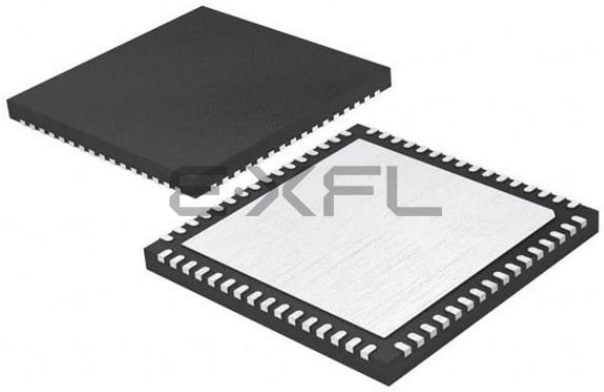

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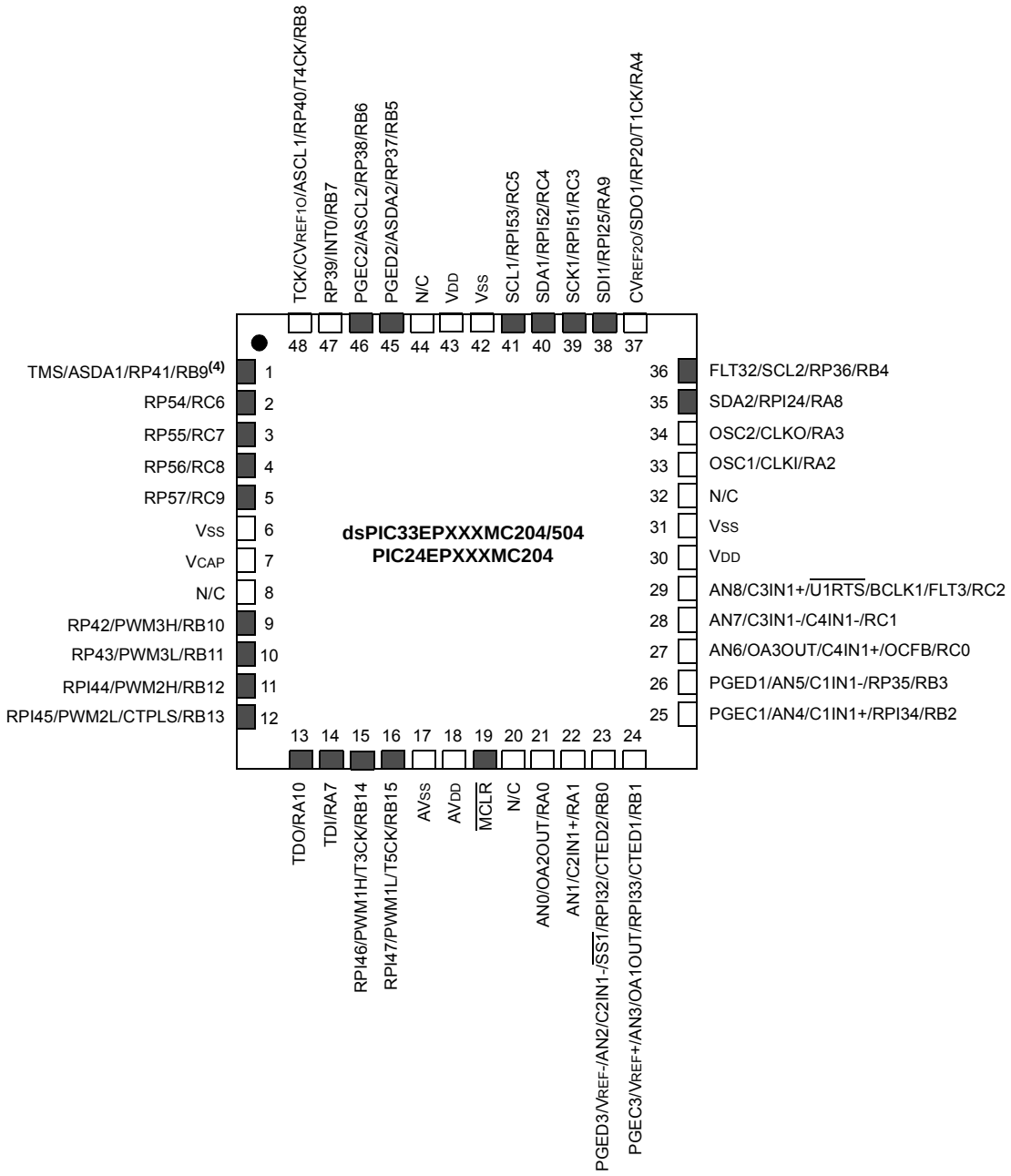
Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	PIC
Core Size	16-Bit
Speed	70 MIPs
Connectivity	I²C, IrDA, LINbus, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, DMA, POR, PWM, WDT
Number of I/O	53
Program Memory Size	64KB (22K x 24)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	4K x 16
Voltage - Supply (Vcc/Vdd)	3V ~ 3.6V
Data Converters	A/D 16x10b/12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	64-VFQFN Exposed Pad
Supplier Device Package	64-VQFN (9x9)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic24ep64gp206-i-mr

Pin Diagrams (Continued)

48-Pin UQFN(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.

REGISTER 3-1: SR: CPU STATUS REGISTER (CONTINUED)

bit 7-5 **IPL<2:0>:** CPU Interrupt Priority Level Status bits(2,3)
111 = CPU Interrupt Priority Level is 7 (15); user interrupts are disabled
110 = CPU Interrupt Priority Level is 6 (14)
101 = CPU Interrupt Priority Level is 5 (13)
100 = CPU Interrupt Priority Level is 4 (12)
011 = CPU Interrupt Priority Level is 3 (11)
010 = CPU Interrupt Priority Level is 2 (10)
001 = CPU Interrupt Priority Level is 1 (9)
000 = CPU Interrupt Priority Level is 0 (8)

bit 4 **RA:** REPEAT Loop Active bit
1 = REPEAT loop in progress
0 = REPEAT loop not in progress

bit 3 **N:** MCU ALU Negative bit
1 = Result was negative
0 = Result was non-negative (zero or positive)

bit 2 **OV:** MCU ALU Overflow bit
This bit is used for signed arithmetic (2's complement). It indicates an overflow of the magnitude that causes the sign bit to change state.
1 = Overflow occurred for signed arithmetic (in this arithmetic operation)
0 = No overflow occurred

bit 1 **Z:** MCU ALU Zero bit
1 = An operation that affects the Z bit has set it at some time in the past
0 = The most recent operation that affects the Z bit has cleared it (i.e., a non-zero result)

bit 0 **C:** MCU ALU Carry/$\overline{\text{Borrow}}$ bit
1 = A carry-out from the Most Significant bit of the result occurred
0 = No carry-out from the Most Significant bit of the result occurred

