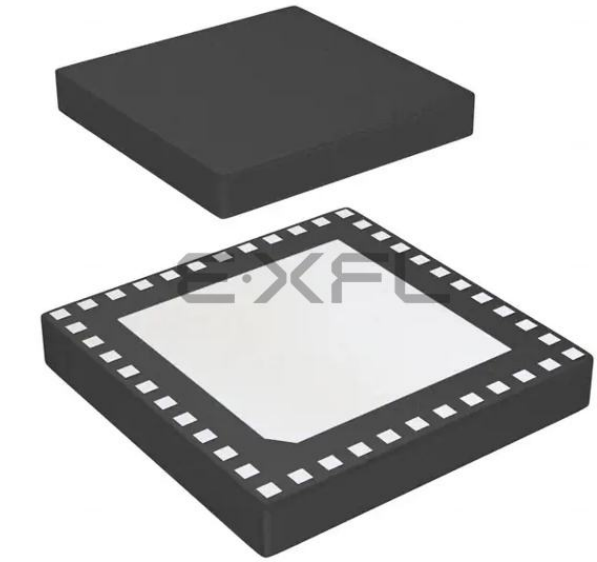
Microchip Technology - DSPIC33EP256MC204-H/TL Datasheet



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Applications of "Embedded - Microcontrollers"

Details	
Product Status	Obsolete
Core Processor	dsPIC
Core Size	16-Bit
Speed	60 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	35
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 9x10b/12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 150°C (TA)
Mounting Type	Surface Mount
Package / Case	44-VFTLA Exposed Pad
Supplier Device Package	44-VTLA (6x6)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/dspic33ep256mc204-h-tl

FIGURE 2-7: INTERLEAVED PFC

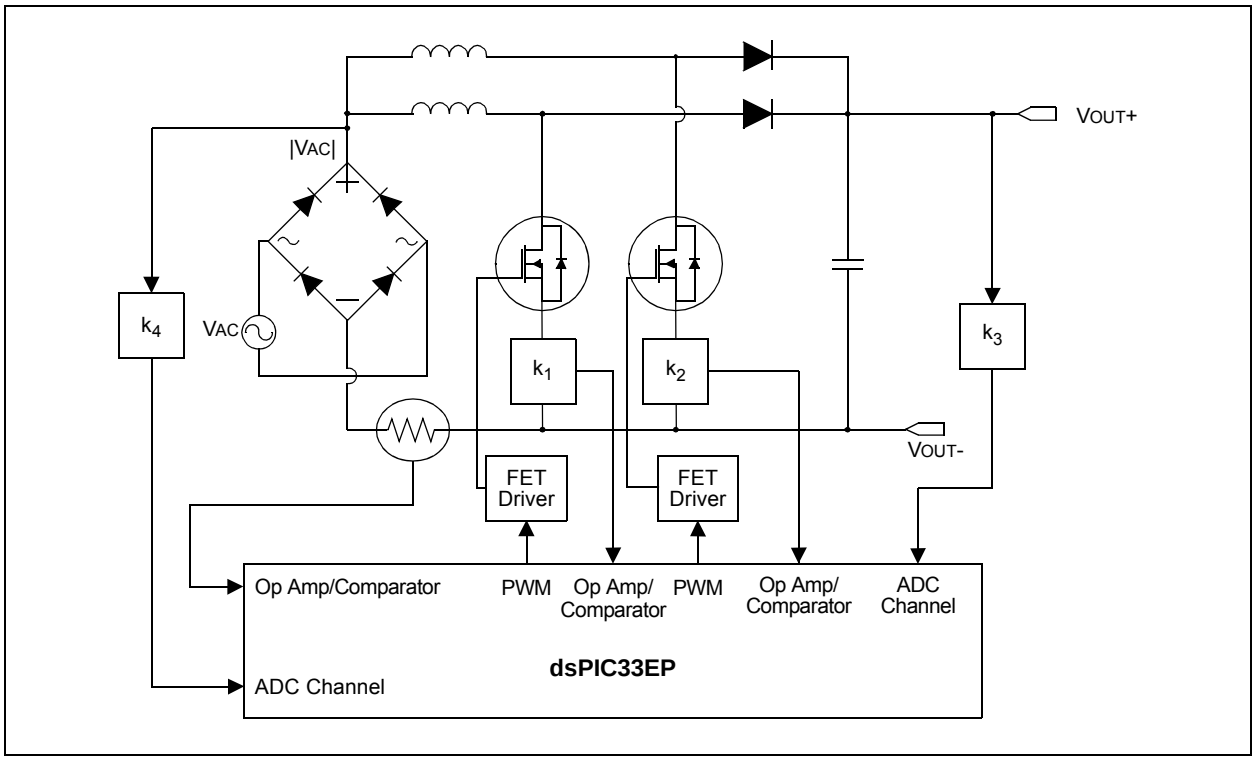
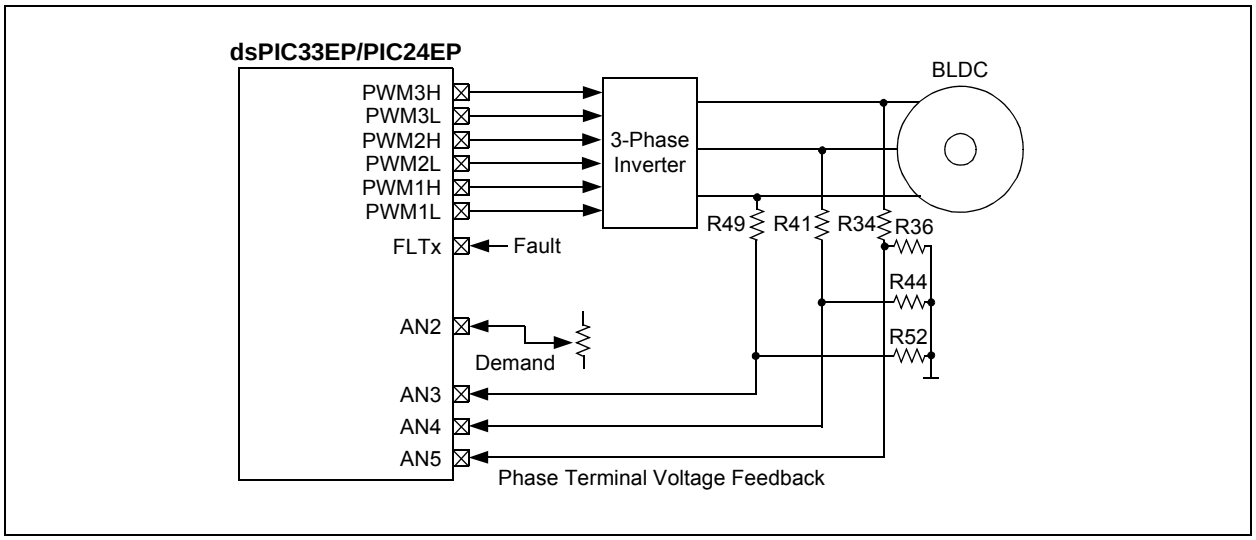


