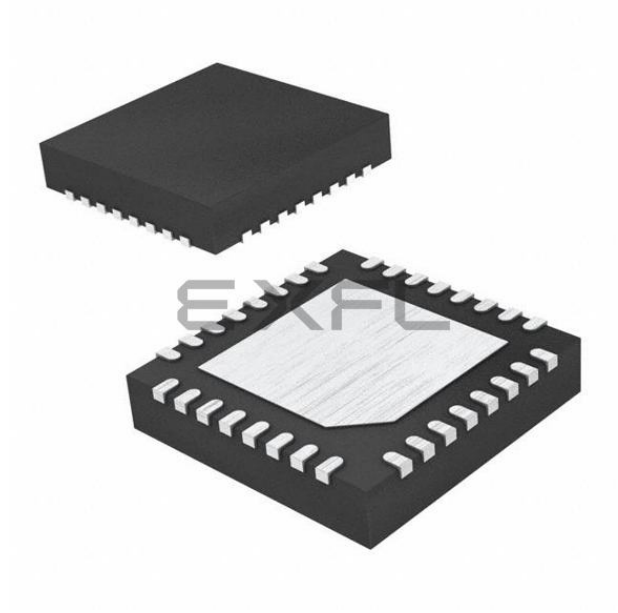
Microchip Technology - DSPIC33EP256MC202T-I/MM Datasheet



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What is "Embedded - Microcontrollers"?

"Embedded - Microcontrollers" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded" because they are embedded within electronic devices to control various functions, rather than serving as standalone computers. Microcontrollers are crucial in modern electronics, providing the intelligence and control needed for a wide range of applications.

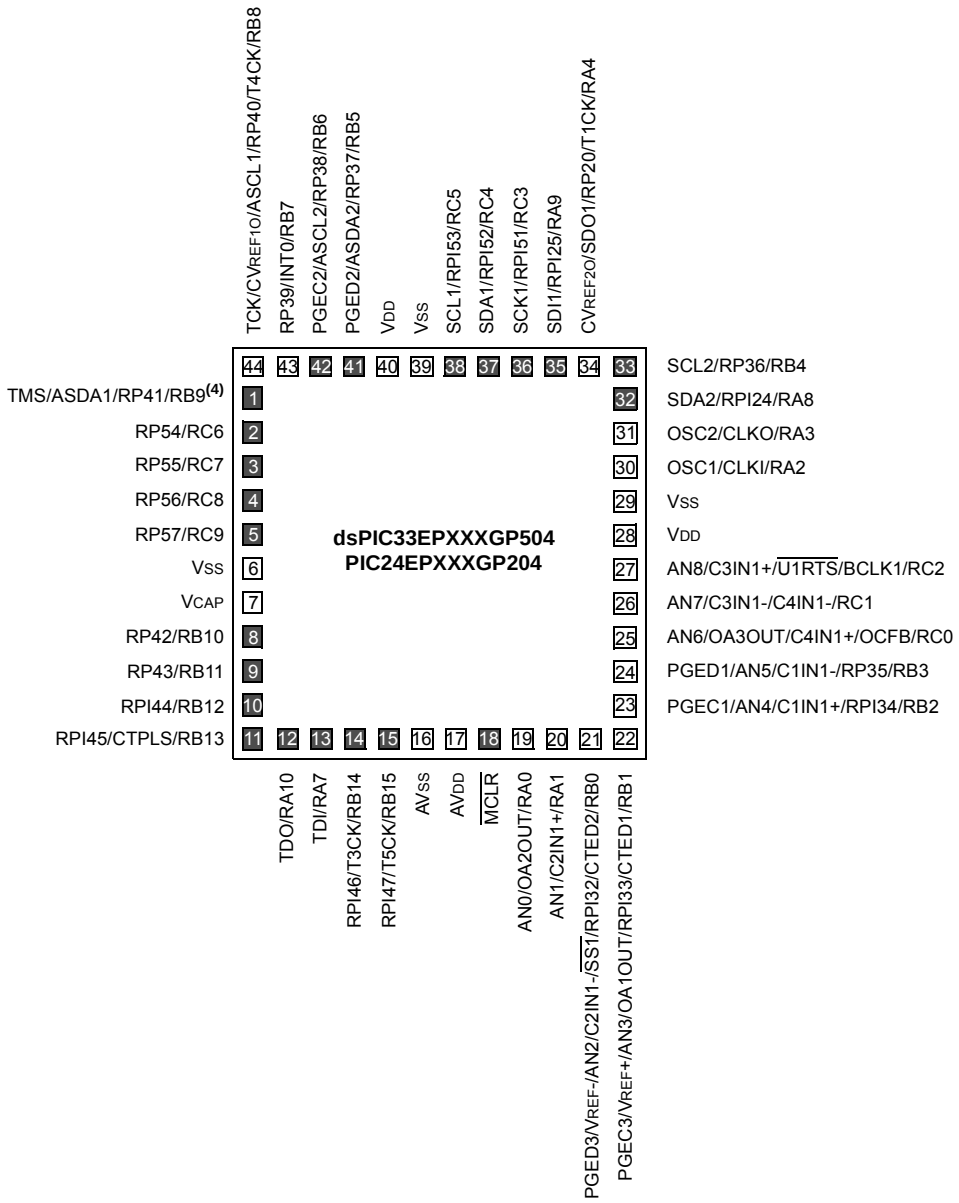
Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	dsPIC
Core Size	16-Bit
Speed	70 MIPs
Connectivity	I²C, IrDA, LINbus, QEI, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, DMA, Motor Control PWM, POR, PWM, WDT
Number of I/O	21
Program Memory Size	256KB (85.5K x 24)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	16K x 16
Voltage - Supply (Vcc/Vdd)	3V ~ 3.6V
Data Converters	A/D 6x10b/12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	28-VQFN Exposed Pad
Supplier Device Package	28-QFN-S (6x6)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/dspic33ep256mc202t-i-mm

Pin Diagrams (Continued)

44-Pin VTLA(1,2,3)

■ = Pins are up to 5V tolerant



Note 1: The RPn/RPIn pins can be used by any remappable peripheral with some limitation. See **Section 11.4 "Peripheral Pin Select (PPS)"** for available peripherals and for information on limitations.

2: Every I/O port pin (RAx-RGx) can be used as a Change Notification pin (CNAx-CNGx). See **Section 11.0 "I/O Ports"** for more information.

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

4: There is an internal pull-up resistor connected to the TMS pin when the JTAG interface is active. See the JTAGEN bit field in Table 27-2.

TABLE 1-1: PINOUT I/O DESCRIPTIONS

Pin Name(4)	Pin Type	Buffer Type	PPS	Description
AN0-AN15	I	Analog	No	Analog input channels.
CLKI	I	ST/ CMOS	No	External clock source input. Always associated with OSC1 pin function.
CLKO	O	—	No	Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode. Optionally functions as CLKO in RC and EC modes. Always associated with OSC2 pin function.
OSC1	I	ST/ CMOS	No	Oscillator crystal input. ST buffer when configured in RC mode; CMOS otherwise.
OSC2	I/O	—	No	Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode. Optionally functions as CLKO in RC and EC modes.
REFCLKO	O	—	Yes	Reference clock output.
IC1-IC4	I	ST	Yes	Capture Inputs 1 through 4.
OCFA	I	ST	Yes	Compare Fault A input (for Compare channels).
OCFB	I	ST	No	Compare Fault B input (for Compare channels).
OC1-OC4	O	—	Yes	Compare Outputs 1 through 4.
INT0	I	ST	No	External Interrupt 0.
INT1	I	ST	Yes	External Interrupt 1.
INT2	I	ST	Yes	External Interrupt 2.
RA0-RA4, RA7-RA12	I/O	ST	No	PORTA is a bidirectional I/O port.
RB0-RB15	I/O	ST	No	PORTB is a bidirectional I/O port.
RC0-RC13, RC15	I/O	ST	No	PORTC is a bidirectional I/O port.
RD5, RD6, RD8	I/O	ST	No	PORTD is a bidirectional I/O port.
RE12-RE15	I/O	ST	No	PORTE is a bidirectional I/O port.
RF0, RF1	I/O	ST	No	PORTF is a bidirectional I/O port.
RG6-RG9	I/O	ST	No	PORTG is a bidirectional I/O port.
T1CK	I	ST	No	Timer1 external clock input.
T2CK	I	ST	Yes	Timer2 external clock input.
T3CK	I	ST	No	Timer3 external clock input.
T4CK	I	ST	No	Timer4 external clock input.
T5CK	I	ST	No	Timer5 external clock input.
CTPLS	O	ST	No	CTMU pulse output.
CTED1	I	ST	No	CTMU External Edge Input 1.
CTED2	I	ST	No	CTMU External Edge Input 2.
$\overline{U1CTS}$	I	ST	No	UART1 Clear-To-Send.
$\overline{U1RTS}$	O	—	No	UART1 Ready-To-Send.
U1RX	I	ST	Yes	UART1 receive.
U1TX	O	—	Yes	UART1 transmit.
BCLK1	O	ST	No	UART1 IrDA® baud clock output.

