWTL	TBLWTL	Ws,Wd	Write Ws to Prog<15:0>	1	2	None
81	ULNK	ULNK		Unlink frame pointer	1	1	None
82	XOR	XOR	f	f = f .XOR. WREG	1	1	N,Z
		XOR	f,WREG	WREG = f .XOR. WREG	1	1	N,Z
		XOR	#lit10,Wn	Wd = lit10 .XOR. Wd	1	1	N,Z
		XOR	Wb,Ws,Wd	Wd = Wb .XOR. Ws	1	1	N,Z
		XOR	Wb,#lit5,Wd	Wd = Wb .XOR. lit5	1	1	N,Z
83	ZE	ZE	Ws,Wnd	Wnd = Zero-extend Ws	1	1	C,Z,N

FIGURE 20-12: SPI MODULE MASTER MODE (CKE = 0) TIMING CHARACTERISTICS



Note: Refer to Figure 20-3 for load conditions.

TABLE 20-29: SPI MASTER MODE (CKE = 0) TIMING REQUIREMENTS

AC CHARACTERISTICS			Standard Operating Conditions: 2.5V to 5.5V (unless otherwise stated) Operating temperature -40°C ≤TA ≤+85°C for Industrial -40°C ≤TA ≤+125°C for Extended				
Param No.	**Symbol**	**Characteristic(1)**	**Min**	**Typ(2)**	**Max**	**Units**	**Conditions**
SP10	TscL	SCKx Output Low Time(3)	TCY/2	—	—	ns	—
SP11	TscH	SCKx Output High Time(3)	TCY/2	—	—	ns	—
SP20	TscF	SCKx Output Fall Time(4	—	—	—	ns	See parameter DO32
SP21	TscR	SCKx Output Rise Time(4)	—	—	—	ns	See parameter DO31
SP30	TdoF	SDOx Data Output Fall Time(4)	—	—	—	ns	See parameter DO32
SP31	TdoR	SDOx Data Output Rise Time(4)	—	—	—	ns	See parameter DO31
SP35	TscH2doV, TscL2doV	SDOx Data Output Valid after SCKx Edge	—	—	30	ns	—
SP40	TdiV2scH, TdiV2scL	Setup Time of SDIx Data Input to SCKx Edge	20	—	—	ns	—
SP41	TscH2diL, TscL2diL	Hold Time of SDIx Data Input to SCKx Edge	20	—	—	ns	—

Note 1: These parameters are characterized but not tested in manufacturing.

2: Data in "Typ" column is at 5V, 25°C unless otherwise stated. Parameters are for design guidance only and are not tested.

3: The minimum clock period for SCK is 100 ns. Therefore, the clock generated in Master mode must not violate this specification.

4: Assumes 50 pF load on all SPI pins.

TABLE 20-33: I²C™ BUS DATA TIMING REQUIREMENTS (MASTER MODE)