FIGURE 2-8: BEMF VOLTAGE MEASURED USING THE ADC MODULE



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.

TABLE 4-14: PWM GENERATOR 2 REGISTER MAP FOR dsPIC33EPXXXMC20X/50X AND PIC24EPXXXMC20X 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
PWMCON2	0C40	FLTSTAT	CLSTAT	TRGSTAT	FLTIEN	CLIEN	TRGIEN	ITB	MDCS	DTC<1:0>		DTCP	—	MTBS	CAM	XPRES	IUE	0000
IOCON2	0C42	PENH	PENL	POLH	POLL	PMOD<1:0>		OVRENH	OVRENL	OVRDAT<1:0>		FLTDAT<1:0>		CLDAT<1:0>		SWAP	OSYNC	C000
FCLCON2	0C44	—	CLSRC<4:0>					CLPOL	CLMOD	FLTSRC<4:0>					FLTPOL	FLTMOD<1:0>		00F8
PDC2	0C46	PDC2<15:0>																0000
PHASE2	0C48	PHASE2<15:0>																0000
DTR2	0C4A	—	—	DTR2<13:0>														0000
ALTDTR2	0C4C	—	—	ALTDTR2<13:0>														0000
TRIG2	0C52	TRGCMP<15:0>																0000
TRGCON2	0C54	TRGDIV<3:0>				—	—	—	—	—	—	TRGSTRT<5:0>						0000
LEBCON2	0C5A	PHR	PHF	PLR	PLF	FLTLEBEN	CLLEBEN	—	—	—	—	BCH	BCL	BPHH	BPHL	BPLH	BPLL	0000
LEBDLY2	0C5C	—	—	—	—	LEB<11:0>												0000
AUXCON2	0C5E	—	—	—	—	BLANKSEL<3:0>				—	—	CHOPSEL<3:0>				CHOPHEN	CHOPLEN	0000

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

TABLE 4-15: PWM GENERATOR 3 REGISTER MAP FOR dsPIC33EPXXXMC20X/50X AND PIC24EPXXXMC20X 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
PWMCON3	0C60	FLTSTAT	CLSTAT	TRGSTAT	FLTIEN	CLIEN	TRGIEN	ITB	MDCS	DTC<1:0>		DTCP	—	MTBS	CAM	XPRES	IUE	0000
IOCON3	0C62	PENH	PENL	POLH	POLL	PMOD<1:0>		OVRENH	OVRENL	OVRDAT<1:0>		FLTDAT<1:0>		CLDAT<1:0>		SWAP	OSYNC	C000
FCLCON3	0C64	—	CLSRC<4:0>					CLPOL	CLMOD	FLTSRC<4:0>					FLTPOL	FLTMOD<1:0>		00F8
PDC3	0C66	PDC3<15:0>																0000
PHASE3	0C68	PHASE3<15:0>																0000
DTR3	0C6A	—	—	DTR3<13:0>														0000
ALTDTR3	0C6C	—	—	ALTDTR3<13:0>														0000
TRIG3	0C72	TRGCMP<15:0>																0000
TRGCON3	0C74	TRGDIV<3:0>				—	—	—	—	—	—	TRGSTRT<5:0>						0000
LEBCON3	0C7A	PHR	PHF	PLR	PLF	FLTLEBEN	CLLEBEN	—	—	—	—	BCH	BCL	BPHH	BPHL	BPLH	BPLL	0000
LEBDLY3	0C7C	—	—	—	—	LEB<11:0>												0000
AUXCON3	0C7E	—	—	—	—	BLANKSEL<3:0>				—	—	CHOPSEL<3:0>				CHOPHEN	CHOPLEN	0000

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

5.0 FLASH PROGRAM MEMORY

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 **"Flash Programming"** (DS70609) 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 internal Flash program memory for storing and executing application code. The memory is readable, writable and erasable during normal operation over the entire VDD range.