Legend: CMOS = CMOS compatible input or output; Analog = Analog input; P = Power
ST = Schmitt Trigger input with CMOS levels; O = Output; I = Input
PPS = Peripheral Pin Select; TTL = TTL input buffer

Note 1: This pin is available on dsPIC33EPXXXMC20X/50X and PIC24EPXXXMC20X devices only.

2: This pin is available on dsPIC33EPXXXGP/MC50X devices only.

3: This is the default Fault on Reset for dsPIC33EPXXXMC20X/50X and PIC24EPXXXMC20X devices. See **Section 16.0 "High-Speed PWM Module (dsPIC33EPXXXMC20X/50X and PIC24EPXXXMC20X Devices Only)"** for more information.

4: Not all pins are available in all packages variants. See the **"Pin Diagrams"** section for pin availability.

5: There is an internal pull-up resistor connected to the TMS pin when the JTAG interface is active. See the JTAGEN bit field in Table 27-2.

FIGURE 2-5: SINGLE-PHASE SYNCHRONOUS BUCK CONVERTER

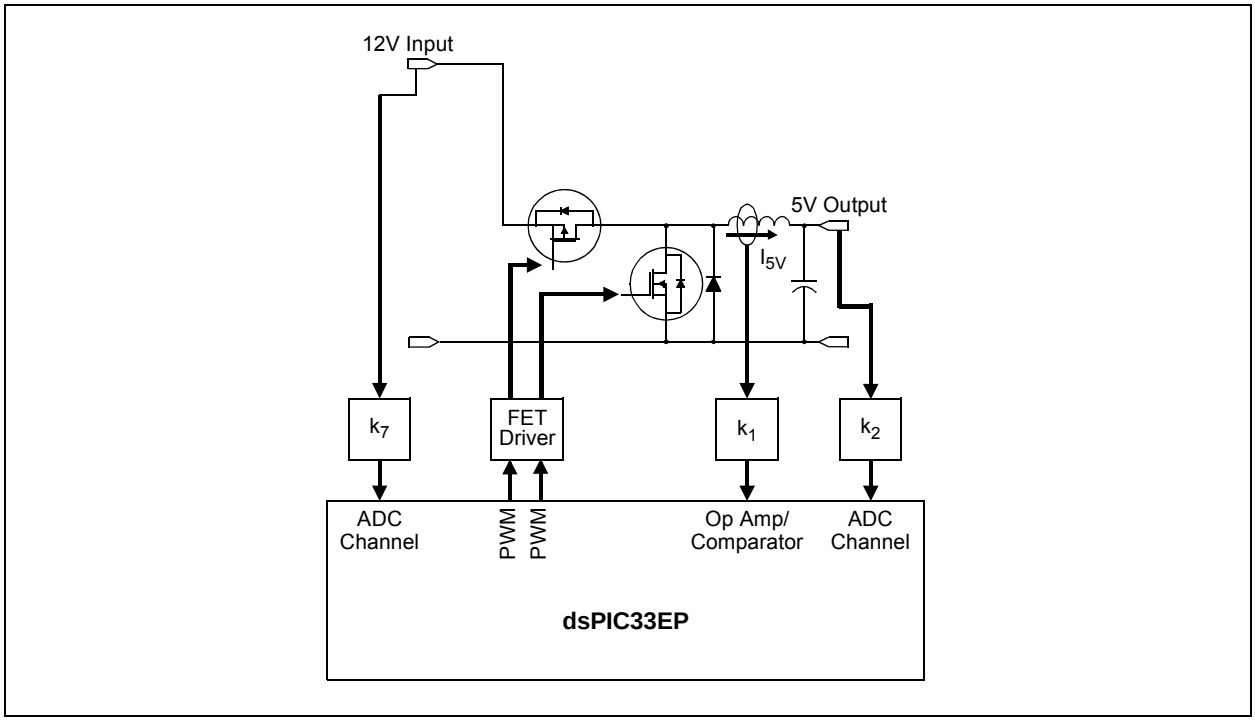
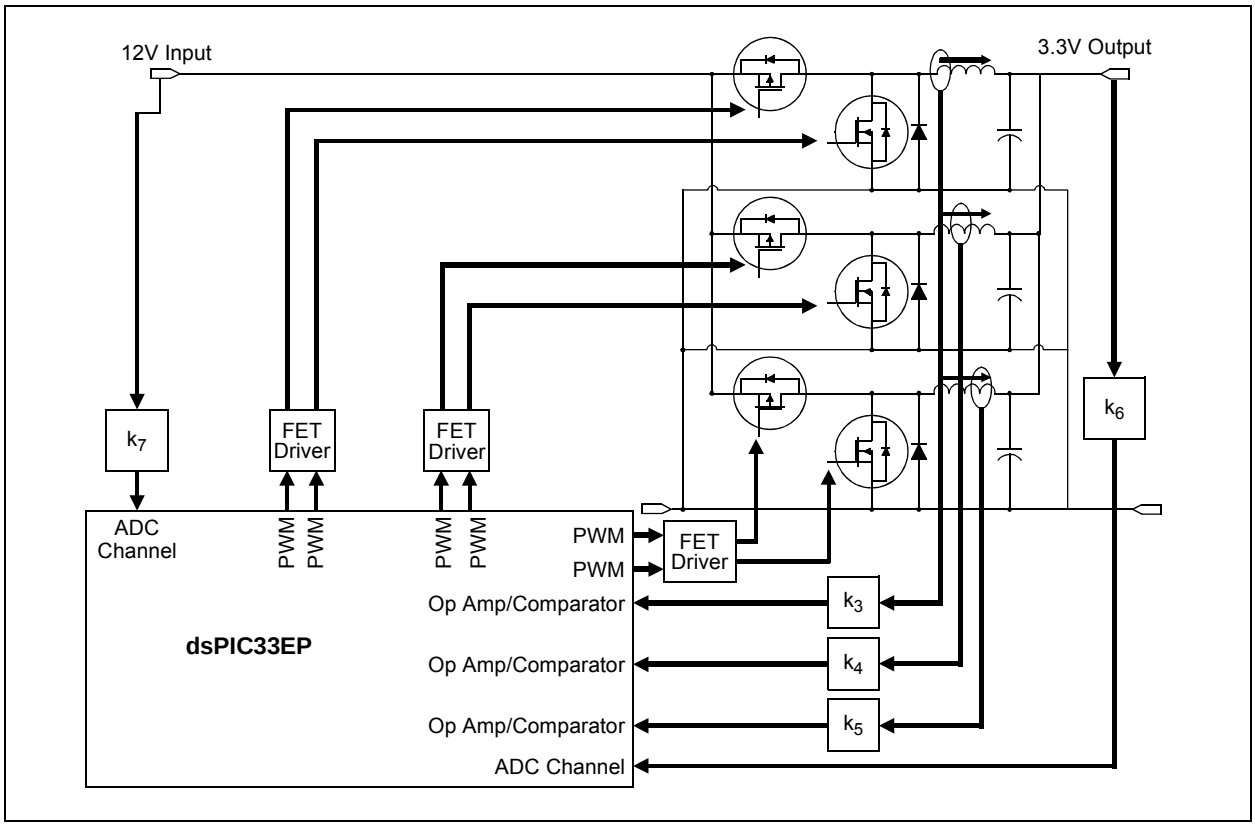


FIGURE 2-6: MULTIPHASE SYNCHRONOUS BUCK CONVERTER



3.0 CPU

Note 1: This data sheet summarizes the features of the dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X and PIC24EPXXXGP/MC20X families of devices. It is not intended to be a comprehensive reference source. To complement the information in this data sheet, refer to **"CPU"** (DS70359) in the "*dsPIC33/PIC24 Family Reference Manual*", which is available from the Microchip web site (www.microchip.com).