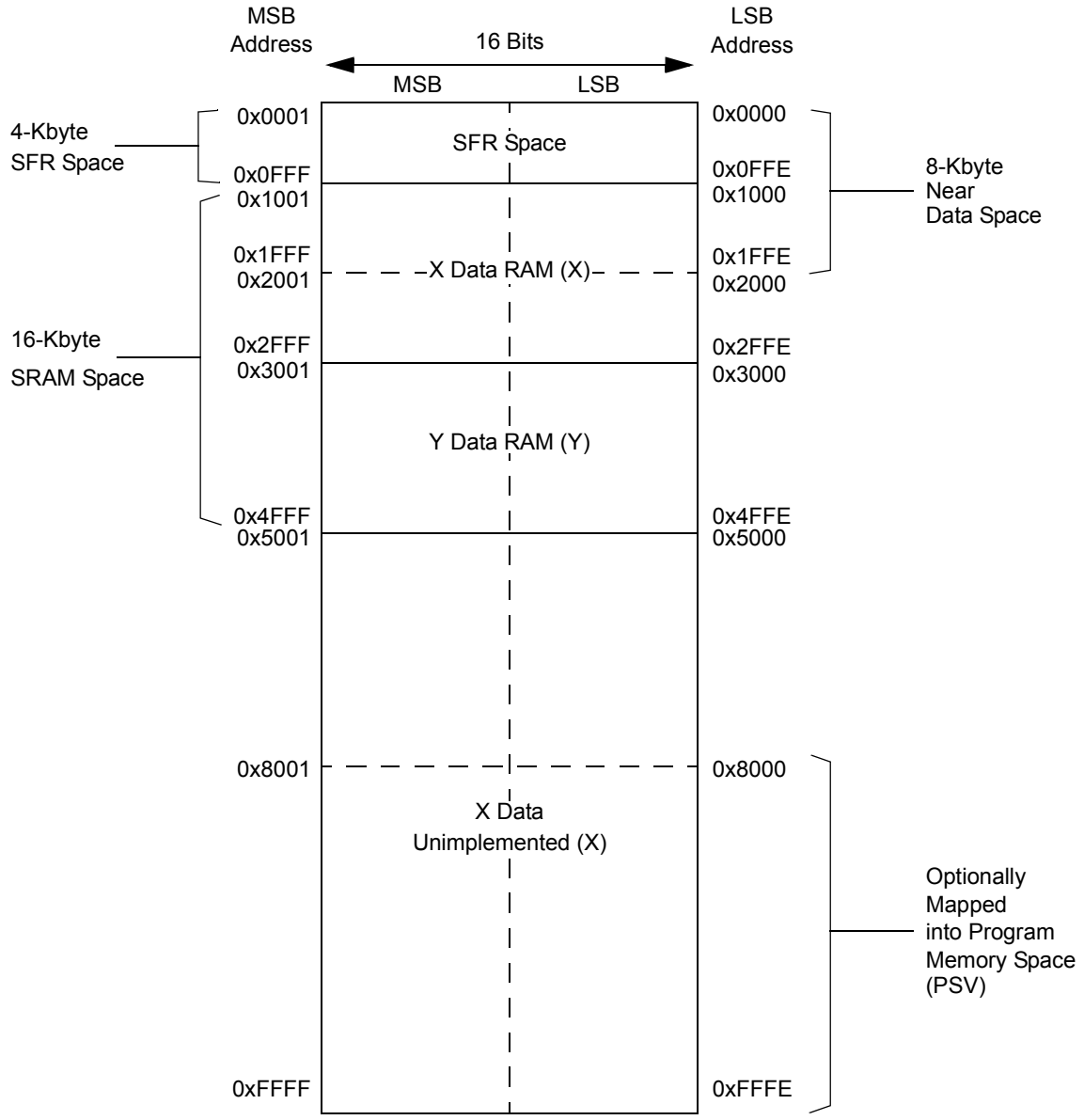
Note 1: This bit is available on dsPIC33EPXXXMC20X/50X and dsPIC33EPXXXGP50X devices only.

2: The IPL<2:0> bits are concatenated with the IPL<3> bit (CORCON<3>) to form the CPU Interrupt Priority Level. The value in parentheses indicates the IPL, if IPL<3> = 1. User interrupts are disabled when IPL<3> = 1.

3: The IPL<2:0> Status bits are read-only when the NSTDIS bit (INTCON1<15>) = 1.

4: A data write to the SR register can modify the SA and SB bits by either a data write to SA and SB or by clearing the SAB bit. To avoid a possible SA or SB bit write race condition, the SA and SB bits should not be modified using bit operations.

FIGURE 4-9: DATA MEMORY MAP FOR dsPIC33EP128MC20X/50X AND dsPIC33EP128GP50X DEVICES



Note: Memory areas are not shown to scale.

TABLE 4-3: INTERRUPT CONTROLLER REGISTER MAP FOR PIC24EPXXXGP20X 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
IFS0	0800	—	DMA1IF	AD1IF	U1TXIF	U1RXIF	SPI1IF	SPI1EIF	T3IF	T2IF	OC2IF	IC2IF	DMA0IF	T1IF	OC1IF	IC1IF	INT0IF	0000
IFS1	0802	U2TXIF	U2RXIF	INT2IF	T5IF	T4IF	OC4IF	OC3IF	DMA2IF	—	—	—	INT1IF	CNIF	CMIF	MI2C1IF	SI2C1IF	0000
IFS2	0804	—	—	—	—	—	—	—	—	—	IC4IF	IC3IF	DMA3IF	—	—	SPI2IF	SPI2EIF	0000
IFS3	0806	—	—	—	—	—	—	—	—	—	—	—	—	—	MI2C2IF	SI2C2IF	—	0000
IFS4	0808	—	—	CTMUIF	—	—	—	—	—	—	—	—	—	CRCIF	U2EIF	U1EIF	—	0000
IFS8	0810	JTAGIF	ICDIF	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0000
IFS9	0812	—	—	—	—	—	—	—	—	—	PTG3IF	PTG2IF	PTG1IF	PTG0IF	PTGWDTIF	PTGSTEPIF	—	0000
IEC0	0820	—	DMA1IE	AD1IE	U1TXIE	U1RXIE	SPI1IE	SPI1EIE	T3IE	T2IE	OC2IE	IC2IE	DMA0IE	T1IE	OC1IE	IC1IE	INT0IE	0000
IEC1	0822	U2TXIE	U2RXIE	INT2IE	T5IE	T4IE	OC4IE	OC3IE	DMA2IE	—	—	—	INT1IE	CNIE	CMIE	MI2C1IE	SI2C1IE	0000
IEC2	0824	—	—	—	—	—	—	—	—	—	IC4IE	IC3IE	DMA3IE	—	—	SPI2IE	SPI2EIE	0000
IEC3	0826	—	—	—	—	—	—	—	—	—	—	—	—	—	MI2C2IE	SI2C2IE	—	0000
IEC4	0828	—	—	CTMUIE	—	—	—	—	—	—	—	—	—	CRCIE	U2EIE	U1EIE	—	0000
IEC8	0830	JTAGIE	ICDIE	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0000
IEC9	0832	—	—	—	—	—	—	—	—	—	PTG3IE	PTG2IE	PTG1IE	PTG0IE	PTGWDTIE	PTGSTEPIE	—	0000
IPC0	0840	—	T1IP<2:0>			—	OC1IP<2:0>			—	IC1IP<2:0>			—	INT0IP<2:0>			4444
IPC1	0842	—	T2IP<2:0>			—	OC2IP<2:0>			—	IC2IP<2:0>			—	DMA0IP<2:0>			4444
IPC2	0844	—	U1RXIP<2:0>			—	SPI1IP<2:0>			—	SPI1EIP<2:0>			—	T3IP<2:0>			4444
IPC3	0846	—	—	—	—	—	DMA1IP<2:0>			—	AD1IP<2:0>			—	U1TXIP<2:0>			0444
IPC4	0848	—	CNIP<2:0>			—	CMIP<2:0>			—	MI2C1IP<2:0>			—	SI2C1IP<2:0>			4444
IPC5	084A	—	—	—	—	—	—	—	—	—	—	—	—	—	INT1IP<2:0>			0004
IPC6	084C	—	T4IP<2:0>			—	OC4IP<2:0>			—	OC3IP<2:0>			—	DMA2IP<2:0>			4444
IPC7	084E	—	U2TXIP<2:0>			—	U2RXIP<2:0>			—	INT2IP<2:0>			—	T5IP<2:0>			4444
IPC8	0850	—	—	—	—	—	—	—	—	—	SPI2IP<2:0>			—	SPI2EIP<2:0>			0044
IPC9	0852	—	—	—	—	—	IC4IP<2:0>			—	IC3IP<2:0>			—	DMA3IP<2:0>			0444
IPC12	0858	—	—	—	—	—	MI2C2IP<2:0>			—	SI2C2IP<2:0>			—	—	—	—	0440
IPC16	0860	—	CRCIP<2:0>			—	U2EIP<2:0>			—	U1EIP<2:0>			—	—	—	—	4440
IPC19	0866	—	—	—	—	—	—	—	—	—	CTMUIP<2:0>			—	—	—	—	0040
IPC35	0886	—	JTAGIP<2:0>			—	ICDIP<2:0>			—	—	—	—	—	—	—	—	4400
IPC36	0888	—	PTG0IP<2:0>			—	PTGWDTIP<2:0>			—	PTGSTEPIP<2:0>			—	—	—	—	4440
IPC37	088A	—	—	—	—	—	PTG3IP<2:0>			—	PTG2IP<2:0>			—	PTG1IP<2:0>			0444
INTCON1	08C0	NSTDIS	OVAERR	OVBERR	—	—	—	—	—	—	DIV0ERR	DMACERR	MATHERR	ADDRERR	STKERR	OSCFAIL	—	0000
INTCON2	08C2	GIE	DISI	SWTRAP	—	—	—	—	—	—	—	—	—	—	INT2EP	INT1EP	INT0EP	8000
INTCON3	08C4	—	—	—	—	—	—	—	—	—	—	DAE	DOOVR	—	—	—	—	0000
INTCON4	08C6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	SGHT	0000
INTTREG	08C8	—	—	—	—	ILR<3:0>				VECNUM<7:0>								0000