Flash memory can be programmed in two ways:

- In-Circuit Serial Programming™ (ICSP™) programming capability
- Run-Time Self-Programming (RTSP)

ICSP allows for a dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X and PIC24EPXXXGP/MC20X device to be serially programmed while in the end application circuit. This is done with two lines for programming clock and programming data (one of the alternate programming pin pairs: PGECx/PGEDx), and three other lines for power (VDD), ground (VSS) and Master Clear (MCLR). This allows customers to manufacture boards with unprogrammed devices and then program the device just before shipping the product. This also allows the most recent firmware or a custom firmware to be programmed.

RTSP is accomplished using TBLRD (Table Read) and TBLWT (Table Write) instructions. With RTSP, the user application can write program memory data a single program memory word, and erase program memory in blocks or 'pages' of 1024 instructions (3072 bytes) at a time.

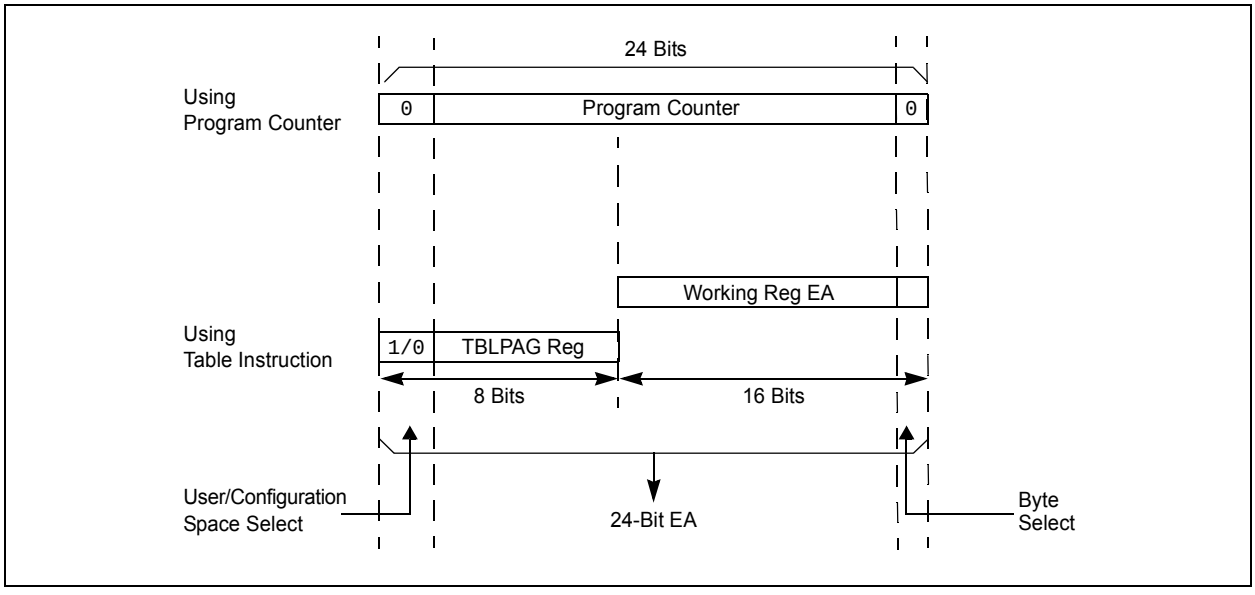
5.1 Table Instructions and Flash Programming

Regardless of the method used, all programming of Flash memory is done with the Table Read and Table Write instructions. These allow direct read and write access to the program memory space from the data memory while the device is in normal operating mode. The 24-bit target address in the program memory is formed using bits<7:0> of the TBLPAG register and the Effective Address (EA) from a W register, specified in the table instruction, as shown in Figure 5-1.

The TBLRDL and the TBLWTL instructions are used to read or write to bits<15:0> of program memory. TBLRDL and TBLWTL can access program memory in both Word and Byte modes.

The TBLRDH and TBLWTH instructions are used to read or write to bits<23:16> of program memory. TBLRDH and TBLWTH can also access program memory in Word or Byte mode.