2: Some registers and associated bits described in this section may not be available on all devices. Refer to **Section 4.0 "Memory Organization"** in this data sheet for device-specific register and bit information.

The dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X and PIC24EPXXXGP/MC20X CPU has a 16-bit (data) modified Harvard architecture with an enhanced instruction set, including significant support for digital signal processing. The CPU has a 24-bit instruction word with a variable length opcode field. The Program Counter (PC) is 23 bits wide and addresses up to 4M x 24 bits of user program memory space.

An instruction prefetch mechanism helps maintain throughput and provides predictable execution. Most instructions execute in a single-cycle effective execution rate, with the exception of instructions that change the program flow, the double-word move (`MOV.D`) instruction, PSV accesses and the table instructions. Overhead-free program loop constructs are supported using the `DO` and `REPEAT` instructions, both of which are interruptible at any point.

3.1 Registers

The dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X and PIC24EPXXXGP/MC20X devices have sixteen, 16-bit working registers in the programmer's model. Each of the working registers can act as a data, address or address offset register. The 16th working register (W15) operates as a Software Stack Pointer for interrupts and calls.

3.2 Instruction Set

The instruction set for dsPIC33EPXXXGP50X and dsPIC33EPXXXMC20X/50X devices has two classes of instructions: the MCU class of instructions and the DSP class of instructions. The instruction set for PIC24EPXXXGP/MC20X devices has the MCU class of instructions only and does not support DSP instructions. These two instruction classes are seamlessly integrated into the architecture and execute from a single execution unit. The instruction set includes many addressing modes and was designed for optimum C compiler efficiency.

3.3 Data Space Addressing

The base Data Space can be addressed as 64 Kbytes (32K words).

The Data Space includes two ranges of memory, referred to as X and Y data memory. Each memory range is accessible through its own independent Address Generation Unit (AGU). The MCU class of instructions operates solely through the X memory AGU, which accesses the entire memory map as one linear Data Space. On dsPIC33EPXXXMC20X/50X and dsPIC33EPXXXGP50X devices, certain DSP instructions operate through the X and Y AGUs to support dual operand reads, which splits the data address space into two parts. The X and Y Data Spaces have memory locations that are device-specific, and are described further in the data memory maps in **Section 4.2 "Data Address Space"**.

The upper 32 Kbytes of the Data Space memory map can optionally be mapped into Program Space (PS) at any 32-Kbyte aligned program word boundary. The Program-to-Data Space mapping feature, known as Program Space Visibility (PSV), lets any instruction access Program Space as if it were Data Space. Moreover, the Base Data Space address is used in conjunction with a Read or Write Page register (DSRPAG or DSWPAG) to form an Extended Data Space (EDS) address. The EDS can be addressed as 8M words or 16 Mbytes. Refer to the **"Data Memory"** (DS70595) and **"Program Memory"** (DS70613) sections in the *"dsPIC33/PIC24 Family Reference Manual"* for more details on EDS, PSV and table accesses.

On the dsPIC33EPXXXMC20X/50X and dsPIC33EPXXXGP50X devices, overhead-free circular buffers (Modulo Addressing) are supported in both X and Y address spaces. The Modulo Addressing removes the software boundary checking overhead for DSP algorithms. The X AGU Circular Addressing can be used with any of the MCU class of instructions. The X AGU also supports Bit-Reversed Addressing to greatly simplify input or output data re-ordering for radix-2 FFT algorithms. PIC24EPXXXGP/MC20X devices do not support Modulo and Bit-Reversed Addressing.

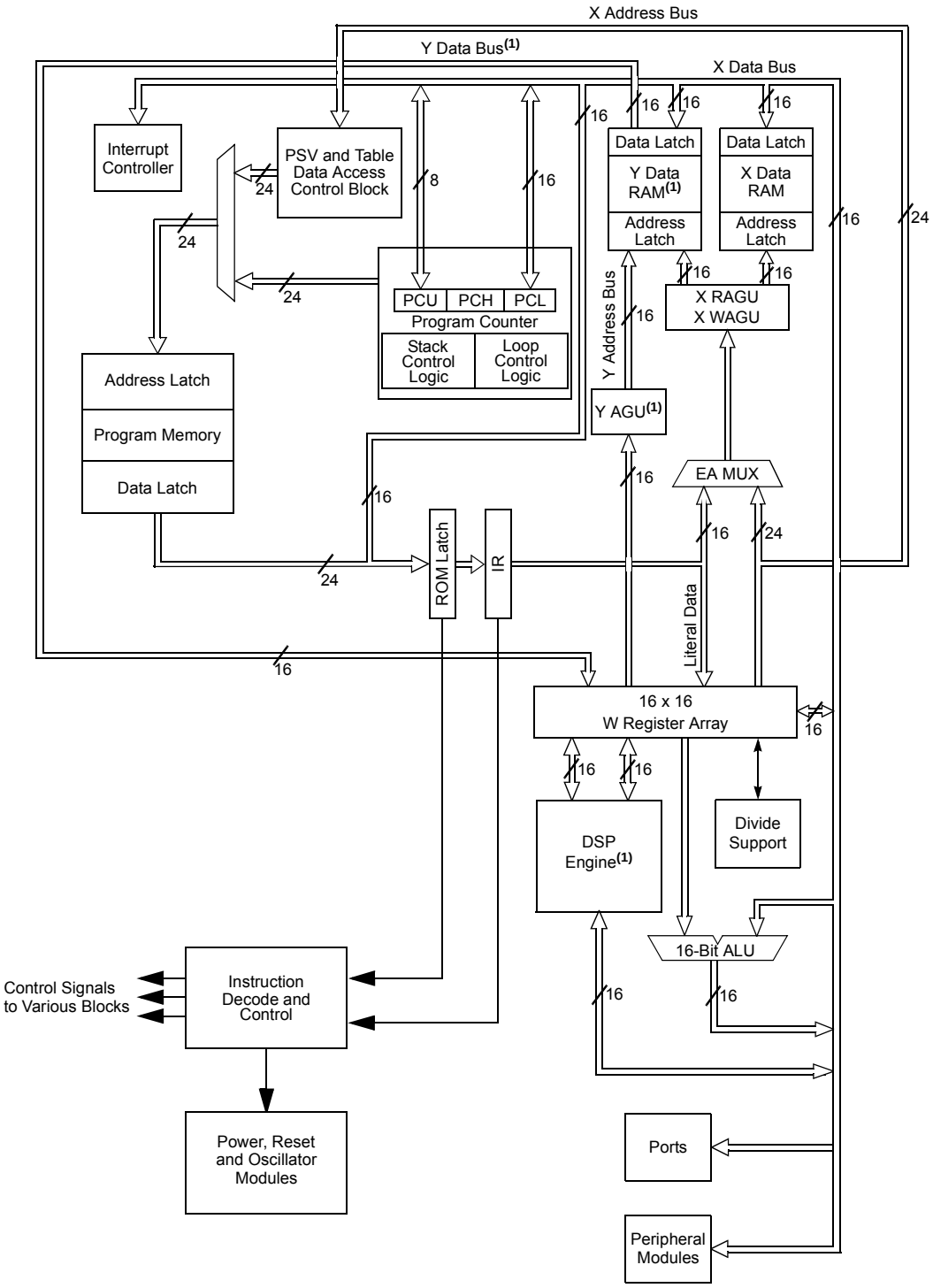
3.4 Addressing Modes

The CPU supports these addressing modes:

- Inherent (no operand)
- Relative
- Literal
- Memory Direct
- Register Direct
- Register Indirect

