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"[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	PIC
Core Size	16-Bit
Speed	60 MIPS
Connectivity	I ² C, 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	512KB (170K x 24)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	24K x 16
Voltage - Supply (Vcc/Vdd)	3V ~ 3.6V
Data Converters	A/D 6x10b/12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 150°C (TA)
Mounting Type	Surface Mount
Package / Case	28-SOIC (0.295", 7.50mm Width)
Supplier Device Package	28-SOIC
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic24ep512mc202-h-so

TABLE 2: dsPIC33EPXXXMC20X/50X and PIC24EPXXXMC20X MOTOR CONTROL FAMILIES

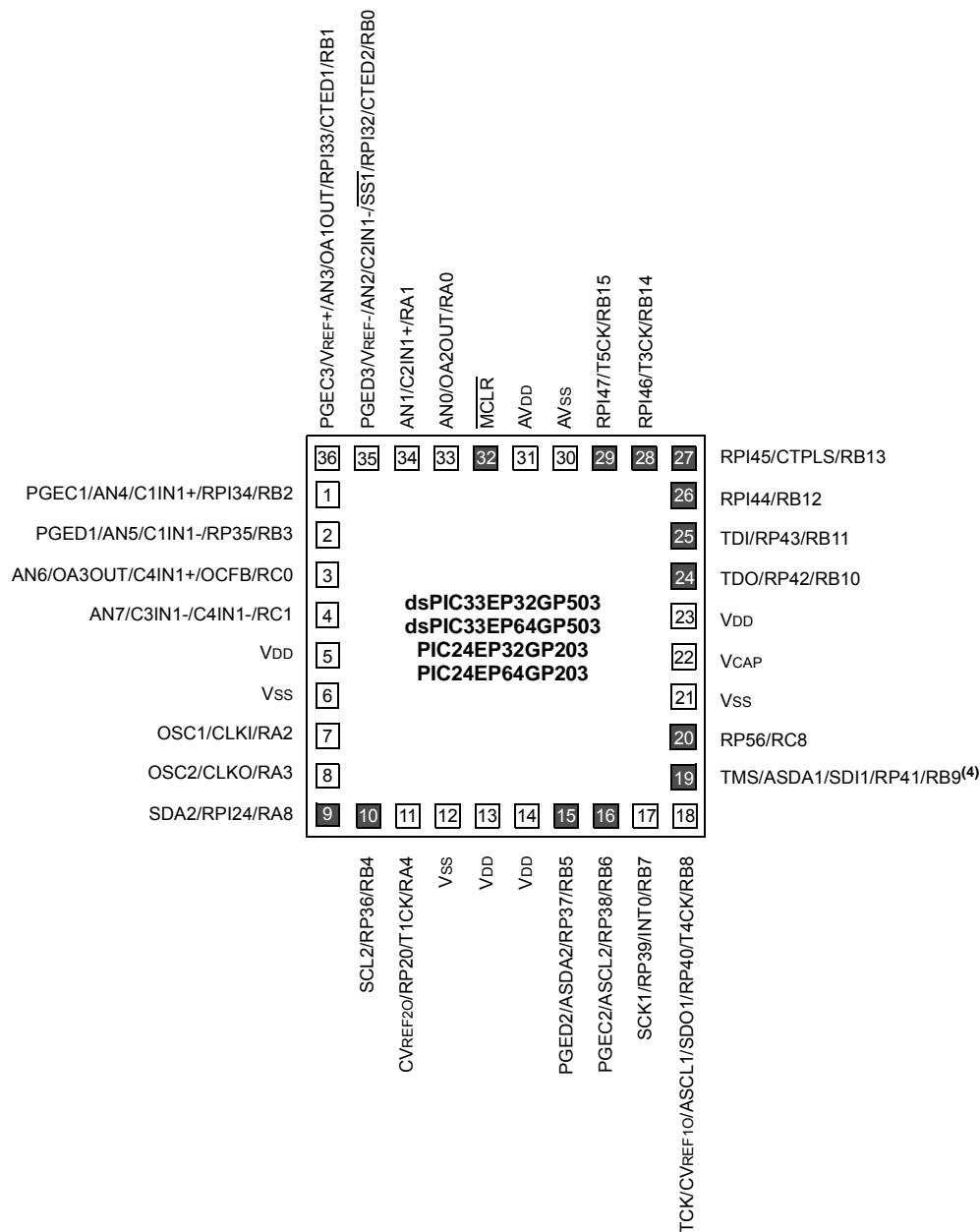
Device	Page Erase Size (Instructions)	Program Flash Memory (Kbytes)	RAM (Kbytes)	Remappable Peripherals								i ² C™	CRC Generator	10-Bit/12-Bit ADC (Channels)	Op Amps/Comparators	CTMU	PTG	I/O Pins	Pins	Packages	
				16-Bit/32-Bit Timers	Input Capture	Output Compare	Motor Control PWM ⁽⁴⁾ (Channels)	Quadrature Encoder Interface	UART	SPI ⁽²⁾	ECAN™ Technology										External Interrupts ⁽³⁾
PIC24EP32MC202	512	32	4	5	4	4	6	1	2	2	—	3	2	1	6	2/3 ⁽¹⁾	Yes	Yes	21	28	SPDIP, SOIC, SSOP ⁽⁵⁾ , QFN-S
PIC24EP64MC202	1024	64	8																		
PIC24EP128MC202	1024	128	16																		
PIC24EP256MC202	1024	256	32																		
PIC24EP512MC202	1024	512	48	5	4	4	6	1	2	2	—	3	2	1	8	3/4	Yes	Yes	25	36	VTLA
PIC24EP32MC203	512	32	4																		
PIC24EP64MC203	1024	64	8																		
PIC24EP32MC204	512	32	4																		
PIC24EP64MC204	1024	64	8	5	4	4	6	1	2	2	—	3	2	1	9	3/4	Yes	Yes	35	44/ 48	VTLA ⁽⁵⁾ , TQFP, QFN, UQFN
PIC24EP128MC204	1024	128	16																		
PIC24EP256MC204	1024	256	32																		
PIC24EP512MC204	1024	512	48																		
PIC24EP64MC206	1024	64	8	5	4	4	6	1	2	2	—	3	2	1	16	3/4	Yes	Yes	53	64	TQFP, QFN
PIC24EP128MC206	1024	128	16																		
PIC24EP256MC206	1024	256	32																		
PIC24EP512MC206	1024	512	48																		
dsPIC33EP32MC202	512	32	4	5	4	4	6	1	2	2	—	3	2	1	6	2/3 ⁽¹⁾	Yes	Yes	21	28	SPDIP, SOIC, SSOP ⁽⁵⁾ , QFN-S
dsPIC33EP64MC202	1024	64	8																		
dsPIC33EP128MC202	1024	128	16																		
dsPIC33EP256MC202	1024	256	32																		
dsPIC33EP512MC202	1024	512	48	5	4	4	6	1	2	2	—	3	2	1	8	3/4	Yes	Yes	25	36	VTLA
dsPIC33EP32MC203	512	32	4																		
dsPIC33EP64MC203	1024	64	8																		
dsPIC33EP32MC204	512	32	4																		
dsPIC33EP64MC204	1024	64	8	5	4	4	6	1	2	2	—	3	2	1	9	3/4	Yes	Yes	35	44/ 48	VTLA ⁽⁵⁾ , TQFP, QFN, UQFN
dsPIC33EP128MC204	1024	128	16																		
dsPIC33EP256MC204	1024	256	32																		
dsPIC33EP512MC204	1024	512	48																		
dsPIC33EP64MC206	1024	64	8	5	4	4	6	1	2	2	—	3	2	1	16	3/4	Yes	Yes	53	64	TQFP, QFN
dsPIC33EP128MC206	1024	128	16																		
dsPIC33EP256MC206	1024	256	32																		
dsPIC33EP512MC206	1024	512	48																		
dsPIC33EP32MC502	512	32	4	5	4	4	6	1	2	2	1	3	2	1	6	2/3 ⁽¹⁾	Yes	Yes	21	28	SPDIP, SOIC, SSOP ⁽⁵⁾ , QFN-S
dsPIC33EP64MC502	1024	64	8																		
dsPIC33EP128MC502	1024	128	16																		
dsPIC33EP256MC502	1024	256	32																		
dsPIC33EP512MC502	1024	512	48	5	4	4	6	1	2	2	1	3	2	1	8	3/4	Yes	Yes	25	36	VTLA
dsPIC33EP32MC503	512	32	4																		
dsPIC33EP64MC503	1024	64	8																		