FIGURE 5-1: ADDRESSING FOR TABLE REGISTERS



REGISTER 8-3: DMAxSTAH: DMA CHANNEL x START ADDRESS REGISTER A (HIGH)

U-0	U-0	U-0	U-0	U-0	U-0	U-0	U-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
STA<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 15-8 **Unimplemented:** Read as ‘0’

bit 7-0 **STA<23:16>:** Primary Start Address bits (source or destination)

REGISTER 8-4: DMAxSTAL: DMA CHANNEL x START ADDRESS REGISTER A (LOW)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
STA<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
STA<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 **STA<15:0>:** Primary Start Address bits (source or destination)

REGISTER 8-11: DMAPWC: DMA PERIPHERAL WRITE 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
—	—	—	—	PWCOL3	PWCOL2	PWCOL1	PWCOL0
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 **PWCOL3:** DMA Channel 3 Peripheral Write Collision Flag bit
1 = Write collision is detected
0 = No write collision is detected

bit 2 **PWCOL2:** DMA Channel 2 Peripheral Write Collision Flag bit
1 = Write collision is detected
0 = No write collision is detected

bit 1 **PWCOL1:** DMA Channel 1 Peripheral Write Collision Flag bit
1 = Write collision is detected
0 = No write collision is detected

bit 0 **PWCOL0:** DMA Channel 0 Peripheral Write Collision Flag bit
1 = Write collision is detected
0 = No write collision is detected

REGISTER 11-10: RPINR18: PERIPHERAL PIN SELECT INPUT REGISTER 18

U-0	U-0	U-0	U-0	U-0	U-0	U-0	U-0
—	—	—	—	—	—	—	—
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
—	U1RXR<6:0>						
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 15-7 **Unimplemented:** Read as ‘0’

bit 6-0 **U1RXR<6:0>:** Assign UART1 Receive (U1RX) to the Corresponding RPn Pin bits (see Table 11-2 for input pin selection numbers)

1111001 = Input tied to RPI121
.
.
.
0000001 = Input tied to CMP1
0000000 = Input tied to Vss

REGISTER 11-11: RPINR19: PERIPHERAL PIN SELECT INPUT REGISTER 19

U-0	U-0	U-0	U-0	U-0	U-0	U-0	U-0
—	—	—	—	—	—	—	—
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
—	U2RXR<6:0>						
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 15-7 **Unimplemented:** Read as ‘0’

bit 6-0 **U2RXR<6:0>:** Assign UART2 Receive (U2RX) to the Corresponding RPn Pin bits (see Table 11-2 for input pin selection numbers)

1111001 = Input tied to RPI121
.
.
.
0000001 = Input tied to CMP1
0000000 = Input tied to Vss

12.0 TIMER1

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 **"Timers"** (DS70362) 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 Timer1 module is a 16-bit timer that can operate as a free-running interval timer/counter.

The Timer1 module has the following unique features over other timers:

- Can be operated in Asynchronous Counter mode from an external clock source
- The external clock input (T1CK) can optionally be synchronized to the internal device clock and the clock synchronization is performed after the prescaler

A block diagram of Timer1 is shown in Figure 12-1.

The Timer1 module can operate in one of the following modes:

- Timer mode
- Gated Timer mode
- Synchronous Counter mode
- Asynchronous Counter mode

In Timer and Gated Timer modes, the input clock is derived from the internal instruction cycle clock (FCY). In Synchronous and Asynchronous Counter modes, the input clock is derived from the external clock input at the T1CK pin.

The Timer modes are determined by the following bits:

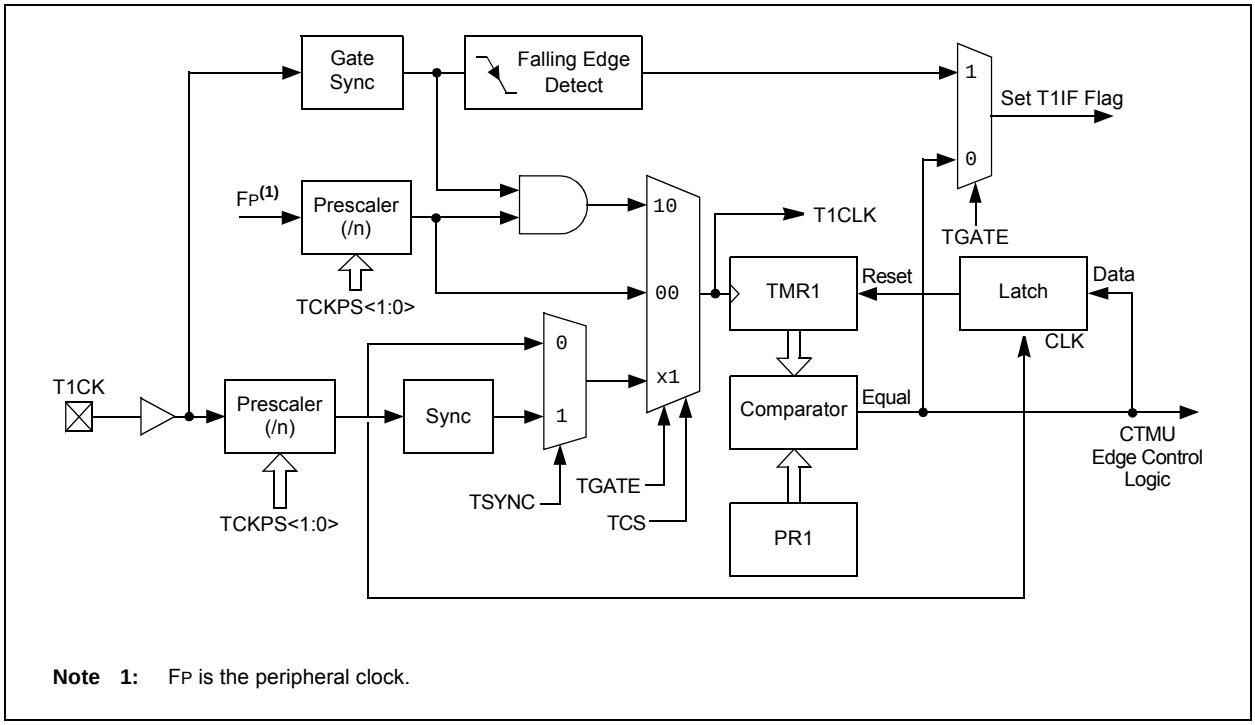
- Timer Clock Source Control bit (TCS): T1CON<1>
- Timer Synchronization Control bit (TSYNC): T1CON<2>
- Timer Gate Control bit (TGATE): T1CON<6>