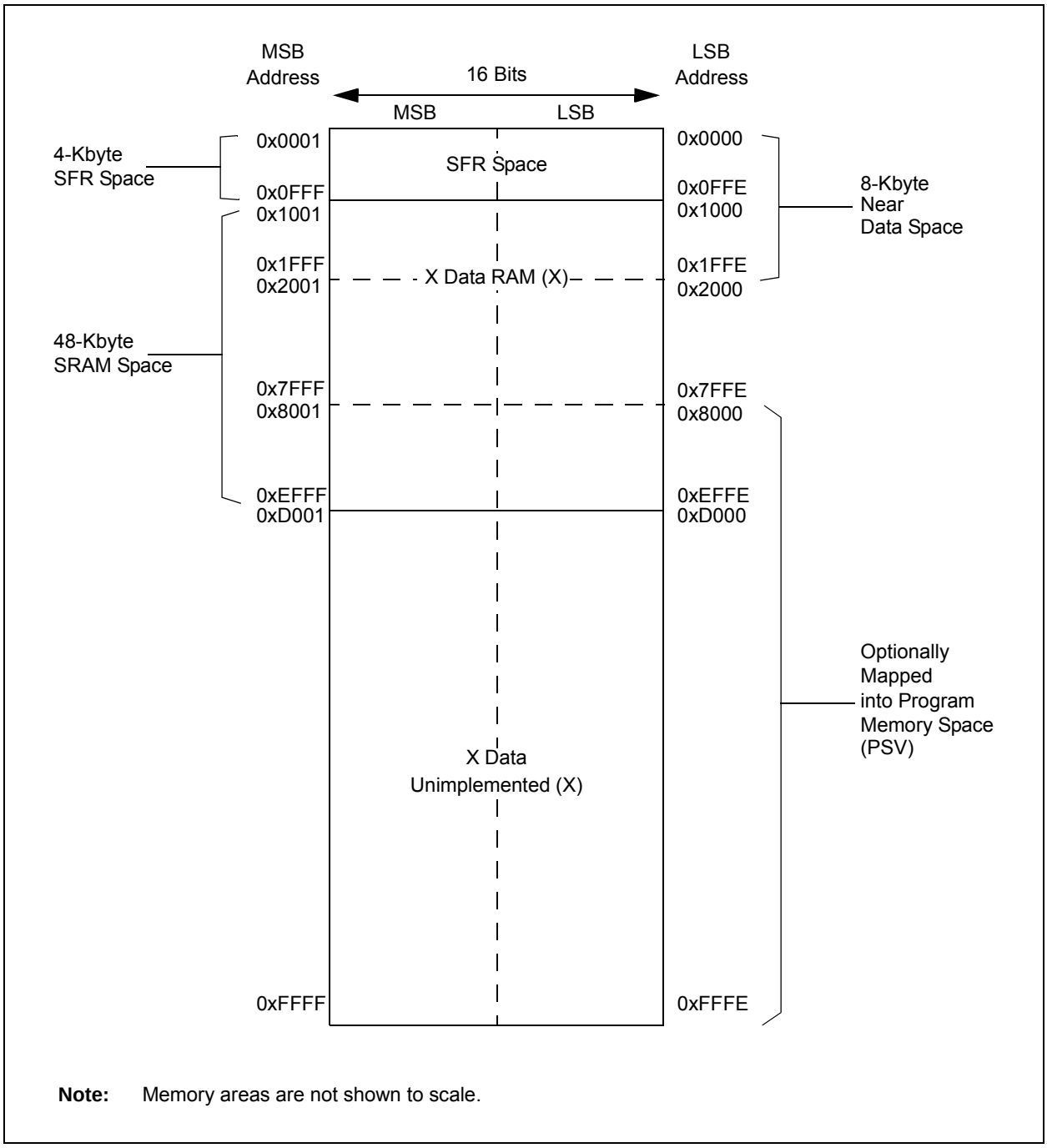
Each instruction is associated with a predefined addressing mode group, depending upon its functional requirements. As many as six addressing modes are supported for each instruction.

FIGURE 3-1: dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X AND PIC24EPXXXGP/MC20X CPU BLOCK DIAGRAM



Note 1: This feature is not available on PIC24EPXXXGP/MC20X devices.

FIGURE 4-16: DATA MEMORY MAP FOR PIC24EP512GP/MC20X/50X DEVICES



Note: Memory areas are not shown to scale.

TABLE 4-24: CRC REGISTER MAP

File 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	All Resets
CRCCON1	0640	CRCEN	—	CSIDL	VWORD<4:0>					CRCFUL	CRCMPT	CRCISEL	CRCGO	LENDIAN	—	—	—	0000
CRCCON2	0642	—	—	—	DWIDTH<4:0>					—	—	—	PLEN<4:0>					0000
CRCXORL	0644	X<15:1>															—	0000
CRCXORH	0646	X<31:16>																0000
CRCDATL	0648	CRC Data Input Low Word																0000
CRCDATH	064A	CRC Data Input High Word																0000
CRCWDATL	064C	CRC Result Low Word																0000
CRCWDATH	064E	CRC Result High Word																0000

Legend: — = unimplemented, read as '0'. Shaded bits are not used in the operation of the programmable CRC module.

TABLE 4-25: PERIPHERAL PIN SELECT OUTPUT REGISTER MAP FOR dsPIC33EPXXXGP/MC202/502 AND PIC24EPXXXGP/MC202 DEVICES ONLY

File 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	All Resets
RPOR0	0680	—	—	RP35R<5:0>						—	—	RP20R<5:0>						0000
RPOR1	0682	—	—	RP37R<5:0>						—	—	RP36R<5:0>						0000
RPOR2	0684	—	—	RP39R<5:0>						—	—	RP38R<5:0>						0000
RPOR3	0686	—	—	RP41R<5:0>						—	—	RP40R<5:0>						0000
RPOR4	0688	—	—	RP43R<5:0>						—	—	RP42R<5:0>						0000

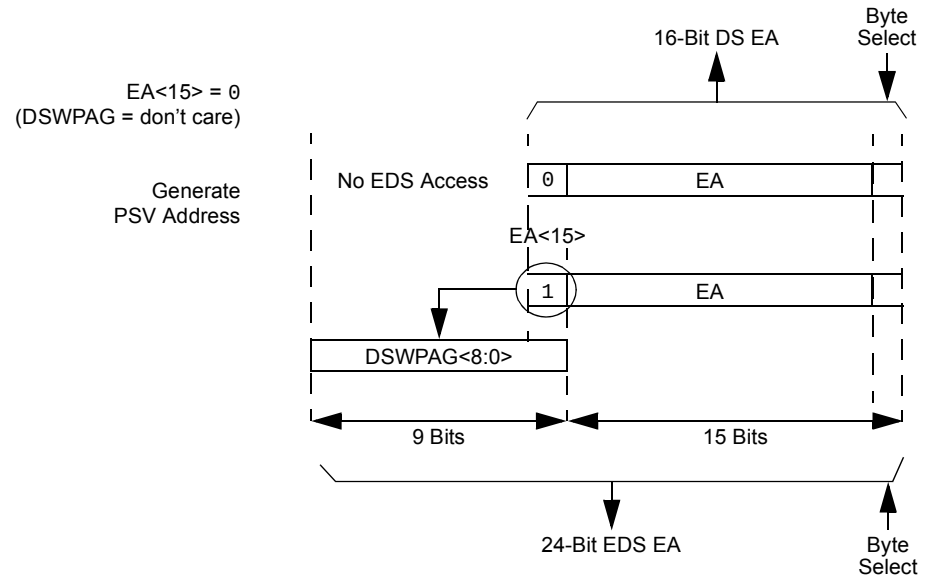
Legend: — = unimplemented, read as '0'. Reset values are shown in hexadecimal.

TABLE 4-26: PERIPHERAL PIN SELECT OUTPUT REGISTER MAP FOR dsPIC33EPXXXGP/MC203/503 AND PIC24EPXXXGP/MC203 DEVICES ONLY

File 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	All Resets
RPOR0	0680	—	—	RP35R<5:0>						—	—	RP20R<5:0>						0000
RPOR1	0682	—	—	RP37R<5:0>						—	—	RP36R<5:0>						0000
RPOR2	0684	—	—	RP39R<5:0>						—	—	RP38R<5:0>						0000
RPOR3	0686	—	—	RP41R<5:0>						—	—	RP40R<5:0>						0000
RPOR4	0688	—	—	RP43R<5:0>						—	—	RP42R<5:0>						0000
RPOR5	068A	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0000
RPOR6	068C	—	—	—	—	—	—	—	—	—	—	RP56R<5:0>						0000

Legend: — = unimplemented, read as '0'. Reset values are shown in hexadecimal.