- Note 1:** On 28-pin devices, Comparator 4 does not have external connections. Refer to **Section 25.0 “Op Amp/Comparator Module”** for details.
2: Only SPI2 is remappable.
3: INT0 is not remappable.
4: Only the PWM Faults are remappable.
5: The SSOP and VTLA packages are not available for devices with 512 Kbytes of memory.

Pin Diagrams (Continued)

36-Pin VTLA^(1,2,3)

■ = Pins are up to 5V tolerant

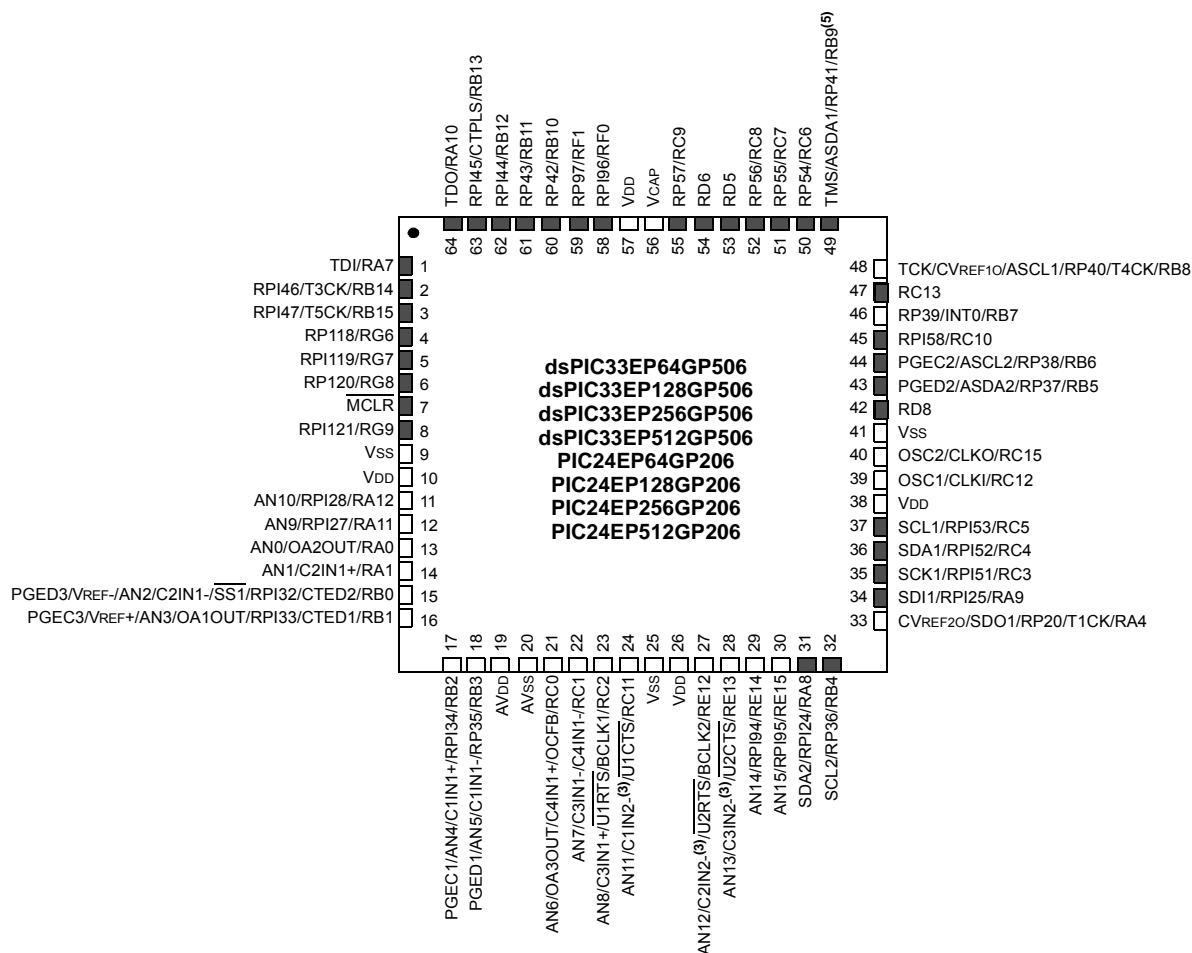


- Note**
- 1: The RPN/RPIN pins can be used by any remappable peripheral with some limitation. See **Section 11.4 “Peripheral Pin Select (PPS)”** for available peripherals and for information on limitations.
 - 2: Every I/O port pin (RAX-RGX) can be used as a Change Notification pin (CNAX-CNGX). See **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.

Pin Diagrams (Continued)

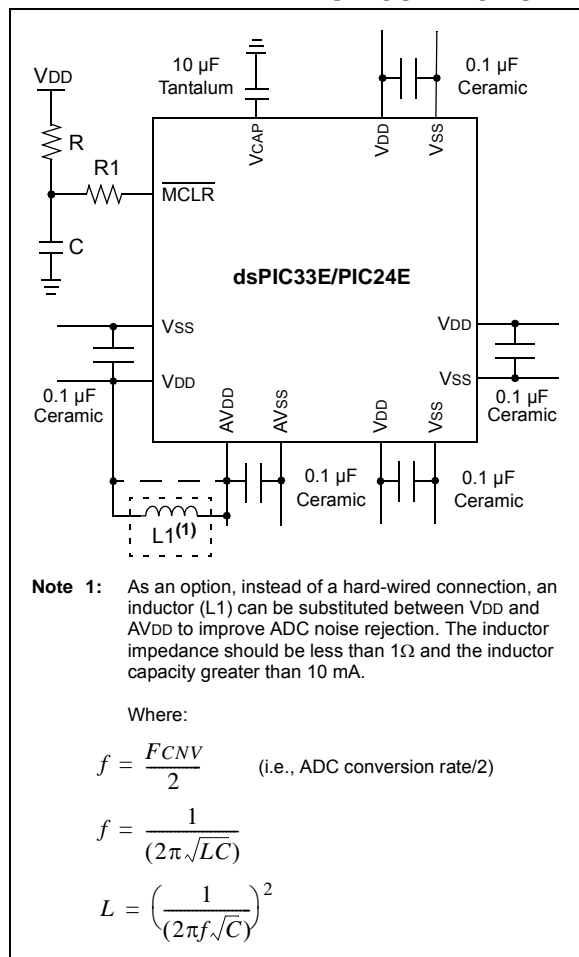
64-Pin QFN^(1,2,3,4)

■ = 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.
- Note 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.
- Note 3:** This pin is not available as an input when OPMODE (CMxCON<10>) = 1.
- Note 4:** The metal pad at the bottom of the device is not connected to any pins and is recommended to be connected to Vss externally.
- Note 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 2-1: RECOMMENDED MINIMUM CONNECTION



2.2.1 TANK CAPACITORS

On boards with power traces running longer than six inches in length, it is suggested to use a tank capacitor for integrated circuits including DSCs to supply a local power source. The value of the tank capacitor should be determined based on the trace resistance that connects the power supply source to the device and the maximum current drawn by the device in the application. In other words, select the tank capacitor so that it meets the acceptable voltage sag at the device. Typical values range from 4.7 µF to 47 µF.