Timer control bit setting for different operating modes are given in the Table 12-1.

TABLE 12-1: TIMER MODE SETTINGS

Mode	TCS	TGATE	TSYNC
Timer	0	0	x
Gated Timer	0	1	x
Synchronous Counter	1	x	1
Asynchronous Counter	1	x	0

FIGURE 12-1: 16-BIT TIMER1 MODULE BLOCK DIAGRAM



Note 1: FP is the peripheral clock.

REGISTER 14-2: ICxCON2: INPUT CAPTURE x CONTROL REGISTER 2 (CONTINUED)

bit 4-0 **SYNCSEL<4:0>:** Input Source Select for Synchronization and Trigger Operation bits(4)

11111 = No Sync or Trigger source for ICx
11110 = Reserved
11101 = Reserved
11100 = CTMU module synchronizes or triggers ICx
11011 = ADC1 module synchronizes or triggers ICx(5)
11010 = CMP3 module synchronizes or triggers ICx(5)
11001 = CMP2 module synchronizes or triggers ICx(5)
11000 = CMP1 module synchronizes or triggers ICx(5)
10111 = Reserved
10110 = Reserved
10101 = Reserved
10100 = Reserved
10011 = IC4 module synchronizes or triggers ICx
10010 = IC3 module synchronizes or triggers ICx
10001 = IC2 module synchronizes or triggers ICx
10000 = IC1 module synchronizes or triggers ICx
01111 = Timer5 synchronizes or triggers ICx
01110 = Timer4 synchronizes or triggers ICx
01101 = Timer3 synchronizes or triggers ICx **(default)**
01100 = Timer2 synchronizes or triggers ICx
01011 = Timer1 synchronizes or triggers ICx
01010 = PTGOx module synchronizes or triggers ICx(6)
01001 = Reserved
01000 = Reserved
00111 = Reserved
00110 = Reserved
00101 = Reserved
00100 = OC4 module synchronizes or triggers ICx
00011 = OC3 module synchronizes or triggers ICx
00010 = OC2 module synchronizes or triggers ICx
00001 = OC1 module synchronizes or triggers ICx
00000 = No Sync or Trigger source for ICx

Note 1: The IC32 bit in both the Odd and Even IC must be set to enable Cascade mode.

2: The input source is selected by the SYNCSEL<4:0> bits of the ICxCON2 register.

3: This bit is set by the selected input source (selected by SYNCSEL<4:0> bits). It can be read, set and cleared in software.

4: Do not use the ICx module as its own Sync or Trigger source.

5: This option should only be selected as a trigger source and not as a synchronization source.

6: Each Input Capture x (ICx) module has one PTG input source. See **Section 24.0 "Peripheral Trigger Generator (PTG) Module"** for more information.
PTGO8 = IC1
PTGO9 = IC2
PTGO10 = IC3
PTGO11 = IC4

REGISTER 16-5: CHOP: PWMx CHOP CLOCK GENERATOR REGISTER

R/W-0	U-0	U-0	U-0	U-0	U-0	R/W-0	R/W-0
CHPCLKEN	—	—	—	—	—	CHOPCLK<9:8>	
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
CHOPCLK<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 **CHPCLKEN:** Enable Chop Clock Generator bit
1 = Chop clock generator is enabled
0 = Chop clock generator is disabled

bit 14-10 **Unimplemented:** Read as ‘0’

bit 9-0 **CHOPCLK<9:0>:** Chop Clock Divider bits
The frequency of the chop clock signal is given by the following expression:
Chop Frequency = (FP/PCLKDIV<2:0)/(CHOPCLK<9:0> + 1)

REGISTER 16-6: MDC: PWMx MASTER DUTY CYCLE 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
MDC<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
MDC<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 **MDC<15:0>:** PWMx Master Duty Cycle Value bits

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 19-3: I2CxMSK: I2Cx SLAVE MODE ADDRESS MASK REGISTER

U-0	U-0	U-0	U-0	U-0	U-0	R/W-0	R/W-0
—	—	—	—	—	—	AMSK9	AMSK8
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
AMSK7	AMSK6	AMSK5	AMSK4	AMSK3	AMSK2	AMSK1	AMSK0
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 15-10 **Unimplemented:** Read as ‘0’

bit 9-0 **AMSK<9:0>:** Address Mask Select bits

For 10-Bit Address:

