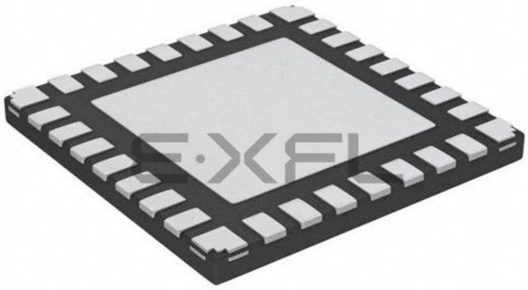

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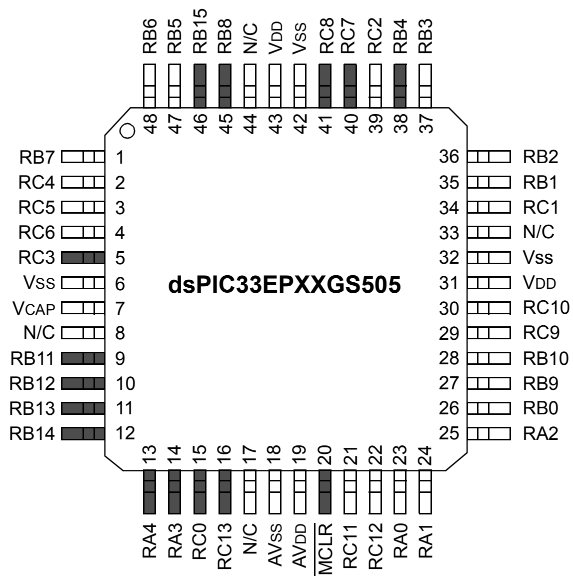
Applications of "Embedded - Microcontrollers"

Details	
Product Status	Obsolete
Core Processor	dsPIC
Core Size	16-Bit
Speed	60 MIPs
Connectivity	I²C, IrDA, LINbus, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	21
Program Memory Size	32KB (32K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	4K x 8
Voltage - Supply (Vcc/Vdd)	3V ~ 3.6V
Data Converters	A/D 12x12b; D/A 1x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 125°C (TA)
Mounting Type	Surface Mount
Package / Case	28-UQFN Exposed Pad
Supplier Device Package	28-UQFN (6x6)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/dspic33ep32gs502t-e-mx

Pin Diagrams (Continued)

48-Pin TQFP



Pin	Pin Function	Pin	Pin Function
1	PGEC1/AN21/SDA1/**RP39**/RB7	25	AN2/PGA1P3/PGA2P2/CMP1C/CMP2A/RA2
2	AN1ALT/**RP52**/RC4	26	AN3/PGA2P3/CMP1D/CMP2B/**RP32**/RB0
3	AN0ALT/**RP53**/RC5	27	AN4/CMP2C/CMP3A/ISRC4/**RP41**/RB9
4	AN17/**RP54**/RC6	28	AN5/CMP2D/CMP3B/ISRC3/**RP42**/RB10
5	**RP51**/RC3	29	AN11/PGA1N3/**RP57**/RC9
6	VSS	30	AN10/PGA1P4/EXTREF2/**RP58**/RC10
7	VCAP	31	VDD
8	N/C	32	VSS
9	TMS/PWM3H/**RP43**/RB11	33	N/C
10	TCK/PWM3L/**RP44**/RB12	34	AN8/PGA2P4/CMP4C/**RP49**/RC1
11	PWM2H/**RP45**/RB13	35	OSC1/CLKI/AN6/CMP3C/CMP4A/ISRC2/**RP33**/RB1
12	PWM2L/**RP46**/RB14	36	OSC2/CLKO/AN7/PGA1N2/CMP3D/CMP4B/**RP34**/RB2
13	PWM1H/RA4	37	PGED2/AN18/DACOUT1/INT0/**RP35**/RB3
14	PWM1L/RA3	38	PGEC2/ADTRG31/**RP36**/RB4
15	FLT12/**RP48**/RC0	39	AN9/CMP4D/EXTREF1/**RP50** /RC2
16	FLT11/**RP61**/RC13	40	ASDA1/**RP55**/RC7
17	N/C	41	ASCL1/**RP56**/RC8
18	AVSS	42	VSS
19	AVDD	43	VDD
20	MCLR	44	N/C
21	AN12/ISRC1/**RP59**/RC11	45	PGED3/SDA2/**RP40**/RB8
22	AN14/PGA2N3/**RP60**/RC12	46	PGEC3/SCL2/**RP47**/RB15
23	AN0/PGA1P1/CMP1A/RA0	47	TDO/AN19/PGA2N2/**RP37**/RB5
24	AN1/PGA1P2/PGA2P1/CMP1B/RA1	48	PGED1/TDI/AN20/SCL1/**RP38**/RB6