EXAMPLE 4-2: EXTENDED DATA SPACE (EDS) WRITE ADDRESS GENERATION



Note: DS read access when DSRPAG = 0x000 will force an address error trap.

The paged memory scheme provides access to multiple 32-Kbyte windows in the EDS and PSV memory. The Data Space Page registers, DSxPAG, in combination with the upper half of the Data Space address, can provide up to 16 Mbytes of additional address space in the EDS and 8 Mbytes (DSRPAG only) of PSV address space. The paged data memory space is shown in Example 4-3.

The Program Space (PS) can be accessed with a DSRPAG of 0x200 or greater. Only reads from PS are supported using the DSRPAG. Writes to PS are not supported, so DSWPAG is dedicated to DS, including EDS only. The Data Space and EDS can be read from, and written to, using DSRPAG and DSWPAG, respectively.

REGISTER 5-1: NVMCON: NONVOLATILE MEMORY (NVM) CONTROL REGISTER

R/SO-0(1)	R/W-0(1)	R/W-0(1)	R/W-0	U-0	U-0	U-0	U-0
WR	WREN	WRERR	NVMSIDL(2)	—	—	—	—
bit 15							bit 8

U-0	U-0	U-0	U-0	R/W-0(1)	R/W-0(1)	R/W-0(1)	R/W-0(1)
—	—	—	—	NVMOP3(3,4)	NVMOP2(3,4)	NVMOP1(3,4)	NVMOP0(3,4)
bit 7							bit 0

Legend:	SO = Settable Only bit		
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 15 **WR:** Write Control bit(1)
- 1 = Initiates a Flash memory program or erase operation; the operation is self-timed and the bit is cleared by hardware once the operation is complete
- 0 = Program or erase operation is complete and inactive

bit 14 **WREN:** Write Enable bit(1)
- 1 = Enables Flash program/erase operations
- 0 = Inhibits Flash program/erase operations

bit 13 **WRERR:** Write Sequence Error Flag bit(1)
- 1 = An improper program or erase sequence attempt or termination has occurred (bit is set automatically on any set attempt of the WR bit)
- 0 = The program or erase operation completed normally

bit 12 **NVMSIDL:** NVM Stop in Idle Control bit(2)
- 1 = Flash voltage regulator goes into Standby mode during Idle mode
- 0 = Flash voltage regulator is active during Idle mode

bit 11-4 **Unimplemented:** Read as '0'

bit 3-0 **NVMOP<3:0>:** NVM Operation Select bits(1,3,4)
- 1111 = Reserved
- 1110 = Reserved
- 1101 = Reserved
- 1100 = Reserved
- 1011 = Reserved
- 1010 = Reserved
- 0011 = Memory page erase operation
- 0010 = Reserved
- 0001 = Memory double-word program operation(5)
- 0000 = Reserved

Note 1: These bits can only be reset on a POR.

2: If this bit is set, there will be minimal power savings (I_{IDLE}) and upon exiting Idle mode, there is a delay (T_{VREG}) before Flash memory becomes operational.

3: All other combinations of NVMOP<3:0> are unimplemented.

4: Execution of the PWRSAV instruction is ignored while any of the NVM operations are in progress.

5: Two adjacent words on a 4-word boundary are programmed during execution of this operation.

REGISTER 8-12: DMARQC: DMA REQUEST COLLISION STATUS REGISTER

U-0	U-0	U-0	U-0	U-0	U-0	U-0	U-0
—	—	—	—	—	—	—	—
bit 15							bit 8

U-0	U-0	U-0	U-0	R-0	R-0	R-0	R-0
—	—	—	—	RQCOL3	RQCOL2	RQCOL1	RQCOL0
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 15-4 **Unimplemented:** Read as '0'

bit 3 **RQCOL3:** DMA Channel 3 Transfer Request Collision Flag bit
1 = User force and interrupt-based request collision is detected
0 = No request collision is detected

bit 2 **RQCOL2:** DMA Channel 2 Transfer Request Collision Flag bit
1 = User force and interrupt-based request collision is detected
0 = No request collision is detected

bit 1 **RQCOL1:** DMA Channel 1 Transfer Request Collision Flag bit
1 = User force and interrupt-based request collision is detected
0 = No request collision is detected

bit 0 **RQCOL0:** DMA Channel 0 Transfer Request Collision Flag bit
1 = User force and interrupt-based request collision is detected
0 = No request collision is detected

17.2 QEI Control Registers

REGISTER 17-1: QEI1CON: QEI1 CONTROL REGISTER

R/W-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
QEIEN	—	QEISIDL	PIMOD2(1)	PIMOD1(1)	PIMOD0(1)	IMV1(2)	IMV0(2)
bit 15							bit 8

U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	INTDIV2(3)	INTDIV1(3)	INTDIV0(3)	CNTPOL	GATEN	CCM1	CCM0
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 15 **QEIEN:** Quadrature Encoder Interface Module Counter Enable bit
1 = Module counters are enabled
0 = Module counters are disabled, but SFRs can be read or written to

bit 14 **Unimplemented:** Read as '0'

bit 13 **QEISIDL:** QEI Stop in Idle Mode bit
1 = Discontinues module operation when device enters Idle mode
0 = Continues module operation in Idle mode

bit 12-10 **PIMOD<2:0>:** Position Counter Initialization Mode Select bits(1)
111 = Reserved
110 = Modulo Count mode for position counter
101 = Resets the position counter when the position counter equals QEI1GEC register
100 = Second index event after home event initializes position counter with contents of QEI1IC register
011 = First index event after home event initializes position counter with contents of QEI1IC register
010 = Next index input event initializes the position counter with contents of QEI1IC register
001 = Every index input event resets the position counter
000 = Index input event does not affect position counter

bit 9 **IMV1:** Index Match Value for Phase B bit(2)
1 = Phase B match occurs when QEB = 1
0 = Phase B match occurs when QEB = 0

bit 8 **IMV0:** Index Match Value for Phase A bit(2)
1 = Phase A match occurs when QEA = 1
0 = Phase A match occurs when QEA = 0

bit 7 **Unimplemented:** Read as '0'

Note 1: When CCM<1:0> = 10 or 11, all of the QEI counters operate as timers and the PIMOD<2:0> bits are ignored.

2: When CCM<1:0> = 00, and QEA and QEB values match the Index Match Value (IMV), the POSCNTH and POSCNTL registers are reset. QEA/QEB signals used for the index match have swap and polarity values applied, as determined by the SWPAB and QEAPOL/QEBPOL bits.

3: The selected clock rate should be at least twice the expected maximum quadrature count rate.

REGISTER 21-11: CxFEN1: ECANx ACCEPTANCE FILTER ENABLE REGISTER 1

R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1
FLTEN15	FLTEN14	FLTEN13	FLTEN12	FLTEN11	FLTEN10	FLTEN9	FLTEN8
bit 15							bit 8

R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1
FLTEN7	FLTEN6	FLTEN5	FLTEN4	FLTEN3	FLTEN2	FLTEN1	FLTEN0
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 15-0 **FLTEN<15:0>:** Enable Filter n to Accept Messages bits
1 = Enables Filter n
0 = Disables Filter n

REGISTER 21-12: CxBUFPNT1: ECANx FILTER 0-3 BUFFER POINTER REGISTER 1

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
F3BP<3:0>				F2BP<3:0>			
bit 15							bit 8

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
F1BP<3:0>				F0BP<3:0>			
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