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

TABLE 7-1: INTERRUPT VECTOR DETAILS

Interrupt Source	Vector #	IRQ #	IVT Address	Interrupt Bit Location		
				Flag	Enable	Priority
Highest Natural Order Priority						
INT0 – External Interrupt 0	8	0	0x000014	IFS0<0>	IEC0<0>	IPC0<2:0>
IC1 – Input Capture 1	9	1	0x000016	IFS0<1>	IEC0<1>	IPC0<6:4>
OC1 – Output Compare 1	10	2	0x000018	IFS0<2>	IEC0<2>	IPC0<10:8>
T1 – Timer1	11	3	0x00001A	IFS0<3>	IEC0<3>	IPC0<14:12>
DMA0 – DMA Channel 0	12	4	0x00001C	IFS0<4>	IEC0<4>	IPC1<2:0>
IC2 – Input Capture 2	13	5	0x00001E	IFS0<5>	IEC0<5>	IPC1<6:4>
OC2 – Output Compare 2	14	6	0x000020	IFS0<6>	IEC0<6>	IPC1<10:8>
T2 – Timer2	15	7	0x000022	IFS0<7>	IEC0<7>	IPC1<14:12>
T3 – Timer3	16	8	0x000024	IFS0<8>	IEC0<8>	IPC2<2:0>
SPI1E – SPI1 Error	17	9	0x000026	IFS0<9>	IEC0<9>	IPC2<6:4>
SPI1 – SPI1 Transfer Done	18	10	0x000028	IFS0<10>	IEC0<10>	IPC2<10:8>
U1RX – UART1 Receiver	19	11	0x00002A	IFS0<11>	IEC0<11>	IPC2<14:12>
U1TX – UART1 Transmitter	20	12	0x00002C	IFS0<12>	IEC0<12>	IPC3<2:0>
AD1 – ADC1 Convert Done	21	13	0x00002E	IFS0<13>	IEC0<13>	IPC3<6:4>
DMA1 – DMA Channel 1	22	14	0x000030	IFS0<14>	IEC0<14>	IPC3<10:8>
Reserved	23	15	0x000032	—	—	—
SI2C1 – I2C1 Slave Event	24	16	0x000034	IFS1<0>	IEC1<0>	IPC4<2:0>
MI2C1 – I2C1 Master Event	25	17	0x000036	IFS1<1>	IEC1<1>	IPC4<6:4>
CM – Comparator Combined Event	26	18	0x000038	IFS1<2>	IEC1<2>	IPC4<10:8>
CN – Input Change Interrupt	27	19	0x00003A	IFS1<3>	IEC1<3>	IPC4<14:12>
INT1 – External Interrupt 1	28	20	0x00003C	IFS1<4>	IEC1<4>	IPC5<2:0>
Reserved	29-31	21-23	0x00003E-0x000042	—	—	—
DMA2 – DMA Channel 2	32	24	0x000044	IFS1<8>	IEC1<8>	IPC6<2:0>
OC3 – Output Compare 3	33	25	0x000046	IFS1<9>	IEC1<9>	IPC6<6:4>
OC4 – Output Compare 4	34	26	0x000048	IFS1<10>	IEC1<10>	IPC6<10:8>
T4 – Timer4	35	27	0x00004A	IFS1<11>	IEC1<11>	IPC6<14:12>
T5 – Timer5	36	28	0x00004C	IFS1<12>	IEC1<12>	IPC7<2:0>
INT2 – External Interrupt 2	37	29	0x00004E	IFS1<13>	IEC1<13>	IPC7<6:4>
U2RX – UART2 Receiver	38	30	0x000050	IFS1<14>	IEC1<14>	IPC7<10:8>
U2TX – UART2 Transmitter	39	31	0x000052	IFS1<15>	IEC1<15>	IPC7<14:12>
SPI2E – SPI2 Error	40	32	0x000054	IFS2<0>	IEC2<0>	IPC8<2:0>
SPI2 – SPI2 Transfer Done	41	33	0x000056	IFS2<1>	IEC2<1>	IPC8<6:4>
C1RX – CAN1 RX Data Ready(1)	42	34	0x000058	IFS2<2>	IEC2<2>	IPC8<10:8>
C1 – CAN1 Event(1)	43	35	0x00005A	IFS2<3>	IEC2<3>	IPC8<14:12>
DMA3 – DMA Channel 3	44	36	0x00005C	IFS2<4>	IEC2<4>	IPC9<2:0>
IC3 – Input Capture 3	45	37	0x00005E	IFS2<5>	IEC2<5>	IPC9<6:4>
IC4 – Input Capture 4	46	38	0x000060	IFS2<6>	IEC2<6>	IPC9<10:8>
Reserved	47-56	39-48	0x000062-0x000074	—	—	—
SI2C2 – I2C2 Slave Event	57	49	0x000076	IFS3<1>	IEC3<1>	IPC12<6:4>
MI2C2 – I2C2 Master Event	58	50	0x000078	IFS3<2>	IEC3<2>	IPC12<10:8>
Reserved	59-64	51-56	0x00007A-0x000084	—	—	—
PSEM – PWM Special Event Match(2)	65	57	0x000086	IFS3<9>	IEC3<9>	IPC14<6:4>

Note 1: This interrupt source is available on dsPIC33EPXXXGP50X and dsPIC33EPXXXMC50X devices only.