Legend: **Shaded pins** are up to 5 VDC tolerant.
RPn represents remappable peripheral functions. See Table 10-1 and Table 10-2 for the complete list of remappable sources.

3.8 Arithmetic Logic Unit (ALU)

The dsPIC33EPXXGS50X family ALU is 16 bits wide and is capable of addition, subtraction, bit shifts and logic operations. Unless otherwise mentioned, arithmetic operations are two's complement in nature. Depending on the operation, the ALU can affect the values of the Carry (C), Zero (Z), Negative (N), Overflow (OV) and Digit Carry (DC) Status bits in the SR register. The C and DC Status bits operate as $\overline{\text{Borrow}}$ and $\overline{\text{Digit Borrow}}$ bits, respectively, for subtraction operations.

The ALU can perform 8-bit or 16-bit operations, depending on the mode of the instruction that is used. Data for the ALU operation can come from the W register array or data memory, depending on the addressing mode of the instruction. Likewise, output data from the ALU can be written to the W register array or a data memory location.

Refer to the *"16-bit MCU and DSC Programmer's Reference Manual"* (DS70157) for information on the SR bits affected by each instruction.

The core CPU incorporates hardware support for both multiplication and division. This includes a dedicated hardware multiplier and support hardware for 16-bit divisor division.

3.8.1 MULTIPLIER

Using the high-speed 17-bit x 17-bit multiplier, the ALU supports unsigned, signed, or mixed-sign operation in several MCU multiplication modes:

- 16-bit x 16-bit signed
- 16-bit x 16-bit unsigned
- 16-bit signed x 5-bit (literal) unsigned
- 16-bit signed x 16-bit unsigned
- 16-bit unsigned x 5-bit (literal) unsigned
- 16-bit unsigned x 16-bit signed
- 8-bit unsigned x 8-bit unsigned

3.8.2 DIVIDER

The divide block supports 32-bit/16-bit and 16-bit/16-bit signed and unsigned integer divide operations with the following data sizes:

- 32-bit signed/16-bit signed divide
- 32-bit unsigned/16-bit unsigned divide
- 16-bit signed/16-bit signed divide
- 16-bit unsigned/16-bit unsigned divide

The quotient for all divide instructions ends up in W0 and the remainder in W1. 16-bit signed and unsigned `DIV` instructions can specify any W register for both the 16-bit divisor (Wn) and any W register (aligned) pair (W(m + 1):Wm) for the 32-bit dividend. The divide algorithm takes one cycle per bit of divisor, so both 32-bit/16-bit and 16-bit/16-bit instructions take the same number of cycles to execute.

3.9 DSP Engine

The DSP engine consists of a high-speed 17-bit x 17-bit multiplier, a 40-bit barrel shifter and a 40-bit adder/subtracter (with two target accumulators, round and saturation logic).

The DSP engine can also perform inherent accumulator-to-accumulator operations that require no additional data. These instructions are, `ADD`, `SUB` and `NEG`.