2.3 CPU Logic Filter Capacitor Connection (VCAP)

A low-ESR (< 1 Ohm) capacitor is required on the VCAP pin, which is used to stabilize the voltage regulator output voltage. The VCAP pin must not be connected to VDD and must have a capacitor greater than 4.7 µF (10 µF is recommended), 16V connected to ground. The type can be ceramic or tantalum. See **Section 30.0 “Electrical Characteristics”** for additional information.

The placement of this capacitor should be close to the VCAP pin. It is recommended that the trace length not exceeds one-quarter inch (6 mm). See **Section 27.3 “On-Chip Voltage Regulator”** for details.

2.4 Master Clear (MCLR) Pin

The MCLR pin provides two specific device functions:

- Device Reset
- Device Programming and Debugging.

During device programming and debugging, the resistance and capacitance that can be added to the pin must be considered. Device programmers and debuggers drive the MCLR pin. Consequently, specific voltage levels (VIH and VIL) and fast signal transitions must not be adversely affected. Therefore, specific values of R and C will need to be adjusted based on the application and PCB requirements.

For example, as shown in Figure 2-2, it is recommended that the capacitor, C, be isolated from the MCLR pin during programming and debugging operations.

Place the components as shown in Figure 2-2 within one-quarter inch (6 mm) from the MCLR pin.

FIGURE 2-2: EXAMPLE OF MCLR PIN CONNECTIONS

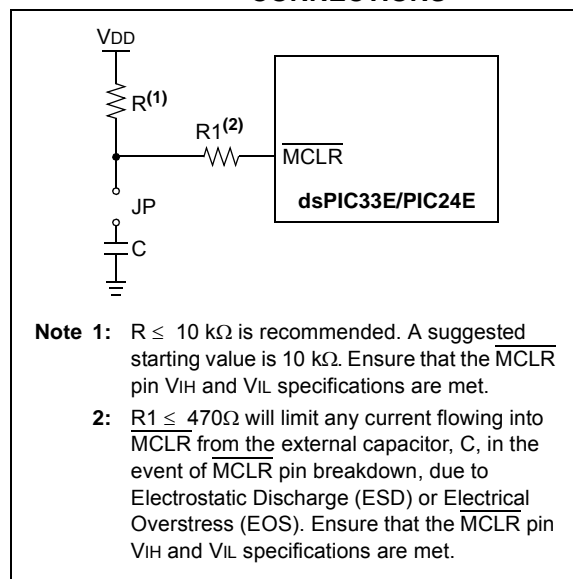


TABLE 4-33: PERIPHERAL PIN SELECT INPUT REGISTER MAP FOR dsPIC33EPXXXMC20X DEVICES ONLY

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		
RPINR0	06A0	—	INT1R<6:0>								—	—	—	—	—	—	—	—	0000	
RPINR1	06A2	—	—	—	—	—	—	—	—	—	INT2R<6:0>								0000	
RPINR3	06A6	—	—	—	—	—	—	—	—	—	T2CKR<6:0>								0000	
RPINR7	06AE	—	IC2R<6:0>								—	IC1R<6:0>								0000
RPINR8	06B0	—	IC4R<6:0>								—	IC3R<6:0>								0000
RPINR11	06B6	—	—	—	—	—	—	—	—	—	OCFAR<6:0>								0000	
RPINR12	06B8	—	FLT2R<6:0>								—	FLT1R<6:0>								0000
RPINR14	06BC	—	QEB1R<6:0>								—	QEA1R<6:0>								0000
RPINR15	06BE	—	HOME1R<6:0>								—	INDX1R<6:0>								0000
RPINR18	06C4	—	—	—	—	—	—	—	—	—	U1RXR<6:0>								0000	
RPINR19	06C6	—	—	—	—	—	—	—	—	—	U2RXR<6:0>								0000	
RPINR22	06CC	—	SCK2INR<6:0>								—	SDI2R<6:0>								0000
RPINR23	06CE	—	—	—	—	—	—	—	—	—	SS2R<6:0>								0000	
RPINR37	06EA	—	SYNCI1R<6:0>								—	—	—	—	—	—	—	—	0000	
RPINR38	06EC	—	DTCMP1R<6:0>								—	—	—	—	—	—	—	—	0000	
RPINR39	06EE	—	DTCMP3R<6:0>								—	DTCMP2R<6:0>								0000

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

4.6.3 MODULO ADDRESSING APPLICABILITY

Modulo Addressing can be applied to the Effective Address (EA) calculation associated with any W register. Address boundaries check for addresses equal to:

- The upper boundary addresses for incrementing buffers
- The lower boundary addresses for decrementing buffers

It is important to realize that the address boundaries check for addresses less than, or greater than, the upper (for incrementing buffers) and lower (for decrementing buffers) boundary addresses (not just equal to). Address changes can, therefore, jump beyond boundaries and still be adjusted correctly.

Note: The modulo corrected Effective Address is written back to the register only when Pre-Modify or Post-Modify Addressing mode is used to compute the Effective Address. When an address offset (such as $[W7 + W2]$) is used, Modulo Addressing correction is performed but the contents of the register remain unchanged.

4.7 Bit-Reversed Addressing (dsPIC33EPXXXMC20X/50X and dsPIC33EPXXXGP50X Devices Only)

Bit-Reversed Addressing mode is intended to simplify data reordering for radix-2 FFT algorithms. It is supported by the X AGU for data writes only.

The modifier, which can be a constant value or register contents, is regarded as having its bit order reversed. The address source and destination are kept in normal order. Thus, the only operand requiring reversal is the modifier.

4.7.1 BIT-REVERSED ADDRESSING IMPLEMENTATION

Bit-Reversed Addressing mode is enabled when all these conditions are met:

- BWMx bits (W register selection) in the MODCON register are any value other than '1111' (the stack cannot be accessed using Bit-Reversed Addressing)
- The BREN bit is set in the XBREV register
- The addressing mode used is Register Indirect with Pre-Increment or Post-Increment

If the length of a bit-reversed buffer is $M = 2^N$ bytes, the last 'N' bits of the data buffer start address must be zeros.

XBREV<14:0> is the Bit-Reversed Addressing modifier, or 'pivot point', which is typically a constant. In the case of an FFT computation, its value is equal to half of the FFT data buffer size.

Note: All bit-reversed EA calculations assume word-sized data (LSb of every EA is always clear). The XBREVx value is scaled accordingly to generate compatible (byte) addresses.

When enabled, Bit-Reversed Addressing is executed only for Register Indirect with Pre-Increment or Post-Increment Addressing and word-sized data writes. It does not function for any other addressing mode or for byte-sized data and normal addresses are generated instead. When Bit-Reversed Addressing is active, the W Address Pointer is always added to the address modifier (XBREVx) and the offset associated with the Register Indirect Addressing mode is ignored. In addition, as word-sized data is a requirement, the LSb of the EA is ignored (and always clear).