2: This interrupt source is available on dsPIC33EPXXXMC20X/50X and PIC24EPXXXMC20X devices only.

10.3 Doze Mode

The preferred strategies for reducing power consumption are changing clock speed and invoking one of the power-saving modes. In some circumstances, this cannot be practical. For example, it may be necessary for an application to maintain uninterrupted synchronous communication, even while it is doing nothing else. Reducing system clock speed can introduce communication errors, while using a power-saving mode can stop communications completely.

Doze mode is a simple and effective alternative method to reduce power consumption while the device is still executing code. In this mode, the system clock continues to operate from the same source and at the same speed. Peripheral modules continue to be clocked at the same speed, while the CPU clock speed is reduced. Synchronization between the two clock domains is maintained, allowing the peripherals to access the SFRs while the CPU executes code at a slower rate.

Doze mode is enabled by setting the DOZEN bit (CLKDIV<11>). The ratio between peripheral and core clock speed is determined by the DOZE<2:0> bits (CLKDIV<14:12>). There are eight possible configurations, from 1:1 to 1:128, with 1:1 being the default setting.

Programs can use Doze mode to selectively reduce power consumption in event-driven applications. This allows clock-sensitive functions, such as synchronous communications, to continue without interruption while the CPU Idles, waiting for something to invoke an interrupt routine. An automatic return to full-speed CPU operation on interrupts can be enabled by setting the ROI bit (CLKDIV<15>). By default, interrupt events have no effect on Doze mode operation.

For example, suppose the device is operating at 20 MIPS and the ECAN™ module has been configured for 500 kbps, based on this device operating speed. If the device is placed in Doze mode with a clock frequency ratio of 1:4, the ECAN module continues to communicate at the required bit rate of 500 kbps, but the CPU now starts executing instructions at a frequency of 5 MIPS.

10.4 Peripheral Module Disable

The Peripheral Module Disable (PMD) registers provide a method to disable a peripheral module by stopping all clock sources supplied to that module. When a peripheral is disabled using the appropriate PMD control bit, the peripheral is in a minimum power consumption state. The control and status registers associated with the peripheral are also disabled, so writes to those registers do not have effect and read values are invalid.

A peripheral module is enabled only if both the associated bit in the PMD register is cleared and the peripheral is supported by the specific dsPIC® DSC variant. If the peripheral is present in the device, it is enabled in the PMD register by default.

Note:	If a PMD bit is set, the corresponding module is disabled after a delay of one instruction cycle. Similarly, if a PMD bit is cleared, the corresponding module is enabled after a delay of one instruction cycle (assuming the module control registers are already configured to enable module operation).

10.5 Power-Saving 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

10.5.1 KEY RESOURCES

- **"Watchdog Timer and Power-Saving Modes"** (DS70615) in the *"dsPIC33/PIC24 Family Reference Manual"*
- Code Samples
- Application Notes
- Software Libraries
- Webinars
- All Related *"dsPIC33/PIC24 Family Reference Manual"* Sections
- Development Tools

NOTES:

REGISTER 17-10: INDX1HLD: INDEX COUNTER 1 HOLD REGISTER

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
INDXHLD<15:8>							
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
INDXHLD<7:0>							
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 15-0 **INDXHLD<15:0>:** Hold Register for Reading and Writing INDX1CNTH bits

REGISTER 17-11: QEI1ICH: QEI1 INITIALIZATION/CAPTURE HIGH WORD REGISTER

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
QEIIC<31:24>							
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
QEIIC<23:16>							
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 **QEIIC<31:16>:** High Word Used to Form 32-Bit Initialization/Capture Register (QEI1IC) bits

REGISTER 17-12: QEI1ICL: QEI1 INITIALIZATION/CAPTURE LOW WORD REGISTER

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
QEIIC<15:8>							
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
QEIIC<7:0>							
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 15-0 **QEIIC<15:0>:** Low Word Used to Form 32-Bit Initialization/Capture Register (QEI1IC) bits

REGISTER 17-17: INT1TMRH: INTERVAL 1 TIMER HIGH WORD REGISTER

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
INTTMR<31:24>							
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
INTTMR<23:16>							
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 **INTTMR<31:16>:** High Word Used to Form 32-Bit Interval Timer Register (INT1TMR) bits

REGISTER 17-18: INT1TMRL: INTERVAL 1 TIMER LOW WORD REGISTER

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
INTTMR<15:8>							
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
INTTMR<7:0>							
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 15-0 **INTTMR<15:0>:** Low Word Used to Form 32-Bit Interval Timer Register (INT1TMR) bits

REGISTER 21-10: CxCFG2: ECANx BAUD RATE CONFIGURATION REGISTER 2

U-0	R/W-x	U-0	U-0	U-0	R/W-x	R/W-x	R/W-x
—	WAKFIL	—	—	—	SEG2PH2	SEG2PH1	SEG2PH0
bit 15							bit 8

R/W-x	R/W-x	R/W-x	R/W-x	R/W-x	R/W-x	R/W-x	R/W-x
SEG2PHTS	SAM	SEG1PH2	SEG1PH1	SEG1PH0	PRSEG2	PRSEG1	PRSEG0
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 **Unimplemented:** Read as '0'

bit 14 **WAKFIL:** Select CAN Bus Line Filter for Wake-up bit
1 = Uses CAN bus line filter for wake-up
0 = CAN bus line filter is not used for wake-up

bit 13-11 **Unimplemented:** Read as '0'

bit 10-8 **SEG2PH<2:0>:** Phase Segment 2 bits
111 = Length is 8 x TQ
•
•
•
000 = Length is 1 x TQ

bit 7 **SEG2PHTS:** Phase Segment 2 Time Select bit
1 = Freely programmable
0 = Maximum of SEG1PHx bits or Information Processing Time (IPT), whichever is greater

bit 6 **SAM:** Sample of the CAN Bus Line bit
1 = Bus line is sampled three times at the sample point
0 = Bus line is sampled once at the sample point

bit 5-3 **SEG1PH<2:0>:** Phase Segment 1 bits
111 = Length is 8 x TQ
•
•
•
000 = Length is 1 x TQ

bit 2-0 **PRSEG<2:0>:** Propagation Time Segment bits
111 = Length is 8 x TQ
•
•
•
000 = Length is 1 x TQ

23.4 ADC Control Registers

REGISTER 23-1: AD1CON1: ADC1 CONTROL REGISTER 1

R/W-0	U-0	R/W-0	R/W-0	U-0	R/W-0	R/W-0	R/W-0
ADON	—	ADSIDL	ADDMABM	—	AD12B	FORM1	FORM0
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, HC, HS	R/C-0, HC, HS
SSRC2	SSRC1	SSRC0	SSRCG	SIMSAM	ASAM	SAMP	DONE(3)
bit 7							bit 0

Legend:	HC = Hardware Clearable bit	HS = Hardware Settable bit	C = Clearable 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 **ADON:** ADC1 Operating Mode bit
1 = ADC module is operating
0 = ADC is off

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

bit 13 **ADSIDL:** ADC1 Stop in Idle Mode bit
1 = Discontinues module operation when device enters Idle mode
0 = Continues module operation in Idle mode

bit 12 **ADDMABM:** DMA Buffer Build Mode bit
1 = DMA buffers are written in the order of conversion; the module provides an address to the DMA channel that is the same as the address used for the non-DMA stand-alone buffer
0 = DMA buffers are written in Scatter/Gather mode; the module provides a Scatter/Gather address to the DMA channel, based on the index of the analog input and the size of the DMA buffer.