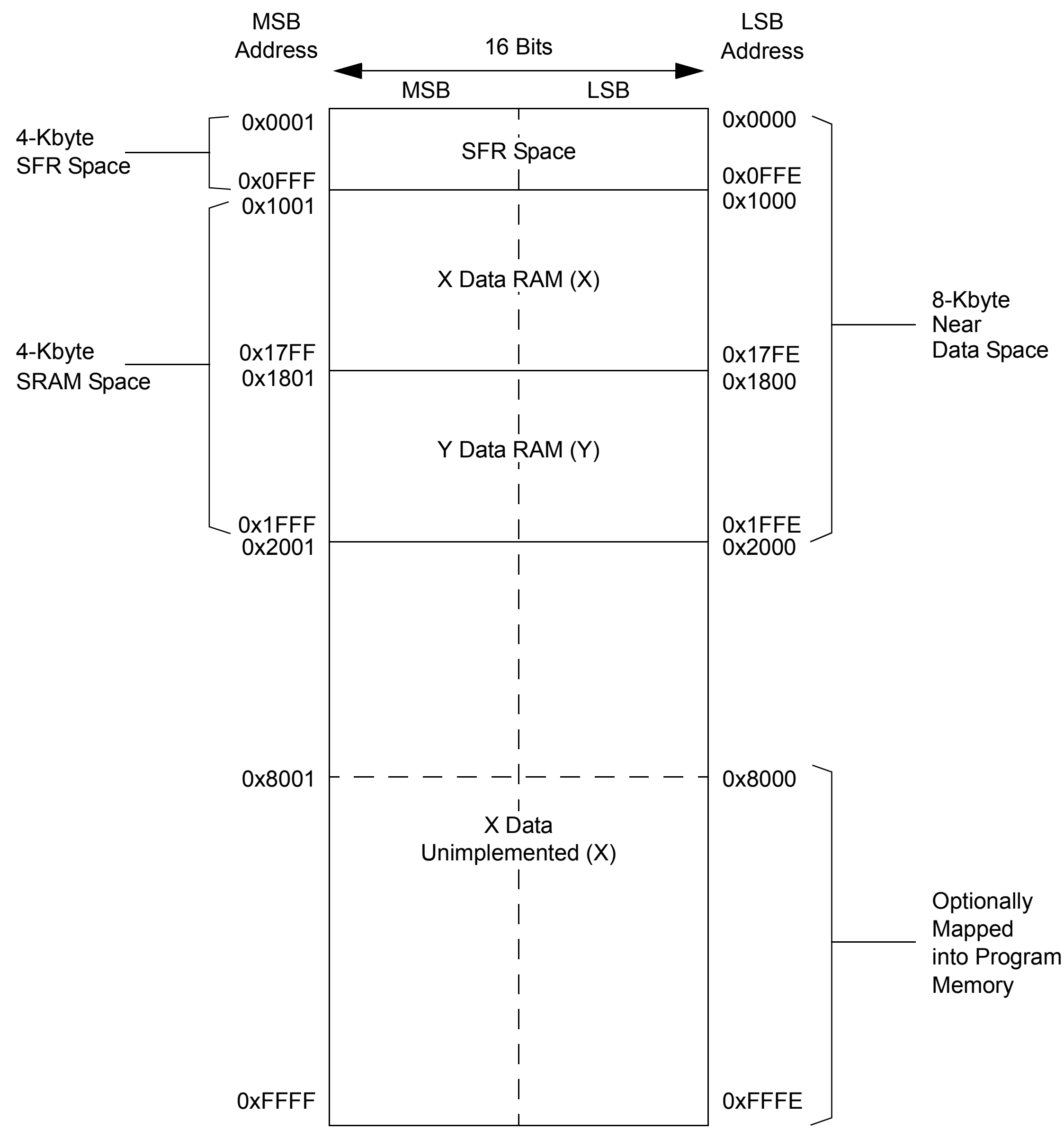
The DSP engine has options selected through bits in the CPU Core Control register (CORCON), as listed below:

- Fractional or integer DSP multiply (IF)
- Signed, unsigned or mixed-sign DSP multiply (USx)
- Conventional or convergent rounding (RND)
- Automatic saturation on/off for ACCA (SATA)
- Automatic saturation on/off for ACCB (SATB)
- Automatic saturation on/off for writes to data memory (SATDW)
- Accumulator Saturation mode selection (ACCSAT)

TABLE 3-2: DSP INSTRUCTIONS SUMMARY

Instruction	Algebraic Operation	ACC Write-Back
`CLR`	$A = 0$	Yes
`ED`	$A = (x - y)^2$	No
`EDAC`	$A = A + (x - y)^2$	No
`MAC`	$A = A + (x \bullet y)$	Yes
`MAC`	$A = A + x^2$	No
`MOVSAC`	No change in A	Yes
`MPY`	$A = x \bullet y$	No
`MPY`	$A = x^2$	No
`MPY.N`	$A = -x \bullet y$	No
`MSC`	$A = A - x \bullet y$	Yes

FIGURE 4-7: DATA MEMORY MAP FOR dsPIC33EP32GS50X DEVICES



Note: Memory areas are not shown to scale.