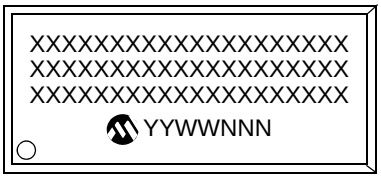
AC CHARACTERISTICS				Standard Operating Conditions: 2.5V to 5.5V (unless otherwise stated) Operating temperature -40°C ≤TA ≤+85°C for Industrial -40°C ≤TA ≤+125°C for Extended			
Param No.	**Symbol**	**Characteristic**		**Min(1)**	**Max**	**Units**	**Conditions**
IM10	TLO:SCL	Clock Low Time	100 kHz mode	TCY/2 (BRG + 1)	—	µs	
			400 kHz mode	TCY/2 (BRG + 1)	—	µs	
			1 MHz mode(2)	TCY/2 (BRG + 1)	—	µs	
IM11	THI:SCL	Clock High Time	100 kHz mode	TCY/2 (BRG + 1)	—	µs	
			400 kHz mode	TCY/2 (BRG + 1)	—	µs	
			1 MHz mode(2)	TCY/2 (BRG + 1)	—	µs	
IM20	TF:SCL	SDA and SCL Fall Time	100 kHz mode	—	300	ns	CB is specified to be from 10 to 400 pF
			400 kHz mode	20 + 0.1 CB	300	ns	
			1 MHz mode(2)	—	100	ns	
IM21	TR:SCL	SDA and SCL Rise Time	100 kHz mode	—	1000	ns	CB is specified to be from 10 to 400 pF
			400 kHz mode	20 + 0.1 CB	300	ns	
			1 MHz mode(2)	—	300	ns	
IM25	TSU:DAT	Data Input Setup Time	100 kHz mode	250	—	ns	
			400 kHz mode	100	—	ns	
			1 MHz mode(2)	—	—	ns	
IM26	THD:DAT	Data Input Hold Time	100 kHz mode	0	—	ns	
			400 kHz mode	0	0.9	µs	
			1 MHz mode(2)	—	—	ns	
IM30	TSU:STA	Start Condition Setup Time	100 kHz mode	TCY/2 (BRG + 1)	—	µs	Only relevant for Repeated Start condition
			400 kHz mode	TCY/2 (BRG + 1)	—	µs	
			1 MHz mode(2)	TCY/2 (BRG + 1)	—	µs	
IM31	THD:STA	Start Condition Hold Time	100 kHz mode	TCY/2 (BRG + 1)	—	µs	After this period the first clock pulse is generated
			400 kHz mode	TCY/2 (BRG + 1)	—	µs	
			1 MHz mode(2)	TCY/2 (BRG + 1)	—	µs	
IM33	TSU:STO	Stop Condition Setup Time	100 kHz mode	TCY/2 (BRG + 1)	—	µs	
			400 kHz mode	TCY/2 (BRG + 1)	—	µs	
			1 MHz mode(2)	TCY/2 (BRG + 1)	—	µs	
IM34	THD:STO	Stop Condition Hold Time	100 kHz mode	TCY/2 (BRG + 1)	—	ns	
			400 kHz mode	TCY/2 (BRG + 1)	—	ns	
			1 MHz mode(2)	TCY/2 (BRG + 1)	—	ns	
IM40	TAA:SCL	Output Valid From Clock	100 kHz mode	—	3500	ns	
			400 kHz mode	—	1000	ns	
			1 MHz mode(2)	—	—	ns	
IM45	TBF:SDA	Bus Free Time	100 kHz mode	4.7	—	µs	Time the bus must be free before a new transmission can start
			400 kHz mode	1.3	—	µs	
			1 MHz mode(2)	—	—	µs	
IM50	CB	Bus Capacitive Loading		—	400	pF	

Note 1: BRG is the value of the I²C Baud Rate Generator. Refer to **Section 21. "Inter-Integrated Circuit™ (I²C)"** (DS70068) in the *dsPIC30F Family Reference Manual* (DS70046).

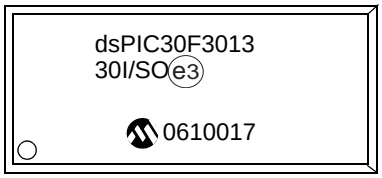
2: Maximum pin capacitance = 10 pF for all I²C™ pins (for 1 MHz mode only).

21.2 Package Marking Information (Continued)

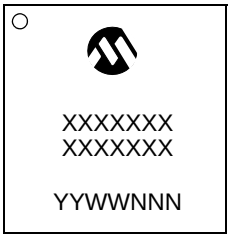
28-Lead SOIC



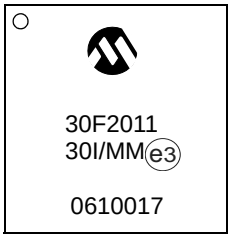
Example



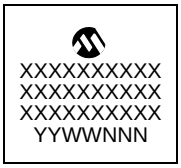
28-Lead QFN-S



Example



44-Lead QFN



Example