Note: Modulo Addressing and Bit-Reversed Addressing can be enabled simultaneously using the same W register, but Bit-Reversed Addressing operation will always take precedence for data writes when enabled.

If Bit-Reversed Addressing has already been enabled by setting the BREN (XBREV<15>) bit, a write to the XBREV register should not be immediately followed by an indirect read operation using the W register that has been designated as the Bit-Reversed Pointer.

4.8.1 DATA ACCESS FROM PROGRAM MEMORY USING TABLE INSTRUCTIONS

The TBLRDH and TBLWTL instructions offer a direct method of reading or writing the lower word of any address within the Program Space without going through Data Space. The TBLRDH and TBLWTL instructions are the only method to read or write the upper 8 bits of a Program Space word 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-wide word address spaces, residing side by side, each with the same address range. TBLRDH and TBLWTL access the space that contains the least significant data word. TBLRDH and TBLWTL access the space that contains the upper data byte.

Two table instructions are provided to move byte or word-sized (16-bit) data to and from Program Space. Both function as either byte or word operations.

- TBLRDH (Table Read High):
 - In Word mode, this instruction maps the lower word of the Program Space location ($P<15:0>$) to a data address ($D<15:0>$)

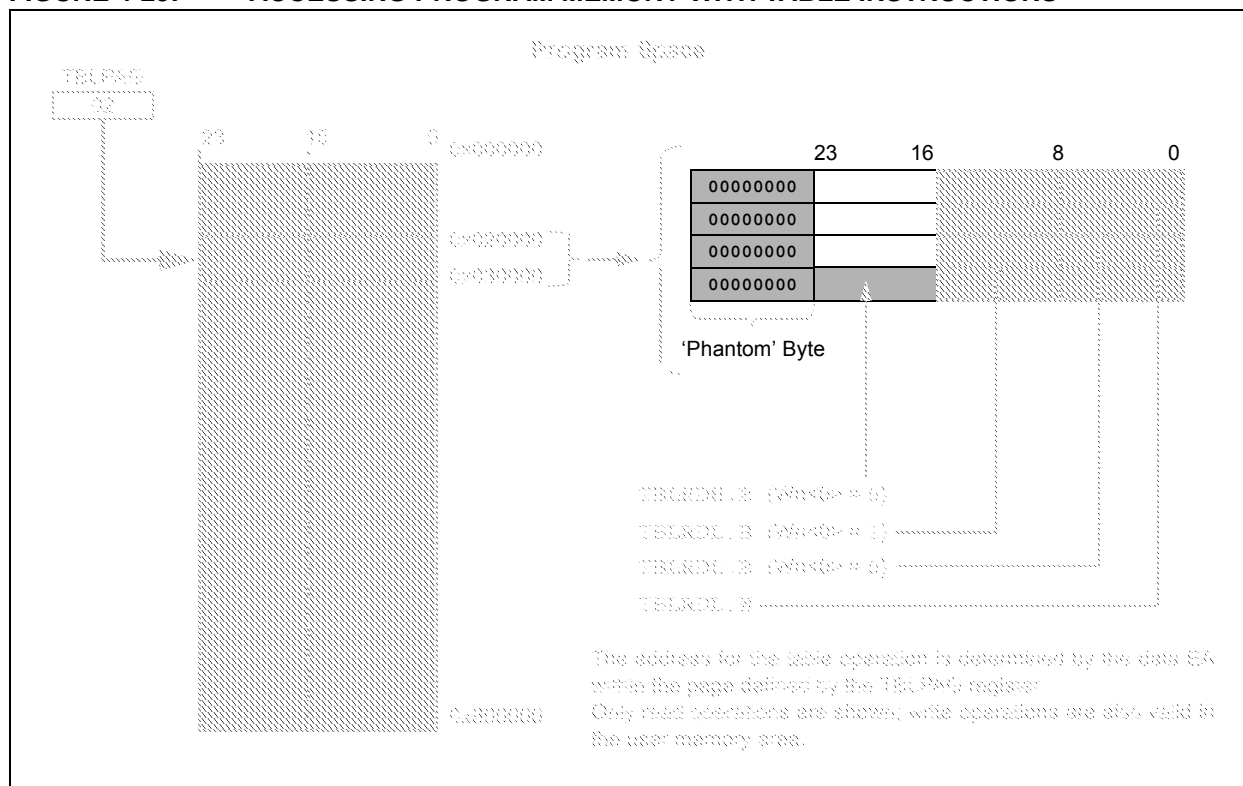
- In Byte mode, either the upper or lower byte of the lower program word is mapped to the lower byte of a data address. The upper byte is selected when Byte Select is '1'; the lower byte is selected when it is '0'.

- TBLRDH (Table Read High):
 - In Word mode, this instruction maps the entire upper word of a program address ($P<23:16>$) to a data address. The 'phantom' byte ($D<15:8>$) is always '0'.
 - In Byte mode, this instruction maps the upper or lower byte of the program word to $D<7:0>$ of the data address in the TBLRDH instruction. The data is always '0' when the upper 'phantom' byte is selected (Byte Select = 1).

In a similar fashion, two table instructions, TBLWTH and TBLWTL, are used to write individual bytes or words to a Program Space address. The details of their operation are explained in **Section 5.0 "Flash Program Memory"**.

For all table operations, the area of program memory space to be accessed is determined by the Table Page register (TBLPAG). TBLPAG covers the entire program memory space of the device, including user application and configuration spaces. When $TBLPAG<7> = 0$, the table page is located in the user memory space. When $TBLPAG<7> = 1$, the page is located in configuration space.

FIGURE 4-23: ACCESSING PROGRAM MEMORY WITH TABLE INSTRUCTIONS



REGISTER 7-3: INTCON1: INTERRUPT CONTROL REGISTER 1 (CONTINUED)

bit 4	MATHERR: Math Error Status bit 1 = Math error trap has occurred 0 = Math error trap has not occurred
bit 3	ADDRERR: Address Error Trap Status bit 1 = Address error trap has occurred 0 = Address error trap has not occurred
bit 2	STKERR: Stack Error Trap Status bit 1 = Stack error trap has occurred 0 = Stack error trap has not occurred
bit 1	OSCFAIL: Oscillator Failure Trap Status bit 1 = Oscillator failure trap has occurred 0 = Oscillator failure trap has not occurred
bit 0	Unimplemented: Read as '0'

Note 1: These bits are available on dsPIC33EPXXXMC20X/50X and dsPIC33EPXXXGP50X devices only.

REGISTER 9-3: PLLFBD: PLL FEEDBACK DIVISOR REGISTER

U-0	U-0	U-0	U-0	U-0	U-0	U-0	R/W-0
—	—	—	—	—	—	—	PLLDIV8
bit 15							bit 8

R/W-0	R/W-0	R/W-1	R/W-1	R/W-0	R/W-0	R/W-0	R/W-0
PLLDIV7	PLLDIV6	PLLDIV5	PLLDIV4	PLLDIV3	PLLDIV2	PLLDIV1	PLLDIV0
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 15-9

Unimplemented: Read as '0'

bit 8-0

PLLDIV<8:0>: PLL Feedback Divisor bits (also denoted as 'M', PLL multiplier)

11111111 = 513

•

•

•

000110000 = 50 (default)

•

•

•

000000010 = 4

000000001 = 3

000000000 = 2

REGISTER 10-2: PMD2: PERIPHERAL MODULE DISABLE CONTROL REGISTER 2

U-0	U-0	U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0
—	—	—	—	IC4MD	IC3MD	IC2MD	IC1MD
bit 15				bit 8			