TABLE 4-7: PWM REGISTER MAP

SFR Name	Addr.	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	All Resets
PTCON	0C00	PTEN	—	PTSIDL	SESTAT	SEIEN	EIPU	SYNCPOL	SYNCOEN	SYNCEN	SYNCSRC2	SYNCSRC1	SYNCSRC0	SEVTPS3	SEVTPS2	SEVTPS1	SEVTPS0	0000
PTCON2	0C02	—	—	—	—	—	—	—	—	—	—	—	—	—	PCLKDIV<2:0>			0000
PTPER	0C04	PWMx Primary Master Time Base Period Register (PTPER<15:0>)																FFF8
SEVTCMP	0C06	PWMx Special Event Compare Register (SEVTCMP12:0>)													—	—	—	0000
MDC	0C0A	PWMx Master Duty Cycle Register (MDC<15:0>)																0000
STCON	0C0E	—	—	—	SESTAT	SEIEN	EIPU	SYNCPOL	SYNCOEN	SYNCEN	SYNCSRC2	SYNCSRC1	SYNCSRC0	SEVTPS3	SEVTPS2	SEVTPS1	SEVTPS0	0000
STCON2	0C10	—	—	—	—	—	—	—	—	—	—	—	—	—	PCLKDIV<2:0>			0000
STPER	0C12	PWMx Secondary Master Time Base Period Register (STPER<15:0>)																FFF8
SSEVTCMP	0C14	PWMx Secondary Special Event Compare Register (SSEVTCMP<12:0>)													—	—	—	0000
CHOP	0C1A	CHPCLKEN	—	—	—	—	—	CHOPCLK6	CHOPCLK5	CHOPCLK4	CHOPCLK3	CHOPCLK2	CHOPCLK1	CHOPCLK0	—	—	—	0000
PWMKEY	0C1E	PWMx Protection Lock/Unlock Key Register (PWMKEY<15:0>)																0000

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

TABLE 4-8: PWM GENERATOR 1 REGISTER MAP

SFR Name	Addr.	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	All Resets
PWMCON1	0C20	FLTSTAT	CLSTAT	TRGSTAT	FLTIEN	CLIEN	TRGIEN	ITB	MDCS	DTC1	DTC0	—	—	MTBS	CAM	XPRES	IUE	0000
IOCON1	0C22	PENH	PENL	POLH	POLL	PMOD1	PMOD0	OVRENH	OVRENL	OVRDAT1	OVRDAT0	FLTDAT1	FLTDAT0	CLDAT1	CLDAT0	SWAP	OSYNC	C000
FCLCON1	0C24	IFLTMOD	CLSRC4	CLSRC3	CLSRC2	CLSRC1	CLSRC0	CLPOL	CLMOD	FLTSRC4	FLTSRC3	FLTSRC2	FLTSRC1	FLTSRC0	FLTPOL	FLTMOD1	FLTMOD0	0000
PDC1	0C26	PWM1 Generator Duty Cycle Register (PDC1<15:0>)																0000
PHASE1	0C28	PWM1 Primary Phase-Shift or Independent Time Base Period Register (PHASE1<15:0>)																0000
DTR1	0C2A	—	—	PWM1 Dead-Time Register (DTR1<13:0>)														0000
ALTDTR1	0C2C	—	—	PWM1 Alternate Dead-Time Register (ALTDTR1<13:0>)														0000
SDC1	0C2E	PWM1 Secondary Duty Cycle Register (SDC1<15:0>)																0000
SPHASE1	0C30	PWM1 Secondary Phase-Shift Register (SPHASE1<15:0>)																0000
TRIG1	0C32	PWM1 Primary Trigger Compare Value Register (TRGCMP<12:0>)													—	—	—	0000
TRGCON1	0C34	TRGDIV3	TRGDIV2	TRGDIV1	TRGDIV0	—	—	—	—	DTM	—	TRGSTRT5	TRGSTRT4	TRGSTRT3	TRGSTRT2	TRGSTRT1	TRGSTRT0	0000
STRIG1	0C36	PWM1 Secondary Trigger Compare Value Register (STRGCMP<12:0>)													—	—	—	0000
PWMCAP1	0C38	PWM1 Primary Time Base Capture Register (PWMCAP<12:0>)													—	—	—	0000
LEBCON1	0C3A	PHR	PHF	PLR	PLF	FLTLEBEN	CLLEBEN	—	—	—	—	BCH	BCL	BPHH	BPHL	BPLH	BPLL	0000
LEBDLY1	0C3C	—	—	—	—	PWM1 Leading-Edge Blanking Delay Register (LEB<8:0>)									—	—	—	0000
AUXCON1	0C3E	HRPDIS	HRDDIS	—	—	BLANKSEL3	BLANKSEL2	BLANKSEL1	BLANKSEL0	—	—	CHOPSEL3	CHOPSEL2	CHOPSEL1	CHOPSEL0	CHOPHEN	CHOPLEN	0000