1 = Enables masking for bit Ax of incoming message address; bit match is not required in this position

0 = Disables masking for bit Ax; bit match is required in this position

For 7-Bit Address (I2CxMSK<6:0> only):

1 = Enables masking for bit Ax + 1 of incoming message address; bit match is not required in this position

0 = Disables masking for bit Ax + 1; bit match is required in this position

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>)

NOTES:

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

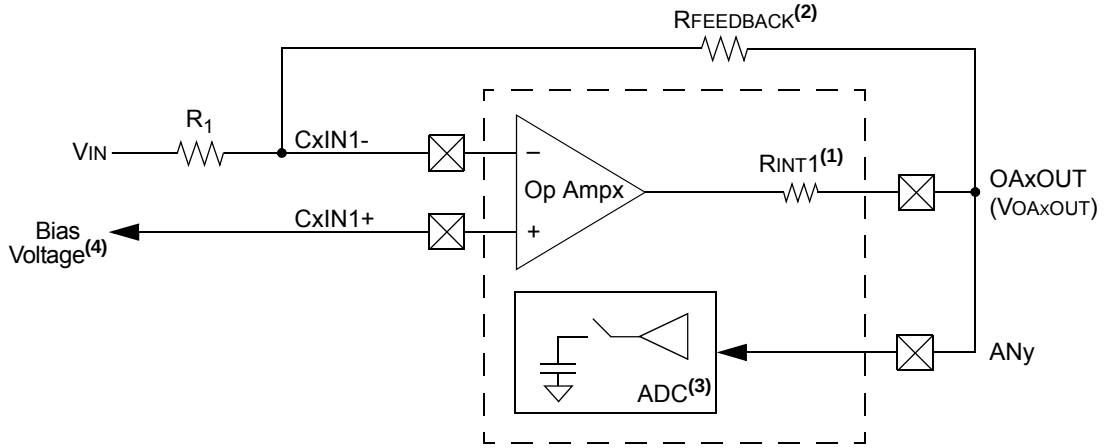
Many useful resources are provided on the main product page of the Microchip web site for the devices listed in this data sheet. This product page, which can be accessed using this link, contains the latest updates and additional information.

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



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

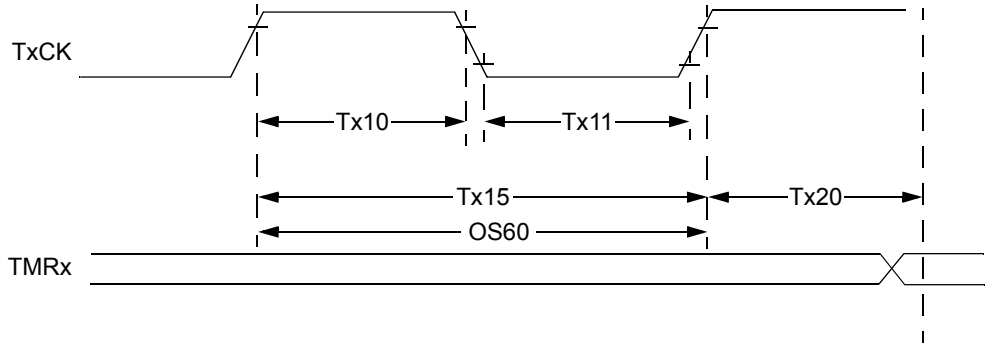
Note 1: See Table 30-53 for the Typical value.
2: See Table 30-53 for the Minimum value for the feedback resistor.
3: See Table 30-60 and Table 30-61 for the minimum sample time (TSAMP).
4: CVREF1O or CVREF2O are two options that are available for supplying bias voltage to the op amps.

TABLE 28-2: INSTRUCTION SET OVERVIEW (CONTINUED)