U-0	U-0	U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0
—	—	—	—	OC4MD	OC3MD	OC2MD	OC1MD
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 **Unimplemented:** Read as '0'

bit 11 **IC4MD:** Input Capture 4 Module Disable bit

1 = Input Capture 4 module is disabled

0 = Input Capture 4 module is enabled

bit 10 **IC3MD:** Input Capture 3 Module Disable bit

1 = Input Capture 3 module is disabled

0 = Input Capture 3 module is enabled

bit 9 **IC2MD:** Input Capture 2 Module Disable bit

1 = Input Capture 2 module is disabled

0 = Input Capture 2 module is enabled

bit 8 **IC1MD:** Input Capture 1 Module Disable bit

1 = Input Capture 1 module is disabled

0 = Input Capture 1 module is enabled

bit 7-4 **Unimplemented:** Read as '0'

bit 3 **OC4MD:** Output Compare 4 Module Disable bit

1 = Output Compare 4 module is disabled

0 = Output Compare 4 module is enabled

bit 2 **OC3MD:** Output Compare 3 Module Disable bit

1 = Output Compare 3 module is disabled

0 = Output Compare 3 module is enabled

bit 1 **OC2MD:** Output Compare 2 Module Disable bit

1 = Output Compare 2 module is disabled

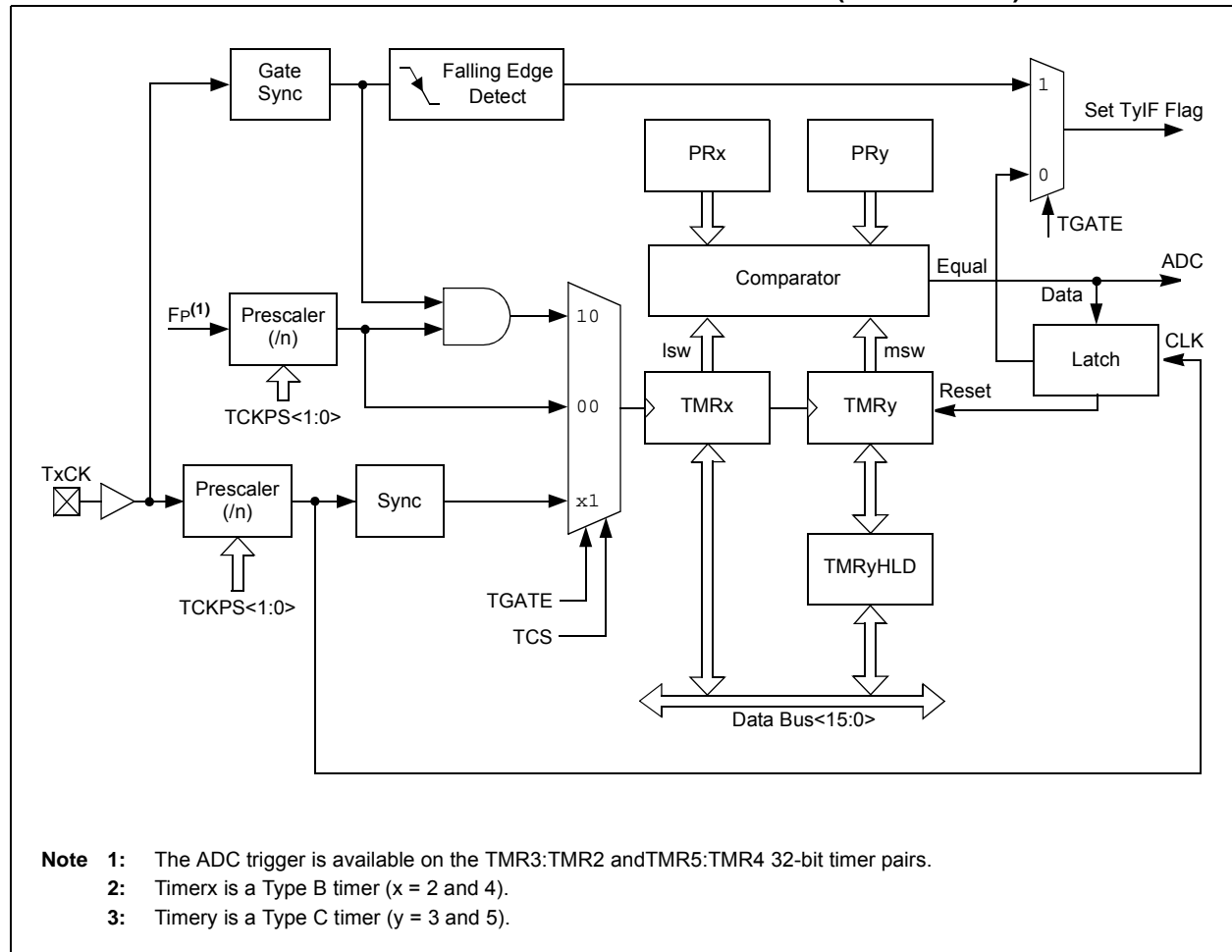
0 = Output Compare 2 module is enabled

bit 0 **OC1MD:** Output Compare 1 Module Disable bit

1 = Output Compare 1 module is disabled

0 = Output Compare 1 module is enabled

FIGURE 13-3: TYPE B/TIME C TIMER PAIR BLOCK DIAGRAM (32-BIT TIMER)



13.1 Timerx/y 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>

13.1.1 KEY RESOURCES

- “Timers” (DS70362) in the “dsPIC33/PIC24 Family Reference Manual”
- Code Samples
- Application Notes
- Software Libraries
- Webinars
- All Related “dsPIC33/PIC24 Family Reference Manual” Sections
- Development Tools

22.2 CTMU Control Registers

REGISTER 22-1: CTMUCON1: CTMU CONTROL REGISTER 1

R/W-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
CTMUEN	—	CTMUSIDL	TGEN	EDGEN	EDGSEQEN	IDISSEN ⁽¹⁾	CTTRIG
bit 15							bit 8

U-0	U-0	U-0	U-0	U-0	U-0	U-0	U-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 **CTMUEN:** CTMU Enable bit
 1 = Module is enabled
 0 = Module is disabled
- bit 14 **Unimplemented:** Read as '0'
- bit 13 **CTMUSIDL:** CTMU Stop in Idle Mode bit
 1 = Discontinues module operation when device enters Idle mode
 0 = Continues module operation in Idle mode
- bit 12 **TGEN:** Time Generation Enable bit
 1 = Enables edge delay generation
 0 = Disables edge delay generation
- bit 11 **EDGEN:** Edge Enable bit
 1 = Hardware modules are used to trigger edges (TMRx, CTEDx, etc.)
 0 = Software is used to trigger edges (manual set of EDGxSTAT)
- bit 10 **EDGSEQEN:** Edge Sequence Enable bit
 1 = Edge 1 event must occur before Edge 2 event can occur
 0 = No edge sequence is needed
- bit 9 **IDISSEN:** Analog Current Source Control bit⁽¹⁾
 1 = Analog current source output is grounded
 0 = Analog current source output is not grounded
- bit 8 **CTTRIG:** ADC Trigger Control bit
 1 = CTMU triggers ADC start of conversion
 0 = CTMU does not trigger ADC start of conversion
- bit 7-0 **Unimplemented:** Read as '0'

Note 1: The ADC module Sample-and-Hold capacitor is not automatically discharged between sample/conversion cycles. Software using the ADC as part of a capacitance measurement must discharge the ADC capacitor before conducting the measurement. The IDISSEN bit, when set to '1', performs this function. The ADC must be sampling while the IDISSEN bit is active to connect the discharge sink to the capacitor array.