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

FIGURE 4-13: BIT-REVERSED ADDRESSING EXAMPLE

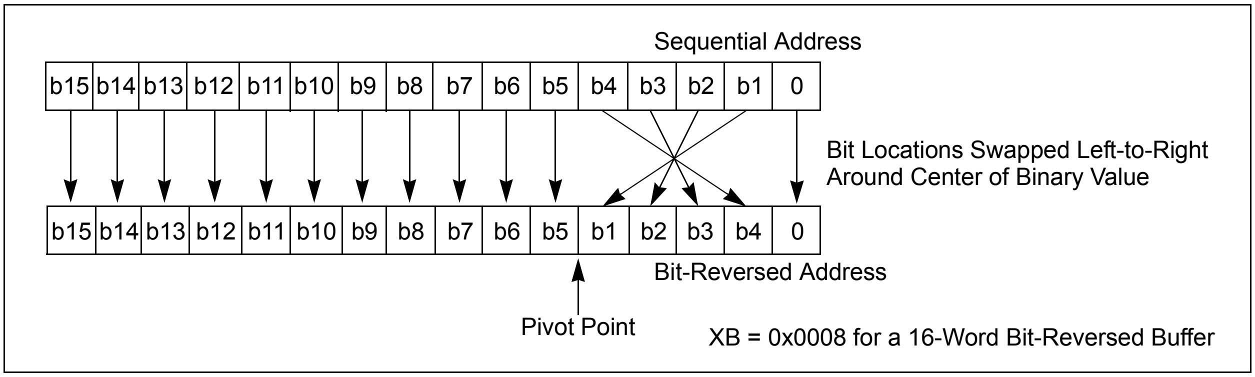


TABLE 4-39: BIT-REVERSED ADDRESSING SEQUENCE (16-ENTRY)

Normal Address					Bit-Reversed Address				
A3	A2	A1	A0	Decimal	A3	A2	A1	A0	Decimal
0	0	0	0	0	0	0	0	0	0
0	0	0	1	1	1	0	0	0	8
0	0	1	0	2	0	1	0	0	4
0	0	1	1	3	1	1	0	0	12
0	1	0	0	4	0	0	1	0	2
0	1	0	1	5	1	0	1	0	10
0	1	1	0	6	0	1	1	0	6
0	1	1	1	7	1	1	1	0	14
1	0	0	0	8	0	0	0	1	1
1	0	0	1	9	1	0	0	1	9
1	0	1	0	10	0	1	0	1	5
1	0	1	1	11	1	1	0	1	13
1	1	0	0	12	0	0	1	1	3
1	1	0	1	13	1	0	1	1	11
1	1	1	0	14	0	1	1	1	7
1	1	1	1	15	1	1	1	1	15

5.2 RTSP Operation

The dsPIC33EPXXGS50X family Flash program memory array is organized into rows of 64 instructions or 192 bytes. RTSP allows the user application to erase a single page (8 rows or 512 instructions) of memory at a time and to program one row at a time. It is possible to program two instructions at a time as well.