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

bit 10 **AD12B:** ADC1 10-Bit or 12-Bit Operation Mode bit
1 = 12-bit, 1-channel ADC operation
0 = 10-bit, 4-channel ADC operation

bit 9-8 **FORM<1:0>:** Data Output Format bits
For 10-Bit Operation:
11 = Signed fractional (DOUT = sddd dddd dd00 0000, where s = .NOT.d<9>)
10 = Fractional (DOUT = dddd dddd dd00 0000)
01 = Signed integer (DOUT = ssss sssd dddd dddd, where s = .NOT.d<9>)
00 = Integer (DOUT = 0000 00dd dddd dddd)
For 12-Bit Operation:
11 = Signed fractional (DOUT = sddd dddd dddd 0000, where s = .NOT.d<11>)
10 = Fractional (DOUT = dddd dddd dddd 0000)
01 = Signed integer (DOUT = ssss sddd dddd dddd, where s = .NOT.d<11>)
00 = Integer (DOUT = 0000 dddd dddd dddd)

Note 1: See **Section 24.0 "Peripheral Trigger Generator (PTG) Module"** for information on this selection.
2: This setting is available in dsPIC33EPXXXMC20X/50X and PIC24EPXXXMC20X devices only.
3: Do not clear the DONE bit in software if Auto-Sample is enabled (ASAM = 1).

REGISTER 23-6: AD1CHS0: ADC1 INPUT CHANNEL 0 SELECT REGISTER

R/W-0	U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
CH0NB	—	—	CH0SB4(1)	CH0SB3(1)	CH0SB2(1)	CH0SB1(1)	CH0SB0(1)
bit 15							bit 8

R/W-0	U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
CH0NA	—	—	CH0SA4(1)	CH0SA3(1)	CH0SA2(1)	CH0SA1(1)	CH0SA0(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 15 **CH0NB:** Channel 0 Negative Input Select for Sample MUXB bit
1 = Channel 0 negative input is AN1(1)
0 = Channel 0 negative input is VREFL

bit 14-13 **Unimplemented:** Read as '0'

bit 12-8 **CH0SB<4:0>:** Channel 0 Positive Input Select for Sample MUXB bits(1)
11111 = Open; use this selection with CTMU capacitive and time measurement
11110 = Channel 0 positive input is connected to the CTMU temperature measurement diode (CTMU TEMP)
11101 = Reserved
11100 = Reserved
11011 = Reserved
11010 = Channel 0 positive input is the output of OA3/AN6(2,3)
11001 = Channel 0 positive input is the output of OA2/AN0(2)
11000 = Channel 0 positive input is the output of OA1/AN3(2)
10111 = Reserved
•
•
•
10000 = Reserved
01111 = Channel 0 positive input is AN15(3)
01110 = Channel 0 positive input is AN14(3)
01101 = Channel 0 positive input is AN13(3)
•
•
•
00010 = Channel 0 positive input is AN2(3)
00001 = Channel 0 positive input is AN1(3)
00000 = Channel 0 positive input is AN0(3)

bit 7 **CH0NA:** Channel 0 Negative Input Select for Sample MUXA bit
1 = Channel 0 negative input is AN1(1)
0 = Channel 0 negative input is VREFL

bit 6-5 **Unimplemented:** Read as '0'

Note 1: AN0 through AN7 are repurposed when comparator and op amp functionality is enabled. See Figure 23-1 to determine how enabling a particular op amp or comparator affects selection choices for Channels 1, 2 and 3.

2: The OAx input is used if the corresponding op amp is selected (OPMODE (CMxCON<10>) = 1); otherwise, the ANx input is used.

3: See the **"Pin Diagrams"** section for the available analog channels for each device.

25.0 OP AMP/COMPARATOR MODULE

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 **"Op Amp/Comparator"** (DS70357) 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 devices contain up to four comparators, which can be configured in various ways. Comparators, CMP1, CMP2 and CMP3, also have the option to be configured as op amps, with the output being brought to an external pin for gain/filtering connections. As shown in Figure 25-1, individual comparator options are specified by the comparator module's Special Function Register (SFR) control bits.

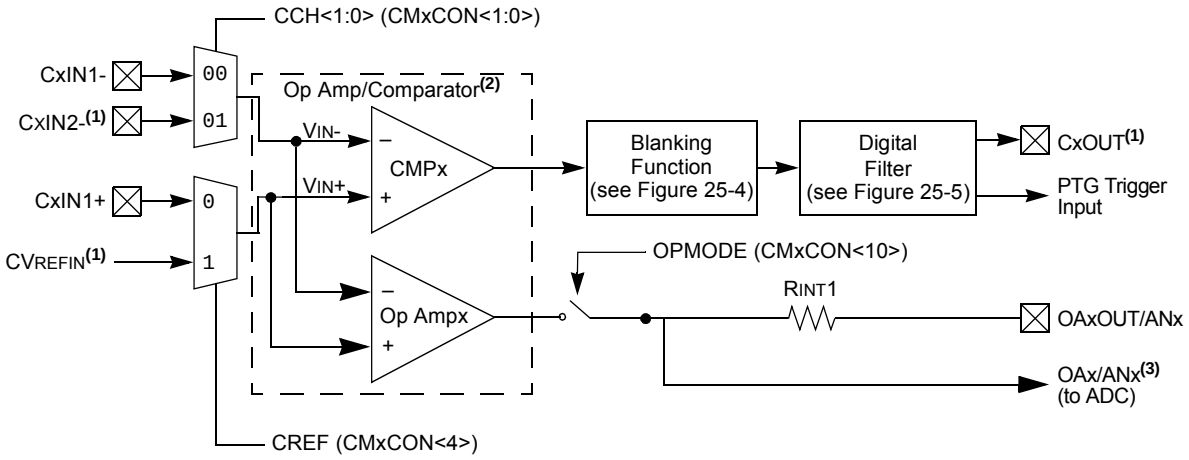
Note: Op Amp/Comparator 3 is not available on the dsPIC33EPXXXGP502/MC502/MC202 and PIC24EP256GP/MC202 (28-pin) devices.

These options allow users to:

- Select the edge for trigger and interrupt generation
- Configure the comparator voltage reference
- Configure output blanking and masking
- Configure as a comparator or op amp (CMP1, CMP2 and CMP3 only)

Note: Not all op amp/comparator input/output connections are available on all devices. See the **"Pin Diagrams"** section for available connections.

FIGURE 25-1: OP AMP/COMPARATOR x MODULE BLOCK DIAGRAM (MODULES 1, 2 AND 3)



Note 1: This input/output is not available as a selection when configured as an op amp (OPMODE (CMxCON<10>) = 1).