REGISTER 24-2: PTGCON: PTG CONTROL REGISTER

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
PTGCLK2	PTGCLK1	PTGCLK0	PTGDIV4	PTGDIV3	PTGDIV2	PTGDIV1	PTGDIV0
bit 15							bit 8

R/W-0	R/W-0	R/W-0	R/W-0	U-0	R/W-0	R/W-0	R/W-0
PTGPWD3	PTGPWD2	PTGPWD1	PTGPWD0	—	PTGWDT2	PTGWDT1	PTGWDT0
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 15-13 **PTGCLK<2:0>:** Select PTG Module Clock Source bits

111 = Reserved
 110 = Reserved
 101 = PTG module clock source will be T3CLK
 100 = PTG module clock source will be T2CLK
 011 = PTG module clock source will be T1CLK
 010 = PTG module clock source will be TAD
 001 = PTG module clock source will be Fosc
 000 = PTG module clock source will be FP

bit 12-8 **PTGDIV<4:0>:** PTG Module Clock Prescaler (divider) bits

11111 = Divide-by-32
 11110 = Divide-by-31
 •
 •
 •
 00001 = Divide-by-2
 00000 = Divide-by-1

bit 7-4 **PTGPWD<3:0>:** PTG Trigger Output Pulse-Width bits

1111 = All trigger outputs are 16 PTG clock cycles wide
 1110 = All trigger outputs are 15 PTG clock cycles wide
 •
 •
 •
 0001 = All trigger outputs are 2 PTG clock cycles wide
 0000 = All trigger outputs are 1 PTG clock cycle wide

bit 3 **Unimplemented:** Read as '0'

bit 2-0 **PTGWDT<2:0>:** Select PTG Watchdog Timer Time-out Count Value bits

111 = Watchdog Timer will time-out after 512 PTG clocks
 110 = Watchdog Timer will time-out after 256 PTG clocks
 101 = Watchdog Timer will time-out after 128 PTG clocks
 100 = Watchdog Timer will time-out after 64 PTG clocks
 011 = Watchdog Timer will time-out after 32 PTG clocks
 010 = Watchdog Timer will time-out after 16 PTG clocks
 001 = Watchdog Timer will time-out after 8 PTG clocks
 000 = Watchdog Timer is disabled

25.1 Op Amp Application Considerations

There are two configurations to take into consideration when designing with the op amp modules that are available in the dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X and PIC24EPXXXGP/MC20X devices. Configuration A (see Figure 25-6) takes advantage of the internal connection to the ADC module to route the output of the op amp directly to the ADC for measurement. Configuration B (see Figure 25-7) requires that the designer externally route the output of the op amp (OAxOUT) to a separate analog input pin (ANy) on the device. Table 30-55 in **Section 30.0 “Electrical Characteristics”** describes the performance characteristics for the op amps, distinguishing between the two configuration types where applicable.

25.1.1 OP AMP CONFIGURATION A

Figure 25-6 shows a typical inverting amplifier circuit taking advantage of the internal connections from the op amp output to the input of the ADC. The advantage of this configuration is that the user does not need to consume another analog input (ANy) on the device, and allows the user to simultaneously sample all three op amps with the ADC module, if needed. However, the presence of the internal resistance, RINT1, adds an error in the feedback path. Since RINT1 is an internal resistance, in relation to the op amp output (VOAxOUT) and ADC internal connection (VADC), RINT1 must be included in the numerator term of the transfer function. 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 25-6 also defines the equations that should be used when calculating the expected voltages at points, VADC and VOAxOUT.

FIGURE 25-6: OP AMP CONFIGURATION A

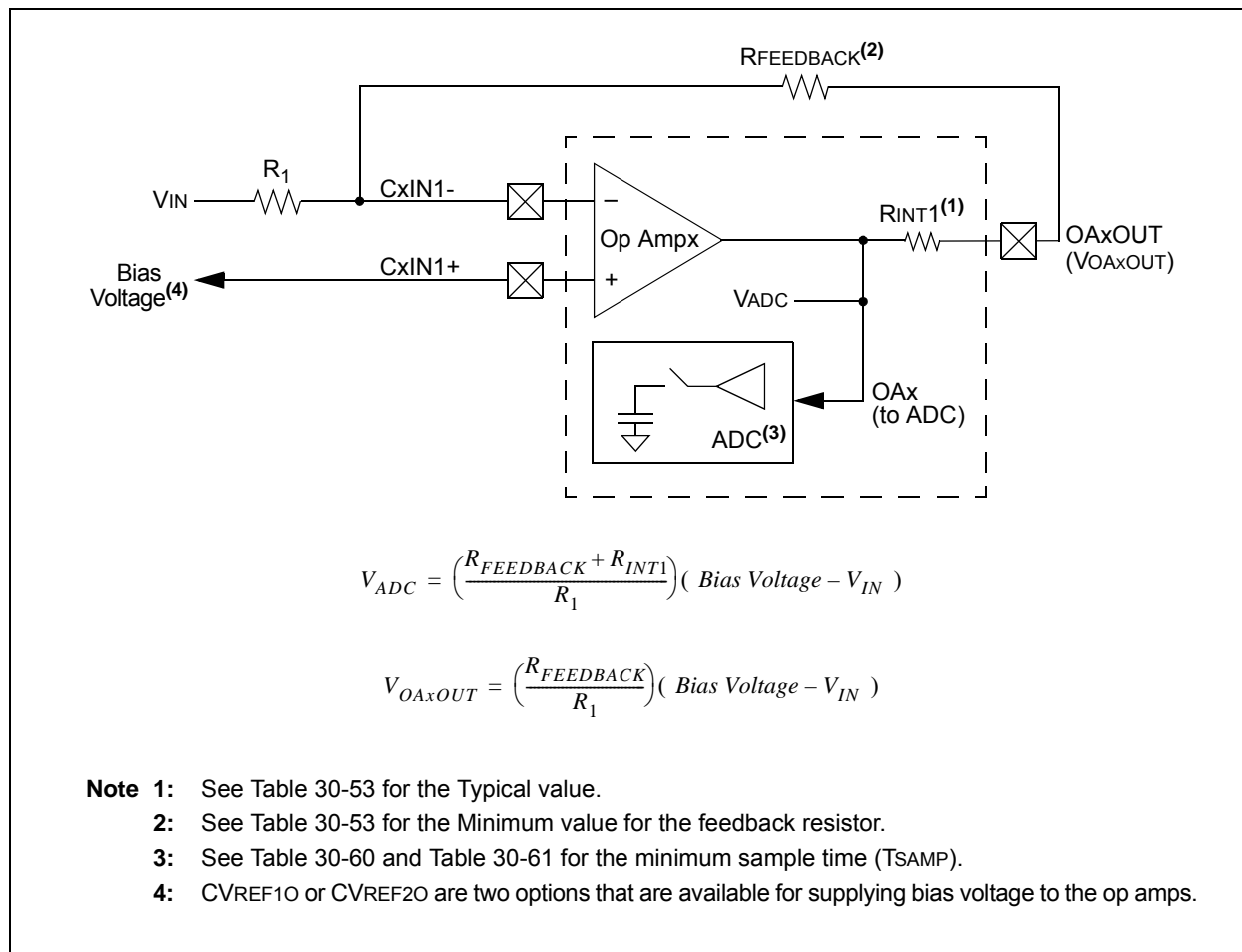


TABLE 30-11: DC CHARACTERISTICS: I/O PIN INPUT SPECIFICATIONS (CONTINUED)