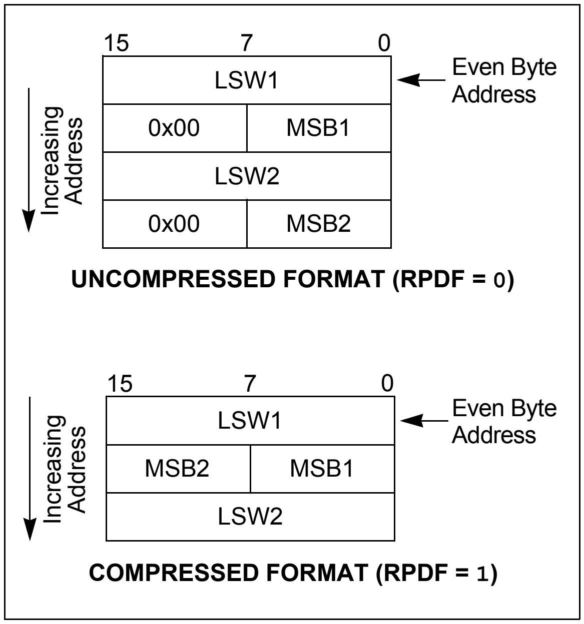
The page erase and single row write blocks are edge-aligned, from the beginning of program memory, on boundaries of 1536 bytes and 192 bytes, respectively. Figure 26-14 in **Section 26.0 "Electrical Characteristics"** lists the typical erase and programming times.

Row programming is performed by loading 192 bytes into data memory and then loading the address of the first byte in that row into the NVMSRCADR register. Once the write has been initiated, the device will automatically load the write latches and increment the NVMSRCADR and the NVMADR(U) registers until all bytes have been programmed. The RPDF bit (NVMCON<9>) selects the format of the stored data in RAM to be either compressed or uncompressed. See Figure 5-2 for data formatting. Compressed data helps to reduce the amount of required RAM by using the upper byte of the second word for the MSB of the second instruction.

The basic sequence for RTSP word programming is to use the `TBLWTL` and `TBLWTH` instructions to load two of the 24-bit instructions into the write latches found in configuration memory space. Refer to Figure 4-1 through Figure 4-4 for write latch addresses. Programming is performed by unlocking and setting the control bits in the NVMCON register.

All erase and program operations may optionally use the NVM interrupt to signal the successful completion of the operation. For example, when performing Flash write operations on the Inactive Partition in Dual Partition mode, where the CPU remains running, it is necessary to wait for the NVM interrupt before programming the next block of Flash program memory.

FIGURE 5-2: UNCOMPRESSED/ COMPRESSED FORMAT



5.3 Programming Operations

A complete programming sequence is necessary for programming or erasing the internal Flash in RTSP mode. The processor stalls (waits) until the programming operation is finished. Setting the WR bit (NVMCON<15>) starts the operation and the WR bit is automatically cleared when the operation is finished.

5.3.1 PROGRAMMING ALGORITHM FOR FLASH PROGRAM MEMORY

Programmers can program two adjacent words (24 bits x 2) of program Flash memory at a time on every other word address boundary (0x000000, 0x000004, 0x000008, etc.). To do this, it is necessary to erase the page that contains the desired address of the location the user wants to change. For protection against accidental operations, the write initiate sequence for NVMKEY must be used to allow any erase or program operation to proceed. After the programming command has been executed, the user application must wait for the programming time until programming is complete. The two instructions following the start of the programming sequence should be `NOP`s.