2: This module can be configured either as an op amp or a comparator using the OPMODE bit.

3: When configured as an op amp (OPMODE = 1), the ADC samples the op amp output; otherwise, the ADC samples the ANx pin.

25.1.2 OP AMP CONFIGURATION B

Figure 25-7 shows a typical inverting amplifier circuit with the output of the op amp (OAxOUT) externally routed to a separate analog input pin (ANy) on the device. This op amp configuration is slightly different in terms of the op amp output and the ADC input connection, therefore, RINT1 is not included in the transfer function. However, this configuration requires the designer to externally route the op amp output (OAxOUT) to another analog input pin (ANy). See Table 30-53 in **Section 30.0 "Electrical Characteristics"** for the typical value of RINT1. Table 30-60 and Table 30-61 in **Section 30.0 "Electrical Characteristics"** describe the minimum sample time (TSAMP) requirements for the ADC module in this configuration.

Figure 25-7 also defines the equation to be used to calculate the expected voltage at point VOAxOUT. This is the typical inverting amplifier equation.

25.2 Op Amp/Comparator Resources

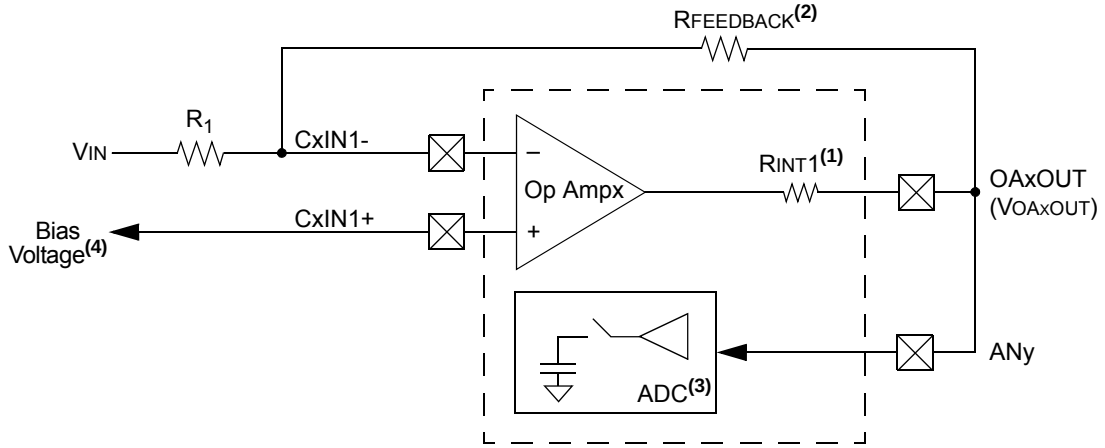
Many useful resources are provided on the main product page of the Microchip web site for the devices listed in this data sheet. This product page, which can be accessed using this link, contains the latest updates and additional information.

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

25.2.1 KEY RESOURCES

- **"Op Amp/Comparator"** (DS70357) in the *"dsPIC33/PIC24 Family Reference Manual"*
- Code Samples
- Application Notes
- Software Libraries
- Webinars
- All Related *"dsPIC33/PIC24 Family Reference Manual"* Sections
- Development Tools

FIGURE 25-7: OP AMP CONFIGURATION B



$$V_{OAxOUT} = \left(\frac{R_{FEEDBACK}}{R_1}\right)(\ Bias\ Voltage - V_{IN} \ )$$

Note 1: See Table 30-53 for the Typical value.
2: See Table 30-53 for the Minimum value for the feedback resistor.
3: See Table 30-60 and Table 30-61 for the minimum sample time (TSAMP).
4: CVREF1O or CVREF2O are two options that are available for supplying bias voltage to the op amps.

27.2 User ID Words

dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X and PIC24EPXXXGP/MC20X devices contain four User ID Words, located at addresses, 0x800FF8 through 0x800FFE. The User ID Words can be used for storing product information such as serial numbers, system manufacturing dates, manufacturing lot numbers and other application-specific information.

The User ID Words register map is shown in Table 27-3.

TABLE 27-3: USER ID WORDS REGISTER MAP

File Name	Address	Bits 23-16	Bits 15-0
FUID0	0x800FF8	—	UID0
FUID1	0x800FFA	—	UID1
FUID2	0x800FFC	—	UID2
FUID3	0x800FFE	—	UID3

Legend: — = unimplemented, read as '1'.

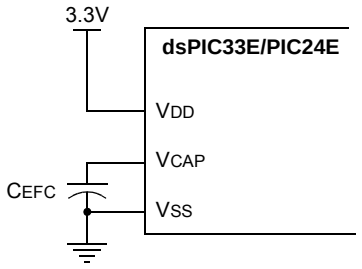
27.3 On-Chip Voltage Regulator

All of the dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X and PIC24EPXXXGP/MC20X devices power their core digital logic at a nominal 1.8V. This can create a conflict for designs that are required to operate at a higher typical voltage, such as 3.3V. To simplify system design, all devices in the dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X and PIC24EPXXXGP/MC20X family incorporate an on-chip regulator that allows the device to run its core logic from VDD.

The regulator provides power to the core from the other VDD pins. A low-ESR (less than 1 Ohm) capacitor (such as tantalum or ceramic) must be connected to the VCAP pin (Figure 27-1). This helps to maintain the stability of the regulator. The recommended value for the filter capacitor is provided in Table 30-5 located in **Section 30.0 "Electrical Characteristics"**.

Note:	It is important for the low-ESR capacitor to be placed as close as possible to the VCAP pin.

FIGURE 27-1: CONNECTIONS FOR THE ON-CHIP VOLTAGE REGULATOR(1,2,3)



Note 1: These are typical operating voltages. Refer to Table 30-5 located in **Section 30.1 "DC Characteristics"** for the full operating ranges of VDD and VCAP.

2: It is important for the low-ESR capacitor to be placed as close as possible to the VCAP pin.

3: Typical VCAP pin voltage = 1.8V when VDD ≥ VDDMIN.

27.4 Brown-out Reset (BOR)

The Brown-out Reset (BOR) module is based on an internal voltage reference circuit that monitors the regulated supply voltage, VCAP. 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 (for example, 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).

A BOR generates a Reset pulse, which resets the device. The BOR selects the clock source, based on the device Configuration bit values (FNOSC<2:0> and POSCMD<1:0>).

If an oscillator mode is selected, the BOR activates the Oscillator Start-up Timer (OST). The system clock is held until OST expires. If the PLL is used, the clock is held until the LOCK bit (OSCCON<5>) is '1'.

Concurrently, the PWRT Time-out (TPWRT) is applied before the internal Reset is released. If TPWRT = 0 and a crystal oscillator is being used, then a nominal delay of TFSCM is applied. The total delay in this case is TFSCM. Refer to Parameter SY35 in Table 30-22 of **Section 30.0 "Electrical Characteristics"** for specific TFSCM values.

The BOR status bit (RCON<1>) is set to indicate that a BOR has occurred. The BOR circuit continues to operate while in Sleep or Idle modes and resets the device should VDD fall below the BOR threshold voltage.