DC CHARACTERISTICS			Standard Operating Conditions: 3.0V to 3.6V (unless otherwise stated) Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$ for Industrial $-40^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$ for Extended				
Param No.	Symbol	Characteristic	Min.	Typ.	Max.	Units	Conditions
DI50	I _{IL}	Input Leakage Current^(1,2) I/O Pins 5V Tolerant ⁽³⁾	-1	—	+1	μA	V _{SS} ≤ V _{PIN} ≤ V _{DD} , Pin at high-impedance
DI51		I/O Pins Not 5V Tolerant ⁽³⁾	-1	—	+1	μA	V _{SS} ≤ V _{PIN} ≤ V _{DD} , Pin at high-impedance, $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$
DI51a		I/O Pins Not 5V Tolerant ⁽³⁾	-1	—	+1	μA	Analog pins shared with external reference pins, $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$
DI51b		I/O Pins Not 5V Tolerant ⁽³⁾	-1	—	+1	μA	V _{SS} ≤ V _{PIN} ≤ V _{DD} , Pin at high-impedance, $-40^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$
DI51c		I/O Pins Not 5V Tolerant ⁽³⁾	-1	—	+1	μA	Analog pins shared with external reference pins, $-40^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$
DI55		MCLR	-5	—	+5	μA	V _{SS} ≤ V _{PIN} ≤ V _{DD}
DI56		OSC1	-5	—	+5	μA	V _{SS} ≤ V _{PIN} ≤ V _{DD} , XT and HS modes

- Note 1:** The leakage current on the MCLR pin is strongly dependent on the applied voltage level. The specified levels represent normal operating conditions. Higher leakage current can be measured at different input voltages.
- 2:** Negative current is defined as current sourced by the pin.
- 3:** See the “Pin Diagrams” section for the 5V tolerant I/O pins.
- 4:** V_{IL} source < (V_{SS} – 0.3). Characterized but not tested.
- 5:** Non-5V tolerant pins V_{IH} source > (V_{DD} + 0.3), 5V tolerant pins V_{IH} source > 5.5V. Characterized but not tested.
- 6:** Digital 5V tolerant pins cannot tolerate any “positive” input injection current from input sources > 5.5V.
- 7:** Non-zero injection currents can affect the ADC results by approximately 4-6 counts.
- 8:** Any number and/or combination of I/O pins not excluded under I_{ICL} or I_{ICH} conditions are permitted provided the mathematical “absolute instantaneous” sum of the input injection currents from all pins do not exceed the specified limit. Characterized but not tested.

TABLE 30-60: ADC CONVERSION (12-BIT MODE) TIMING REQUIREMENTS

AC CHARACTERISTICS			Standard Operating Conditions: 3.0V to 3.6V (unless otherwise stated) ⁽¹⁾ Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended				
Param No.	Symbol	Characteristic	Min.	Typ.	Max.	Units	Conditions
Clock Parameters							
AD50	TAD	ADC Clock Period	117.6	—	—	ns	
AD51	tRC	ADC Internal RC Oscillator Period ⁽²⁾	—	250	—	ns	
Conversion Rate							
AD55	tCONV	Conversion Time	—	14 TAD	—	ns	
AD56	FCNV	Throughput Rate	—	—	500	ksps	
AD57a	TSAMP	Sample Time when Sampling any ANx Input	3 TAD	—	—	—	
AD57b	TSAMP	Sample Time when Sampling the Op Amp Outputs (Configuration A and Configuration B) ^(4,5)	3 TAD	—	—	—	
Timing Parameters							
AD60	tPCS	Conversion Start from Sample Trigger ^(2,3)	2 TAD	—	3 TAD	—	Auto-convert trigger is not selected
AD61	tPSS	Sample Start from Setting Sample (SAMP) bit ^(2,3)	2 TAD	—	3 TAD	—	
AD62	tCSS	Conversion Completion to Sample Start (ASAM = 1) ^(2,3)	—	0.5 TAD	—	—	
AD63	tDPU	Time to Stabilize Analog Stage from ADC Off to ADC On ^(2,3)	—	—	20	μs	(Note 6)

Note 1: Device is functional at VBORMIN < VDD < VDDMIN, but will have degraded performance. Device functionality is tested, but not characterized. Analog modules (ADC, op amp/comparator and comparator voltage reference) may have degraded performance. Refer to Parameter BO10 in Table 30-13 for the minimum and maximum BOR values.

2: Parameters are characterized but not tested in manufacturing.

3: Because the sample caps will eventually lose charge, clock rates below 10 kHz may affect linearity performance, especially at elevated temperatures.

4: See Figure 25-6 for configuration information.

5: See Figure 25-7 for configuration information.

6: The parameter, tDPU, is the time required for the ADC module to stabilize at the appropriate level when the module is turned on (ADON (AD1CON1<15>) = 1). During this time, the ADC result is indeterminate.

31.2 AC Characteristics and Timing Parameters

The information contained in this section defines dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X and PIC24EPXXXGP/MC20X AC characteristics and timing parameters for high-temperature devices. However, all AC timing specifications in this section are the same as those in **Section 30.2 “AC Characteristics and Timing Parameters”**, with the exception of the parameters listed in this section.

Parameters in this section begin with an H, which denotes High temperature. For example, Parameter OS53 in **Section 30.2 “AC Characteristics and Timing Parameters”** is the Industrial and Extended temperature equivalent of HOS53.

TABLE 31-9: TEMPERATURE AND VOLTAGE SPECIFICATIONS – AC

AC CHARACTERISTICS	Standard Operating Conditions: 3.0V to 3.6V (unless otherwise stated)
	Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +150^{\circ}\text{C}$ Operating voltage VDD range as described in Table 31-1.

FIGURE 31-1: LOAD CONDITIONS FOR DEVICE TIMING SPECIFICATIONS

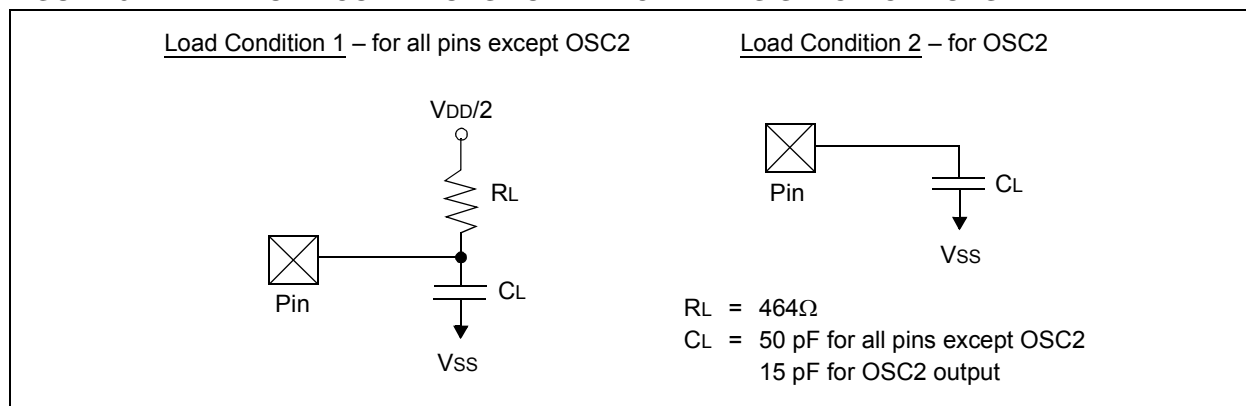


TABLE 31-10: PLL CLOCK TIMING SPECIFICATIONS

AC CHARACTERISTICS			Standard Operating Conditions: 3.0V to 3.6V (unless otherwise stated) Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +150^{\circ}\text{C}$				
Param No.	Symbol	Characteristic	Min	Typ	Max	Units	Conditions
HOS53	DCLK	CLKO Stability (Jitter) ⁽¹⁾	-5	0.5	5	%	Measured over 100 ms period