Base Instr #	Assembly Mnemonic	Assembly Syntax		Description	# of Words	# of Cycles(2)	Status Flags Affected
72	SL	SL	f	f = Left Shift f	1	1	C,N,OV,Z
		SL	f,WREG	WREG = Left Shift f	1	1	C,N,OV,Z
		SL	Ws,Wd	Wd = Left Shift Ws	1	1	C,N,OV,Z
		SL	Wb,Wns,Wnd	Wnd = Left Shift Wb by Wns	1	1	N,Z
		SL	Wb,#lit5,Wnd	Wnd = Left Shift Wb by lit5	1	1	N,Z
73	SUB	SUB	Acc(1)	Subtract Accumulators	1	1	OA,OB,OAB, SA,SB,SAB
		SUB	f	f = f – WREG	1	1	C,DC,N,OV,Z
		SUB	f,WREG	WREG = f – WREG	1	1	C,DC,N,OV,Z
		SUB	#lit10,Wn	Wn = Wn – lit10	1	1	C,DC,N,OV,Z
		SUB	Wb,Ws,Wd	Wd = Wb – Ws	1	1	C,DC,N,OV,Z
		SUB	Wb,#lit5,Wd	Wd = Wb – lit5	1	1	C,DC,N,OV,Z
74	SUBB	SUBB	f	f = f – WREG – ($\overline{C}$)	1	1	C,DC,N,OV,Z
		SUBB	f,WREG	WREG = f – WREG – ($\overline{C}$)	1	1	C,DC,N,OV,Z
		SUBB	#lit10,Wn	Wn = Wn – lit10 – ($\overline{C}$)	1	1	C,DC,N,OV,Z
		SUBB	Wb,Ws,Wd	Wd = Wb – Ws – ($\overline{C}$)	1	1	C,DC,N,OV,Z
		SUBB	Wb,#lit5,Wd	Wd = Wb – lit5 – ($\overline{C}$)	1	1	C,DC,N,OV,Z
75	SUBR	SUBR	f	f = WREG – f	1	1	C,DC,N,OV,Z
		SUBR	f,WREG	WREG = WREG – f	1	1	C,DC,N,OV,Z
		SUBR	Wb,Ws,Wd	Wd = Ws – Wb	1	1	C,DC,N,OV,Z
		SUBR	Wb,#lit5,Wd	Wd = lit5 – Wb	1	1	C,DC,N,OV,Z
76	SUBBR	SUBBR	f	f = WREG – f – ($\overline{C}$)	1	1	C,DC,N,OV,Z
		SUBBR	f,WREG	WREG = WREG – f – ($\overline{C}$)	1	1	C,DC,N,OV,Z
		SUBBR	Wb,Ws,Wd	Wd = Ws – Wb – ($\overline{C}$)	1	1	C,DC,N,OV,Z
		SUBBR	Wb,#lit5,Wd	Wd = lit5 – Wb – ($\overline{C}$)	1	1	C,DC,N,OV,Z
77	SWAP	SWAP.b	Wn	Wn = nibble swap Wn	1	1	None
		SWAP	Wn	Wn = byte swap Wn	1	1	None
78	TBLRDH	TBLRDH	Ws,Wd	Read Prog<23:16> to Wd<7:0>	1	5	None
79	TBLRDL	TBLRDL	Ws,Wd	Read Prog<15:0> to Wd	1	5	None
80	TBLWTH	TBLWTH	Ws,Wd	Write Ws<7:0> to Prog<23:16>	1	2	None
81	TBLWTL	TBLWTL	Ws,Wd	Write Ws to Prog<15:0>	1	2	None
82	ULNK	ULNK		Unlink Frame Pointer	1	1	SFA
83	XOR	XOR	f	f = f .XOR. WREG	1	1	N,Z
		XOR	f,WREG	WREG = f .XOR. WREG	1	1	N,Z
		XOR	#lit10,Wn	Wd = lit10 .XOR. Wd	1	1	N,Z
		XOR	Wb,Ws,Wd	Wd = Wb .XOR. Ws	1	1	N,Z
		XOR	Wb,#lit5,Wd	Wd = Wb .XOR. lit5	1	1	N,Z
84	ZE	ZE	Ws,Wnd	Wnd = Zero-extend Ws	1	1	C,Z,N

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.

FIGURE 30-5: TIMER1-TIMER5 EXTERNAL CLOCK TIMING CHARACTERISTICS



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

TABLE 30-23: TIMER1 EXTERNAL CLOCK TIMING REQUIREMENTS(1)

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(2)**		**Min.**	**Typ.**	**Max.**	**Units**	**Conditions**
TA10	TTXH	T1CK High Time	Synchronous mode	Greater of: 20 or (TCY + 20)/N	—	—	ns	Must also meet Parameter TA15, N = prescaler value (1, 8, 64, 256)
			Asynchronous	35	—	—	ns	
TA11	TTXL	T1CK Low Time	Synchronous mode	Greater of: 20 or (TCY + 20)/N	—	—	ns	Must also meet Parameter TA15, N = prescaler value (1, 8, 64, 256)
			Asynchronous	10	—	—	ns	
TA15	TTXP	T1CK Input Period	Synchronous mode	Greater of: 40 or (2 TCY + 40)/N	—	—	ns	N = prescale value (1, 8, 64, 256)
OS60	Ft1	T1CK Oscillator Input Frequency Range (oscillator enabled by setting bit, TCS (T1CON<1>))		DC	—	50	kHz	
TA20	TCKEXTMRL	Delay from External T1CK Clock Edge to Timer Increment		0.75 TCY + 40	—	1.75 TCY + 40	ns	

Note 1: Timer1 is a Type A.

2: These parameters are characterized, but are not tested in manufacturing.