TABLE 28-2: INSTRUCTION SET OVERVIEW (CONTINUED)

Base Instr #	Assembly Mnemonic	Assembly Syntax		Description	# of Words	# of Cycles(2)	Status Flags Affected
53	NEG	NEG	Acc(1)	Negate Accumulator	1	1	OA,OB,OAB, SA,SB,SAB
		NEG	f	f = $\bar{f}$ + 1	1	1	C,DC,N,OV,Z
		NEG	f,WREG	WREG = $\bar{f}$ + 1	1	1	C,DC,N,OV,Z
		NEG	Ws,Wd	Wd = $\overline{Ws}$ + 1	1	1	C,DC,N,OV,Z
54	NOP	NOP		No Operation	1	1	None
		NOPR		No Operation	1	1	None
55	POP	POP	f	Pop f from Top-of-Stack (TOS)	1	1	None
		POP	Wdo	Pop from Top-of-Stack (TOS) to Wdo	1	1	None
		POP.D	Wnd	Pop from Top-of-Stack (TOS) to W(nd):W(nd + 1)	1	2	None
		POP.S		Pop Shadow Registers	1	1	All
56	PUSH	PUSH	f	Push f to Top-of-Stack (TOS)	1	1	None
		PUSH	Wso	Push Wso to Top-of-Stack (TOS)	1	1	None
		PUSH.D	Wns	Push W(ns):W(ns + 1) to Top-of-Stack (TOS)	1	2	None
		PUSH.S		Push Shadow Registers	1	1	None
57	PWRSAV	PWRSAV	#lit1	Go into Sleep or Idle mode	1	1	WDTO,Sleep
58	RCALL	RCALL	Expr	Relative Call	1	4	SFA
		RCALL	Wn	Computed Call	1	4	SFA
59	REPEAT	REPEAT	#lit15	Repeat Next Instruction lit15 + 1 times	1	1	None
		REPEAT	Wn	Repeat Next Instruction (Wn) + 1 times	1	1	None
60	RESET	RESET		Software device Reset	1	1	None
61	RETFIE	RETFIE		Return from interrupt	1	6 (5)	SFA
62	RETLW	RETLW	#lit10,Wn	Return with literal in Wn	1	6 (5)	SFA
63	RETURN	RETURN		Return from Subroutine	1	6 (5)	SFA
64	RLC	RLC	f	f = Rotate Left through Carry f	1	1	C,N,Z
		RLC	f,WREG	WREG = Rotate Left through Carry f	1	1	C,N,Z
		RLC	Ws,Wd	Wd = Rotate Left through Carry Ws	1	1	C,N,Z
65	RLNC	RLNC	f	f = Rotate Left (No Carry) f	1	1	N,Z
		RLNC	f,WREG	WREG = Rotate Left (No Carry) f	1	1	N,Z
		RLNC	Ws,Wd	Wd = Rotate Left (No Carry) Ws	1	1	N,Z
66	RRC	RRC	f	f = Rotate Right through Carry f	1	1	C,N,Z
		RRC	f,WREG	WREG = Rotate Right through Carry f	1	1	C,N,Z
		RRC	Ws,Wd	Wd = Rotate Right through Carry Ws	1	1	C,N,Z
67	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
68	SAC	SAC	Acc,#Slit4,Wdo(1)	Store Accumulator	1	1	None
		SAC.R	Acc,#Slit4,Wdo(1)	Store Rounded Accumulator	1	1	None
69	SE	SE	Ws,Wnd	Wnd = sign-extended Ws	1	1	C,N,Z
70	SETM	SETM	f	f = 0xFFFF	1	1	None
		SETM	WREG	WREG = 0xFFFF	1	1	None
		SETM	Ws	Ws = 0xFFFF	1	1	None
71	SFTAC	SFTAC	Acc,Wn(1)	Arithmetic Shift Accumulator by (Wn)	1	1	OA,OB,OAB, SA,SB,SAB
		SFTAC	Acc,#Slit6(1)	Arithmetic Shift Accumulator by Slit6	1	1	OA,OB,OAB, SA,SB,SAB

Note 1: These instructions are available in dsPIC33EPXXXMC20X/50X and PIC24EPXXXMC20X devices only.

2: Read and Read-Modify-Write (e.g., bit operations and logical operations) on non-CPU SFRs incur an additional instruction cycle.

30.2 AC Characteristics and Timing Parameters

This section defines dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X and PIC24EPXXXGP/MC20X AC characteristics and timing parameters.

TABLE 30-15: TEMPERATURE AND VOLTAGE SPECIFICATIONS – AC

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 Operating voltage VDD range as described in **Section 30.1 "DC Characteristics"**.

FIGURE 30-1: LOAD CONDITIONS FOR DEVICE TIMING SPECIFICATIONS

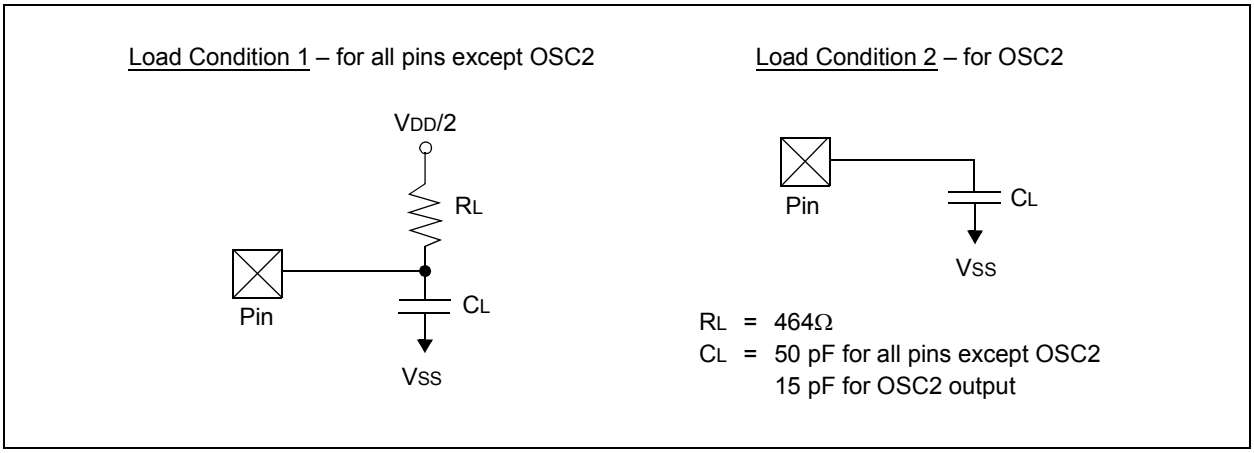
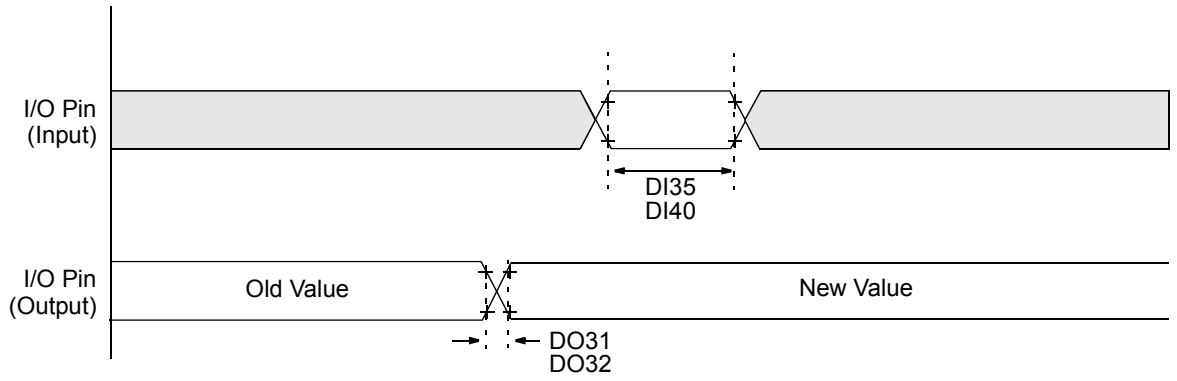