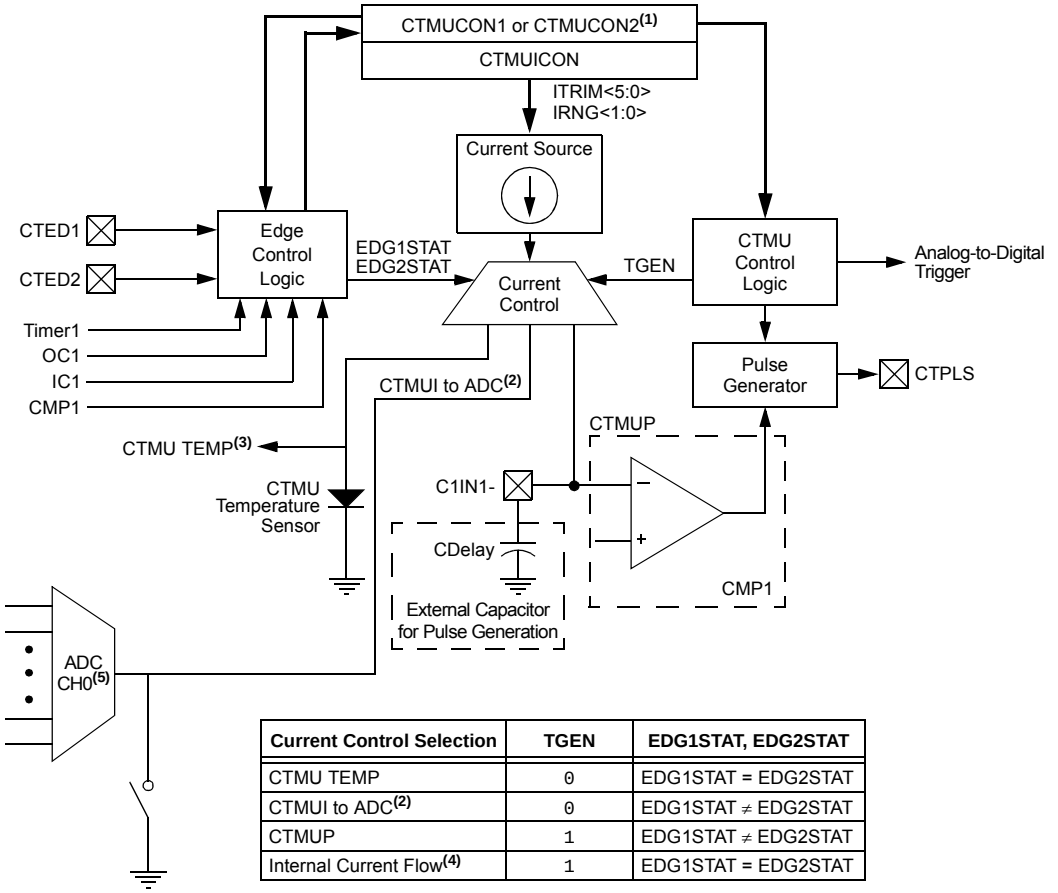
bit 15-12 **F3BP<3:0>:** RX Buffer Mask for Filter 3 bits
1111 = Filter hits received in RX FIFO buffer
1110 = Filter hits received in RX Buffer 14
•
•
•
0001 = Filter hits received in RX Buffer 1
0000 = Filter hits received in RX Buffer 0

bit 11-8 **F2BP<3:0>:** RX Buffer Mask for Filter 2 bits (same values as bits<15:12>)

bit 7-4 **F1BP<3:0>:** RX Buffer Mask for Filter 1 bits (same values as bits<15:12>)

bit 3-0 **F0BP<3:0>:** RX Buffer Mask for Filter 0 bits (same values as bits<15:12>)

FIGURE 22-1: CTMU BLOCK DIAGRAM



Current Control Selection	TGEN	EDG1STAT, EDG2STAT
CTMU TEMP	0	EDG1STAT = EDG2STAT
CTMUI to ADC(2)	0	EDG1STAT ≠ EDG2STAT
CTMUP	1	EDG1STAT ≠ EDG2STAT
Internal Current Flow(4)	1	EDG1STAT = EDG2STAT

Note 1: When the CTMU is not actively used, set TGEN = 1, and ensure that EDG1STAT = EDG2STAT. All other settings allow current to flow into the ADC or the C1IN1- pin. If using the ADC for other purposes besides the CTMU, set IDISSEN = 0. If IDISSEN is set to '1', it will short the output of the ADC CH0 MUX to VSS.

2: CTMUI connects to the output of the ADC CH0 MUX. When CTMU current is steered into this node, the current will flow out through the selected ADC channel determined by the CH0 MUX (see the CH0Sx bits in the AD1CHS0 register).

3: CTMU TEMP connects to one of the ADC CH0 inputs; see CH0SA and CH0SB (AD1CHS0<12:8,4:0).

4: If TGEN = 1 and EDG1STAT = EDG2STAT, CTMU current source is still enabled and may be shunted to VSS internally. This should be considered in low-power applications.

5: The switch connected to ADC CH0 is closed when IDISSEN (CTMUCON1<9>) = 1, and opened when IDISSEN = 0.

22.1 CTMU Resources

Many useful resources are provided on the main product page of the Microchip web site for the devices listed in this data sheet. This product page, which can be accessed using this link, contains the latest updates and additional information.

Note: In the event you are not able to access the product page using the link above, enter this URL in your browser: http://www.microchip.com/wwwproducts/Devices.aspx?dDocName=en555464

22.1.1 KEY RESOURCES

- **"Charge Time Measurement Unit (CTMU)"** (DS70661) in the *"dsPIC33/PIC24 Family Reference Manual"*
- Code Samples
- Application Notes
- Software Libraries
- Webinars
- All Related *"dsPIC33/PIC24 Family Reference Manual"* Sections
- Development Tools

24.3 PTG Control Registers

REGISTER 24-1: PTGCST: PTG CONTROL/STATUS REGISTER

R/W-0	U-0	R/W-0	R/W-0	U-0	R/W-0	R/W-0	R/W-0
PTGEN	—	PTGSIDL	PTGTOGL	—	PTGSWT(2)	PTGSSEN(3)	PTGIVIS
bit 15							bit 8

R/W-0	HS-0	U-0	U-0	U-0	U-0	R/W-0	
PTGSTRT	PTGWDTO	—	—	—	—	PTGITM1(1)	PTGITM0(1)
bit 7							bit 0

Legend:	HS = Hardware Settable bit		
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 15 **PTGEN:** Module Enable bit
1 = PTG module is enabled
0 = PTG module is disabled

bit 14 **Unimplemented:** Read as '0'

bit 13 **PTGSIDL:** PTG Stop in Idle Mode bit
1 = Discontinues module operation when device enters Idle mode
0 = Continues module operation in Idle mode

bit 12 **PTGTOGL:** PTG TRIG Output Toggle Mode bit
1 = Toggle state of the PTGOx for each execution of the PTGTRIG command
0 = Each execution of the PTGTRIG command will generate a single PTGOx pulse determined by the value in the PTGPWDx bits

bit 11 **Unimplemented:** Read as '0'

bit 10 **PTGSWT:** PTG Software Trigger bit(2)
1 = Triggers the PTG module
0 = No action (clearing this bit will have no effect)

bit 9 **PTGSSEN:** PTG Enable Single-Step bit(3)
1 = Enables Single-Step mode
0 = Disables Single-Step mode

bit 8 **PTGIVIS:** PTG Counter/Timer Visibility Control bit
1 = Reads of the PTGSDLIM, PTGCxLIM or PTGTxLIM registers return the current values of their corresponding counter/timer registers (PTGSD, PTGCx, PTGTx)
0 = Reads of the PTGSDLIM, PTGCxLIM or PTGTxLIM registers return the value previously written to those limit registers

bit 7 **PTGSTRT:** PTG Start Sequencer bit
1 = Starts to sequentially execute commands (Continuous mode)
0 = Stops executing commands

bit 6 **PTGWDTO:** PTG Watchdog Timer Time-out Status bit
1 = PTG Watchdog Timer has timed out
0 = PTG Watchdog Timer has not timed out.

bit 5-2 **Unimplemented:** Read as '0'

Note 1: These bits apply to the PTGWHI and PTGWLO commands only.
2: This bit is only used with the PTGCTRL step command software trigger option.
3: Use of the PTG Single-Step mode is reserved for debugging tools only.