TABLE 30-57: ADC MODULE SPECIFICATIONS

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**
Device Supply							
AD01	AVDD	Module VDD Supply	Greater of: VDD – 0.3 or 3.0	—	Lesser of: VDD + 0.3 or 3.6	V	
AD02	AVSS	Module VSS Supply	VSS – 0.3	—	VSS + 0.3	V	
Reference Inputs							
AD05	VREFH	Reference Voltage High	AVSS + 2.5	—	AVDD	V	VREFH = VREF+ VREFL = VREF- **(Note 1)**
AD05a			3.0	—	3.6	V	VREFH = AVDD VREFL = AVSS = 0
AD06	VREFL	Reference Voltage Low	AVSS	—	AVDD – 2.5	V	**(Note 1)**
AD06a			0	—	0	V	VREFH = AVDD VREFL = AVSS = 0
AD07	VREF	Absolute Reference Voltage	2.5	—	3.6	V	VREF = VREFH - VREFL
AD08	IREF	Current Drain	— —	— —	10 600	μA μA	ADC off ADC on
AD09	IAD	Operating Current[2]	—	5	—	mA	ADC operating in 10-bit mode **(Note 1)**
			—	2	—	mA	ADC operating in 12-bit mode **(Note 1)**
Analog Input							
AD12	VINH	Input Voltage Range VINH	VINL	—	VREFH	V	This voltage reflects Sample-and-Hold Channels 0, 1, 2 and 3 (CH0-CH3), positive input
AD13	VINL	Input Voltage Range VINL	VREFL	—	AVSS + 1V	V	This voltage reflects Sample-and-Hold Channels 0, 1, 2 and 3 (CH0-CH3), negative input
AD17	RIN	Recommended Impedance of Analog Voltage Source	—	—	200	Ω	Impedance to achieve maximum performance of ADC

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: Parameter is characterized but not tested in manufacturing.

31.0 HIGH-TEMPERATURE ELECTRICAL CHARACTERISTICS

This section provides an overview of dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X and PIC24EPXXXGP/MC20X electrical characteristics for devices operating in an ambient temperature range of -40°C to +150°C.

The specifications between -40°C to +150°C are identical to those shown in **Section 30.0 "Electrical Characteristics"** for operation between -40°C to +125°C, 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 DC10 in **Section 30.0 "Electrical Characteristics"** is the Industrial and Extended temperature equivalent of HDC10.

Absolute maximum ratings for the dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X and PIC24EPXXXGP/MC20X high-temperature devices are listed below. Exposure to these maximum rating conditions for extended periods can affect device reliability. Functional operation of the device at these or any other conditions above the parameters indicated in the operation listings of this specification is not implied.

Absolute Maximum Ratings(1)

Ambient temperature under bias(2) ..... -40°C to +150°C
Storage temperature ..... -65°C to +160°C
Voltage on V_{DD} with respect to V_{SS} ..... -0.3V to +4.0V
Voltage on any pin that is not 5V tolerant with respect to V_{SS}(3) ..... -0.3V to (V_{DD} + 0.3V)
Voltage on any 5V tolerant pin with respect to V_{SS} when V_{DD} < 3.0V(3) ..... -0.3V to 3.6V
Voltage on any 5V tolerant pin with respect to V_{SS} when $V_{DD} \geq 3.0V$(3) ..... -0.3V to 5.5V
Maximum current out of V_{SS} pin ..... 60 mA
Maximum current into V_{DD} pin(4) ..... 60 mA
Maximum junction temperature ..... +155°C
Maximum current sourced/sunk by any 4x I/O pin ..... 10 mA
Maximum current sourced/sunk by any 8x I/O pin ..... 15 mA
Maximum current sunk by all ports combined ..... 70 mA
Maximum current sourced by all ports combined(4) ..... 70 mA

Note 1: Stresses above those listed under "Absolute Maximum Ratings" can cause permanent damage to the device. This is a stress rating only, and functional operation of the device at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods can affect device reliability.

2: AEC-Q100 reliability testing for devices intended to operate at +150°C is 1,000 hours. Any design in which the total operating time from +125°C to +150°C will be greater than 1,000 hours is not warranted without prior written approval from Microchip Technology Inc.

3: Refer to the **"Pin Diagrams"** section for 5V tolerant pins.

4: Maximum allowable current is a function of device maximum power dissipation (see Table 31-2).

TABLE A-2: MAJOR SECTION UPDATES (CONTINUED)

Section Name	Update Description
Section 30.0 "Electrical Characteristics" (Continued)	These SPI2 Timing Requirements were updated: • Maximum value for Parameter SP10 and the minimum clock period value for SCKx in Note 3 (see Table 30-36, Table 30-37, and Table 30-38) • Maximum value for Parameter SP70 and the minimum clock period value for SCKx in Note 3 (see Table 30-40 and Table 30-42) • The Maximum Data Rate values were updated for the SPI2 Maximum Data/Clock Rate Summary (see Table 30-43) These SPI1 Timing Requirements were updated: • Maximum value for Parameters SP10 and the minimum clock period value for SCKx in Note 3 (see Table 30-44, Table 30-45, and Table 30-46) • Maximum value for Parameters SP70 and the minimum clock period value for SCKx in Note 3 (see Table 30-47 through Table 30-50) • Minimum value for Parameters SP40 and SP41 see Table 30-44 through Table 30-50) Updated all Typical values for the CTMU Current Source Specifications (see Table 30-55). Updated Note1, the Maximum value for Parameter AD06, the Minimum value for AD07, and the Typical values for AD09 in the ADC Module Specifications (see Table 30-56). Added Note 1 to the ADC Module Specifications (12-bit Mode) (see Table 30-57). Added Note 1 to the ADC Module Specifications (10-bit Mode) (see Table 30-58). Updated the Minimum and Maximum values for Parameter AD21b in the 10-bit Mode ADC Module Specifications (see Table 30-58). Updated Note 2 in the ADC Conversion (12-bit Mode) Timing Requirements (see Table 30-59). Updated Note 1 in the ADC Conversion (10-bit Mode) Timing Requirements (see Table 30-60).