TABLE 30-16: CAPACITIVE LOADING REQUIREMENTS ON OUTPUT PINS

Param No.	Symbol	Characteristic	Min.	Typ.	Max.	Units	Conditions
DO50	COSCO	OSC2 Pin	—	—	15	pF	In XT and HS modes, when external clock is used to drive OSC1
DO56	CIO	All I/O Pins and OSC2	—	—	50	pF	EC mode
DO58	CB	SCLx, SDAx	—	—	400	pF	In I^2C™ mode

FIGURE 30-3: I/O TIMING CHARACTERISTICS



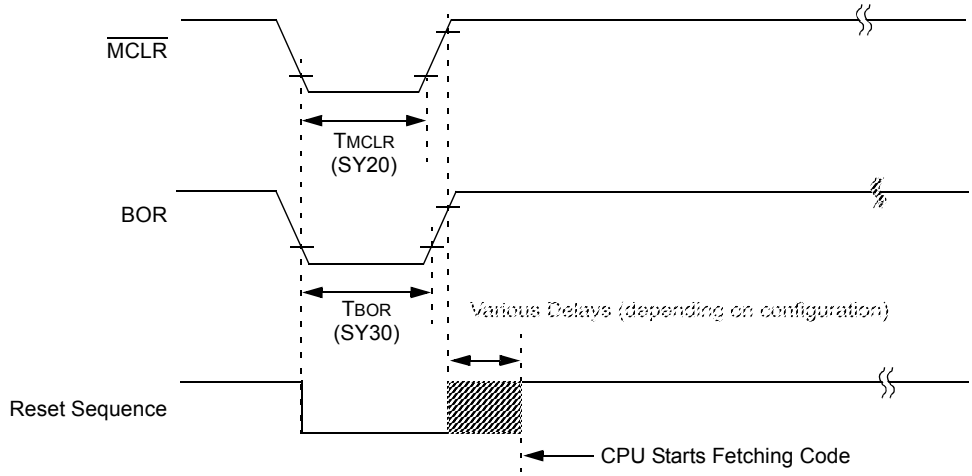
Note: Refer to Figure 30-1 for load conditions.

TABLE 30-21: I/O TIMING REQUIREMENTS

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**	**Min.**	**Typ.(1)**	**Max.**	**Units**	**Conditions**
DO31	TIOR	Port Output Rise Time	—	5	10	ns	
DO32	TIOF	Port Output Fall Time	—	5	10	ns	
DI35	TINP	INTx Pin High or Low Time (input)	20	—	—	ns	
DI40	TRBP	CNx High or Low Time (input)	2	—	—	TCY	

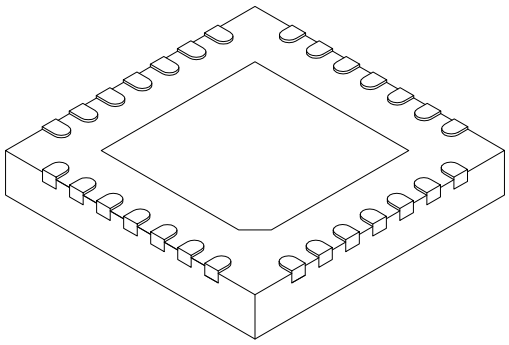
Note 1: Data in "Typical" column is at 3.3V, +25°C unless otherwise stated.

FIGURE 30-4: BOR AND MASTER CLEAR RESET TIMING CHARACTERISTICS



28-Lead Plastic Quad Flat, No Lead Package (MM) - 6x6x0.9mm Body [QFN-S] With 0.40 mm Terminal Length

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		28	
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		6.00 BSC	
Exposed Pad Width	E2	3.65	3.70	4.70
Overall Length	D		6.00 BSC	
Exposed Pad Length	D2	3.65	3.70	4.70
Terminal Width	b	0.23	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.

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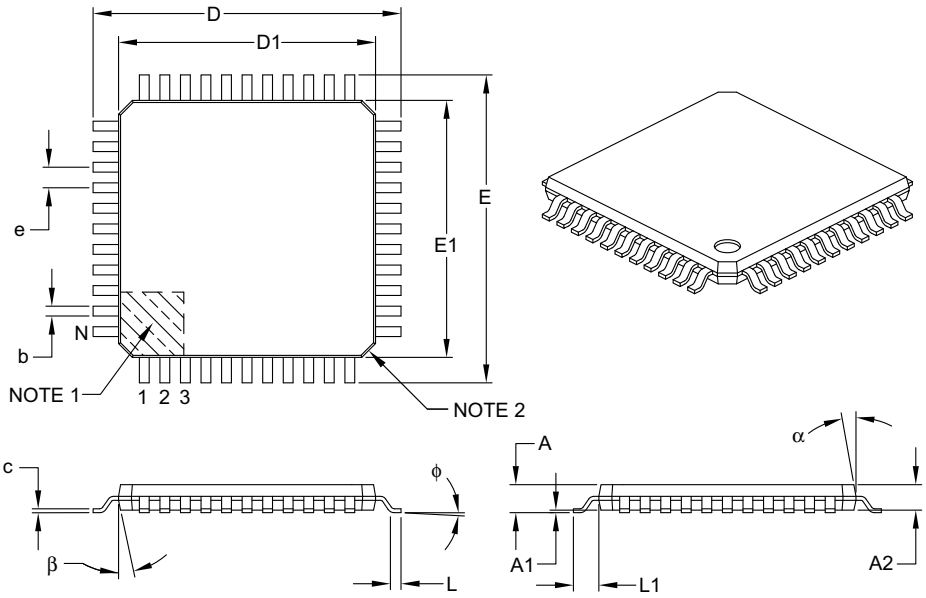
44-Lead Plastic Thin Quad Flatpack (PT) – 10x10x1 mm Body, 2.00 mm [TQFP]

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 Leads	N		44	
Lead Pitch	e		0.80 BSC	
Overall Height	A	–	–	1.20
Molded Package Thickness	A2	0.95	1.00	1.05
Standoff	A1	0.05	–	0.15
Foot Length	L	0.45	0.60	0.75
Footprint	L1		1.00 REF	
Foot Angle	ϕ	0°	3.5°	7°
Overall Width	E		12.00 BSC	
Overall Length	D		12.00 BSC	
Molded Package Width	E1		10.00 BSC	
Molded Package Length	D1		10.00 BSC	
Lead Thickness	c	0.09	–	0.20
Lead Width	b	0.30	0.37	0.45
Mold Draft Angle Top	α	11°	12°	13°
Mold Draft Angle Bottom	β	11°	12°	13°

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Chamfers at corners are optional; size may vary.
3. Dimensions D1 and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.25 mm per side.
4. 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 C04-076B