Note 1: These parameters are characterized by similarity, but are not tested in manufacturing. This specification is based on clock cycle by clock cycle measurements. To calculate the effective jitter for individual time bases or communication clocks use this formula:

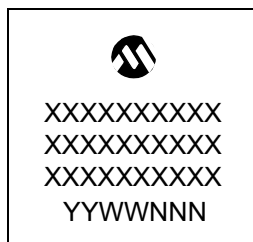
$$\text{Peripheral Clock Jitter} = \frac{DCLK}{\sqrt{\left(\frac{FOSC}{\text{Peripheral Bit Rate Clock}}\right)}}$$

For example: FOSC = 32 MHz, DCLK = 5%, SPIx bit rate clock (i.e., SCKx) is 2 MHz.

$$\text{SPI SCK Jitter} = \left[\frac{DCLK}{\sqrt{\left(\frac{32 \text{ MHz}}{2 \text{ MHz}}\right)}} \right] = \left[\frac{5\%}{\sqrt{16}} \right] = \left[\frac{5\%}{4} \right] = 1.25\%$$

33.1 Package Marking Information (Continued)

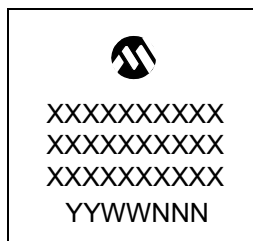
36-Lead VTLA (TLA)



Example



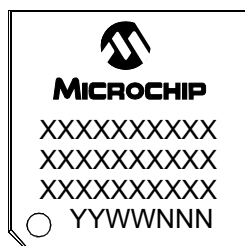
44-Lead VTLA (TLA)



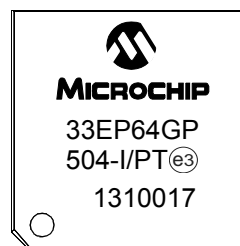
Example



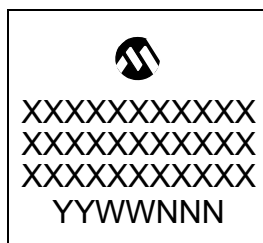
44-Lead TQFP



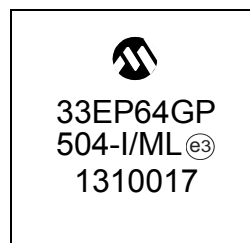
Example



44-Lead QFN (8x8x0.9 mm)

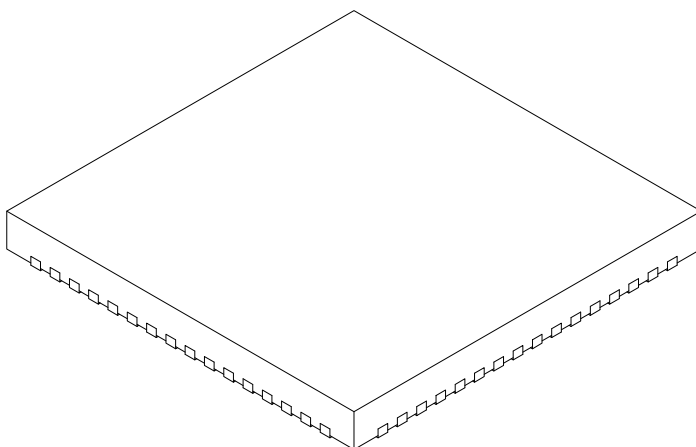


Example



64-Lead Plastic Quad Flat, No Lead Package (MR) – 9x9x0.9 mm Body with 5.40 x 5.40 Exposed Pad [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	64		
Pitch	e	0.50 BSC		
Overall Height	A	0.80	0.90	1.00
Standoff	A1	0.00	0.02	0.05
Contact Thickness	A3	0.20 REF		
Overall Width	E	9.00 BSC		
Exposed Pad Width	E2	5.30	5.40	5.50
Overall Length	D	9.00 BSC		
Exposed Pad Length	D2	5.30	5.40	5.50
Contact Width	b	0.20	0.25	0.30
Contact Length	L	0.30	0.40	0.50
Contact-to-Exposed Pad	K	0.20	-	-

Notes:

- Pin 1 visual index feature may vary, but must be located within the hatched area.
- Package is saw singulated.
- 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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TABLE A-2: MAJOR SECTION UPDATES (CONTINUED)

Section Name	Update Description
Section 16.0 “High-Speed PWM Module (dsPIC33EPXXXMC20X/50X and PIC24EPXXXMC20X Devices Only)”	Updated the High-Speed PWM Module Register Interconnection Diagram (see Figure 16-2). Added the TRGCONx and TRIGx registers (see Register 16-12 and Register 16-14, respectively).
Section 21.0 “Enhanced CAN (ECAN™) Module (dsPIC33EPXXXGP/MC50X Devices Only)”	Updated the CANCKS bit value definitions in CiCTRL1: ECAN Control Register 1 (see Register 21-1).
Section 22.0 “Charge Time Measurement Unit (CTMU)”	Updated the IRNG<1:0> bit value definitions and added Note 2 in the CTMU Current Control Register (see Register 22-3).
Section 25.0 “Op amp/Comparator Module”	Updated the Op amp/Comparator I/O Operating Modes Diagram (see Figure 25-1). Updated the User-programmable Blanking Function Block Diagram (see Figure 25-3). Updated the Digital Filter Interconnect Block Diagram (see Figure 25-4). Added Section 25.1 “Op amp Application Considerations” . Added Note 2 to the Comparator Control Register (see Register 25-2). Updated the bit definitions in the Comparator Mask Gating Control Register (see Register 25-5).
Section 27.0 “Special Features”	Updated the FICD Configuration Register, updated Note 1, and added Note 3 in the Configuration Byte Register Map (see Table 27-1). Added Section 27.2 “User ID Words” .
Section 30.0 “Electrical Characteristics”	Updated the following Absolute Maximum Ratings: <ul style="list-style-type: none"> Maximum current out of VSS pin Maximum current into VDD pin Added Note 1 to the Operating MIPS vs. Voltage (see Table 30-1). Updated all Idle Current (IDLE) Typical and Maximum DC Characteristics values (see Table 30-7). Updated all Doze Current (IDOZE) Typical and Maximum DC Characteristics values (see Table 30-9). Added Note 2, removed Parameter CM24, updated the Typical values Parameters CM10, CM20, CM21, CM32, CM41, CM44, and CM45, and updated the Minimum values for CM40 and CM41, and the Maximum value for CM40 in the AC/DC Characteristics: Op amp/Comparator (see Table 30-14). Updated Note 2 and the Typical value for Parameter VR310 in the Op amp/Comparator Reference Voltage Settling Time Specifications (see Table 30-15). Added Note 1, removed Parameter VRD312, and added Parameter VRD314 to the Op amp/Comparator Voltage Reference DC Specifications (see Table 30-16). Updated the Minimum, Typical, and Maximum values for Internal LPRC Accuracy (see Table 30-22). Updated the Minimum, Typical, and Maximum values for Parameter SY37 in the Reset, Watchdog Timer, Oscillator Start-up Timer, Power-up Timer Timing Requirements (see Table 30-24). The Maximum Data Rate values were updated for the SPI2 Maximum Data/Clock Rate Summary (see Table 30-35)