FIGURE 30-12: QEA/QEB INPUT CHARACTERISTICS (dsPIC33EPXXXMC20X/50X and PIC24EPXXXMC20X DEVICES ONLY)

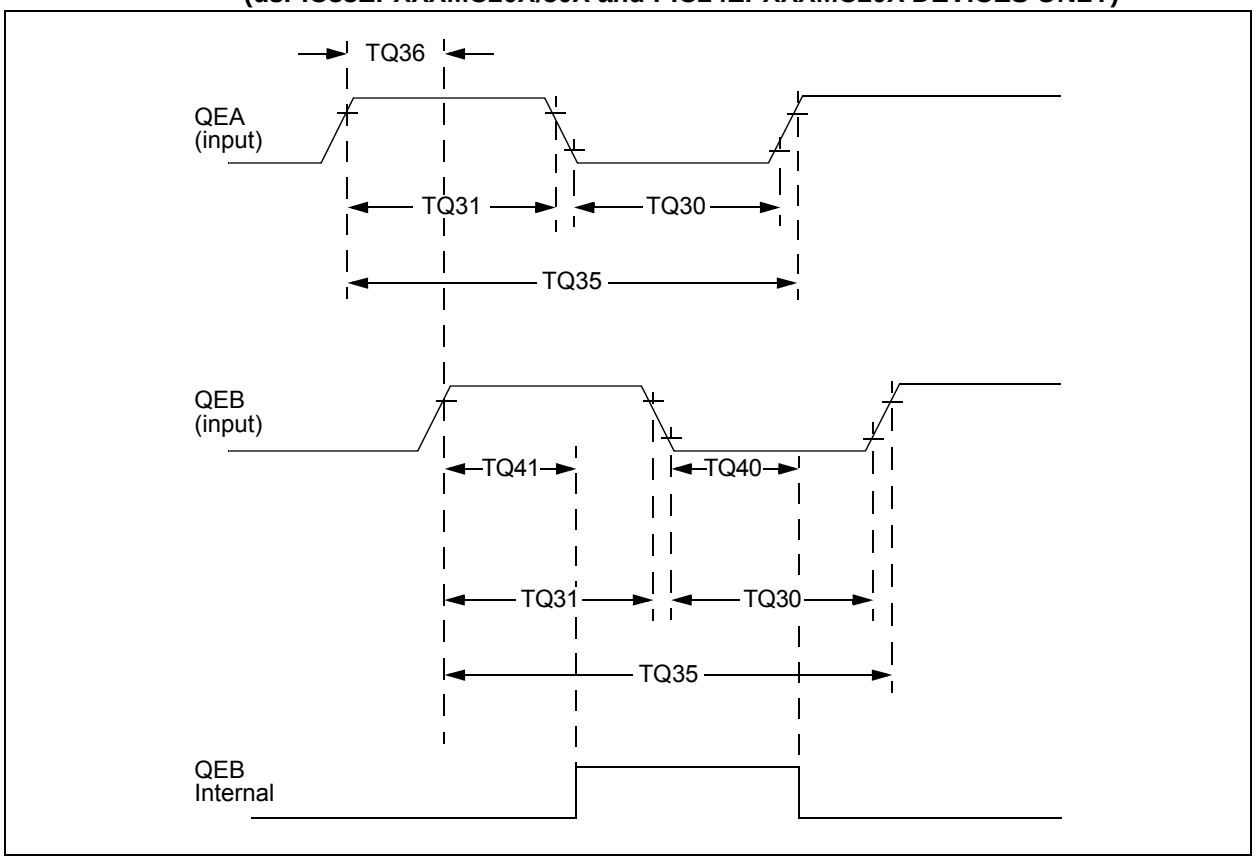


TABLE 30-31: QUADRATURE DECODER TIMING REQUIREMENTS (dsPIC33EPXXXMC20X/50X and PIC24EPXXXMC20X DEVICES ONLY)

AC CHARACTERISTICS			Standard Operating Conditions: 3.0V to 3.6V (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended			
Param No.	**Symbol**	**Characteristic(1)**	**Typ.(2)**	**Max.**	**Units**	**Conditions**
TQ30	TQUL	Quadrature Input Low Time	6 TCY	—	ns	
TQ31	TQUH	Quadrature Input High Time	6 TCY	—	ns	
TQ35	TQUIN	Quadrature Input Period	12 TCY	—	ns	
TQ36	TQUP	Quadrature Phase Period	3 TCY	—	ns	
TQ40	TQUFL	Filter Time to Recognize Low, with Digital Filter	3 * N * TCY	—	ns	N = 1, 2, 4, 16, 32, 64, 128 and 256 **(Note 3)**
TQ41	TQUFH	Filter Time to Recognize High, with Digital Filter	3 * N * TCY	—	ns	N = 1, 2, 4, 16, 32, 64, 128 and 256 **(Note 3)**

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

2: Data in "Typical" column is at 3.3V, +25°C unless otherwise stated. Parameters are for design guidance only and are not tested.

3: N = Index Channel Digital Filter Clock Divide Select bits. Refer to **"Quadrature Encoder Interface (QEI)"** (DS70601) in the "*dsPIC33/PIC24 Family Reference Manual*". Please see the Microchip web site for the latest family reference manual sections.

FIGURE 30-29: SPI1 SLAVE MODE (FULL-DUPLEX, CKE = 0, CKP = 0, SMP = 0) TIMING CHARACTERISTICS

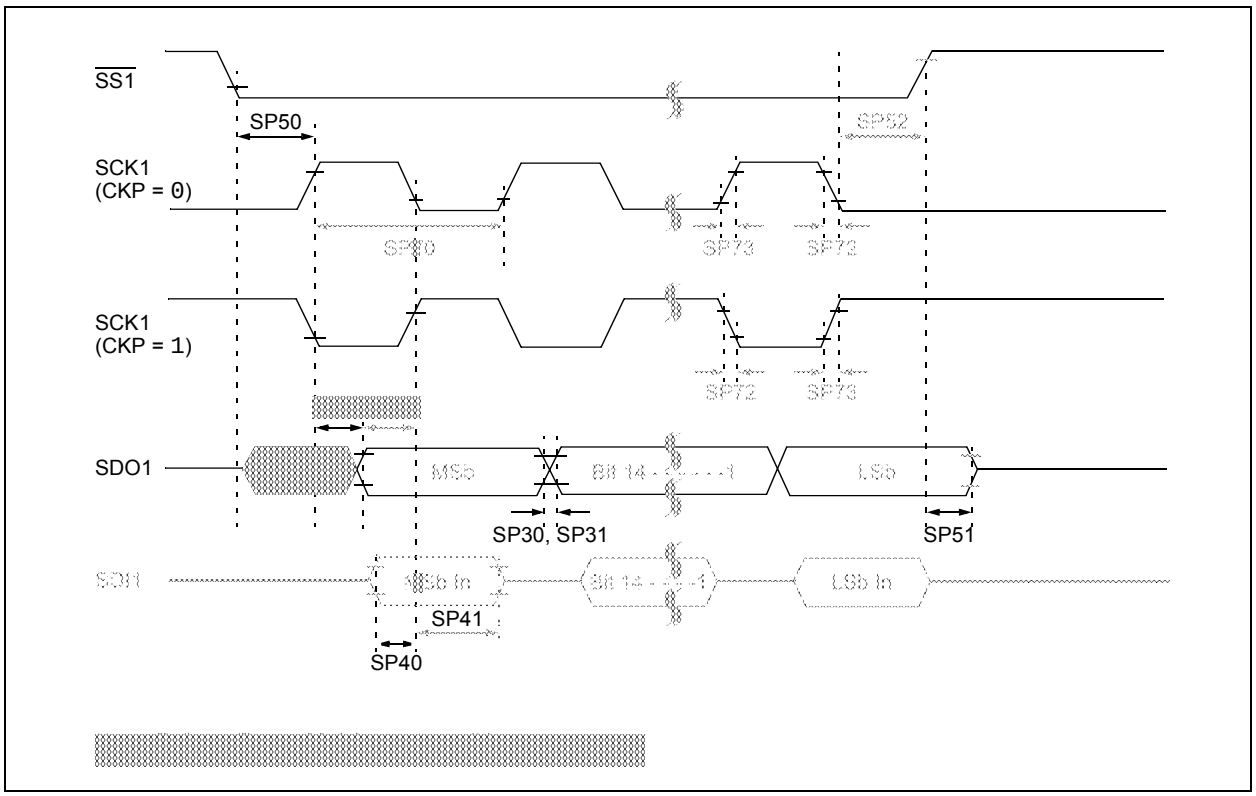
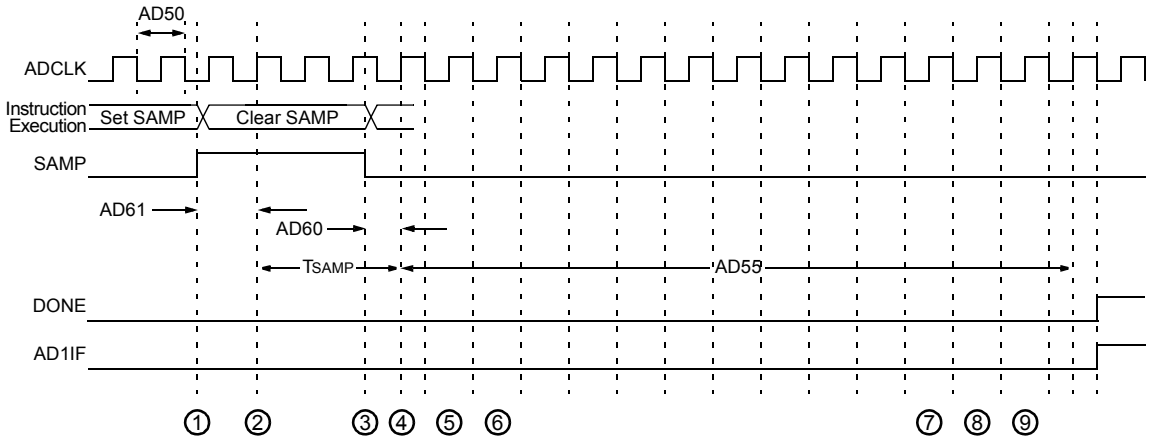


FIGURE 30-36: ADC CONVERSION (12-BIT MODE) TIMING CHARACTERISTICS (ASAM = 0, SSRC<2:0> = 000, SSRCG = 0)



① – Software sets AD1CON1. SAMP to start sampling.

② – Sampling starts after discharge period. TSAMP is described in **"Analog-to-Digital Converter (ADC)"** (DS70621) in the *"dsPIC33/PIC24 Family Reference Manual"*.

③ – Software clears AD1CON1. SAMP to start conversion.

④ – Sampling ends, conversion sequence starts.

⑤ – Convert bit 11.

⑥ – Convert bit 10.

⑦ – Convert bit 1.

⑧ – Convert bit 0.

⑨ – One TAD for end of conversion.

TABLE 31-11: INTERNAL RC ACCURACY

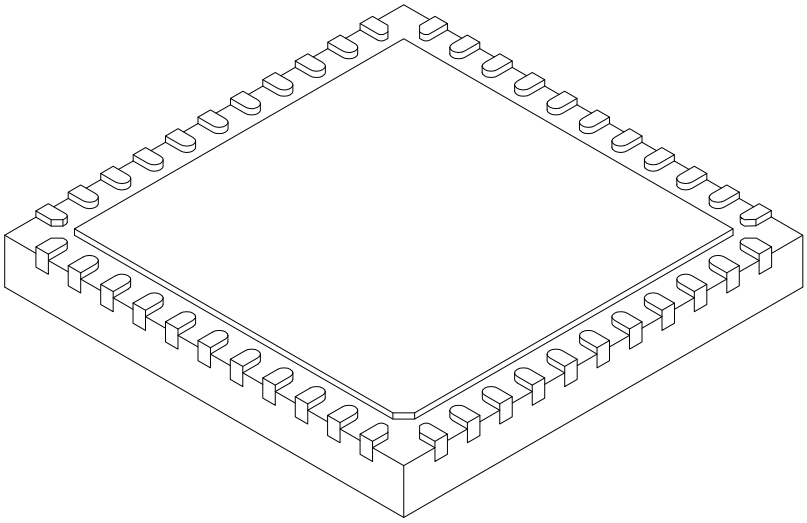
AC CHARACTERISTICS		Standard Operating Conditions: 3.0V to 3.6V (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +150°C					
Param No.	Characteristic	Min	Typ	Max	Units	Conditions	
	LPRC @ 32.768 kHz(1,2)						
HF21	LPRC	-30	—	+30	%	-40°C ≤ TA ≤ +150°C	VDD = 3.0-3.6V

Note 1: Change of LPRC frequency as VDD changes.

2: LPRC accuracy impacts the Watchdog Timer Time-out Period (TWDT). See **Section 27.5 "Watchdog Timer (WDT)"** for more information.

44-Lead Plastic Quad Flat, No Lead Package (ML) - 8x8 mm Body [QFN]

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



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		44	
Pitch	e		0.65 BSC	
Overall Height	A	0.80	0.90	1.00
Standoff	A1	0.00	0.02	0.05
Terminal Thickness	A3		0.20 REF	
Overall Width	E		8.00 BSC	
Exposed Pad Width	E2	6.25	6.45	6.60
Overall Length	D		8.00 BSC	
Exposed Pad Length	D2	6.25	6.45	6.60
Terminal Width	b	0.20	0.30	0.35
Terminal Length	L	0.30	0.40	0.50
Terminal-to-Exposed-Pad	K	0.20	-	-

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package is saw singulated
3. 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 C04-103C Sheet 2 of 2

Revision C (December 2011)

This revision includes typographical and formatting changes throughout the data sheet text.

In addition, where applicable, new sections were added to each peripheral chapter that provide information and links to related resources, as well as helpful tips. For examples, see **Section 20.1 "UART Helpful Tips"** and **Section 3.6 "CPU Resources"**.

All occurrences of TLA were updated to VTLA throughout the document, with the exception of the pin diagrams (updated diagrams were not available at time of publication).

A new chapter, **Section 31.0 "DC and AC Device Characteristics Graphs"**, was added.

All other major changes are referenced by their respective section in Table A-2.

TABLE A-2: MAJOR SECTION UPDATES

Section Name	Update Description
"16-bit Microcontrollers and Digital Signal Controllers (up to 256-Kbyte Flash and 32-Kbyte SRAM) with High-Speed PWM, Op amps, and Advanced Analog"	The content on the first page of this section was extensively reworked to provide the reader with the key features and functionality of this device family in an "at-a-glance" format.
Section 1.0 "Device Overview"	Updated the dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X, and PIC24EPXXXGP/MC20X Block Diagram (see Figure 1-1), which now contains a CPU block and a reference to the CPU diagram. Updated the description and Note references in the Pinout I/O Descriptions for these pins: C1IN2-, C2IN2-, C3IN2-, OA1OUT, OA2OUT, and OA3OUT (see Table 1-1).
Section 2.0 "Guidelines for Getting Started with 16-bit Digital Signal Controllers and Microcontrollers"	Updated the Recommended Minimum Connection diagram (see Figure 2-1).
Section 3.0 "CPU"	Updated the dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X, and PIC24EPXXXGP/MC20X CPU Block Diagram (see Figure 3-1). Updated the Status register definition in the Programmer's Model (see Figure 3-2).
Section 4.0 "Memory Organization"	Updated the Data Memory Maps (see Figure 4-6 and Figure 4-11). Removed the DCB<1:0> bits from the OC1CON2, OC2CON2, OC3CON2, and OC4CON2 registers in the Output Compare 1 Through Output Compare 4 Register Map (see Table 4-10). Added the TRIG1 and TRGCON1 registers to the PWM Generator 1 Register Map (see Table 4-13). Added the TRIG2 and TRGCON2 registers to the PWM Generator 2 Register Map (see Table 4-14). Added the TRIG3 and TRGCON3 registers to the PWM Generator 3 Register Map (see Table 4-15). Updated the second note in **Section 4.7.1 "Bit-Reversed Addressing Implementation"**.
Section 8.0 "Direct Memory Access (DMA)"	Updated the DMA Controller diagram (see Figure 8-1).
Section 14.0 "Input Capture"	Updated the bit values for the ICx clock source of the ICTSEL<12:10> bits in the ICxCON1 register (see Register 14-1).
Section 15.0 "Output Compare"	Updated the bit values for the OCx clock source of the OCTSEL<2:0> bits in the OCxCON1 register (see Register 15-1). Removed the DCB<1:0> bits from the Output Compare x Control Register 2 (see Register 15-2).