REGISTER 9-5: PMD6: PERIPHERAL MODULE DISABLE CONTROL REGISTER 6

U-0	U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	—	—	PWM5MD	PWM4MD	PWM3MD	PWM2MD	PWM1MD
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 15-13 **Unimplemented:** Read as ‘0’

bit 12 **PWM5MD:** PWM5 Module Disable bit
1 = PWM5 module is disabled
0 = PWM5 module is enabled

bit 11 **PWM4MD:** PWM4 Module Disable bit
1 = PWM4 module is disabled
0 = PWM4 module is enabled

bit 10 **PWM3MD:** PWM3 Module Disable bit
1 = PWM3 module is disabled
0 = PWM3 module is enabled

bit 9 **PWM2MD:** PWM2 Module Disable bit
1 = PWM2 module is disabled
0 = PWM2 module is enabled

bit 8 **PWM1MD:** PWM1 Module Disable bit
1 = PWM1 module is disabled
0 = PWM1 module is enabled

bit 7-0 **Unimplemented:** Read as ‘0’

10.7 Peripheral Pin Select Registers

REGISTER 10-1: RPINR0: PERIPHERAL PIN SELECT INPUT REGISTER 0

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
INT1R<7:0>							
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 15-8 **INT1R<7:0>:** Assign External Interrupt 1 (INT1) to the Corresponding RPn Pin bits
10110101 = Input tied to RP181
10110100 = Input tied to RP180
•
•
•
00000001 = Input tied to RP1
00000000 = Input tied to VSS

bit 7-0 **Unimplemented:** Read as ‘0’

REGISTER 10-2: RPINR1: PERIPHERAL PIN SELECT INPUT REGISTER 1

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
INT2R<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 15-8 **Unimplemented:** Read as ‘0’

bit 7-0 **INT2R<7:0>:** Assign External Interrupt 2 (INT2) to the Corresponding RPn Pin bits
10110101 = Input tied to RP181
10110100 = Input tied to RP180
•
•
•
00000001 = Input tied to RP1
00000000 = Input tied to VSS

REGISTER 10-5: RPINR7: PERIPHERAL PIN SELECT INPUT REGISTER 7

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
IC2R7	IC2R6	IC2R5	IC2R4	IC2R3	IC2R2	IC2R1	IC2R0
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
IC1R7	IC1R6	IC1R5	IC1R4	IC1R3	IC1R2	IC1R1	IC1R0
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 **IC2R<7:0>:** Assign Input Capture 2 (IC2) to the Corresponding RPn Pin bits

10110101 = Input tied to RP181
10110100 = Input tied to RP180
•
•
•
00000001 = Input tied to RP1
00000000 = Input tied to Vss

bit 7-0 **IC1R<7:0>:** Assign Input Capture 1 (IC1) to the Corresponding RPn Pin bits

10110101 = Input tied to RP181
10110100 = Input tied to RP180
•
•
•
00000001 = Input tied to RP1
00000000 = Input tied to Vss

REGISTER 15-20: IOCONx: PWMx I/O CONTROL REGISTER (x = 1 to 5) (CONTINUED)

bit 3-2 **CLDAT<1:0>:** State for PWMxH and PWMxL Pins if CLMOD is Enabled bits[2]

IFLTMOD (FCLCONx<15>) = 0: Normal Fault Mode:
If current limit is active, then CLDAT1 provides the state for the PWMxH pin.
If current limit is active, then CLDAT0 provides the state for the PWMxL pin.

IFLTMOD (FCLCONx<15>) = 1: Independent Fault Mode:
CLDAT<1:0> bits are ignored.

bit 1 **SWAP:** SWAP PWMxH and PWMxL Pins bit

1 = PWMxH output signal is connected to the PWMxL pins; PWMxL output signal is connected to the PWMxH pins
0 = PWMxH and PWMxL pins are mapped to their respective pins

bit 0 **OSYNC:** Output Override Synchronization bit

1 = Output overrides via the OVRDAT<1:0> bits are synchronized to the PWMx time base
0 = Output overrides via the OVRDAT<1:0> bits occur on the next CPU clock boundary

Note 1: These bits should not be changed after the PWMx module is enabled (PTEN = 1).
2: State represents the active/inactive state of the PWMx depending on the POLH and POLL bits settings.

REGISTER 15-21: TRIGx: PWMx PRIMARY TRIGGER COMPARE VALUE REGISTER (x = 1 to 5)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
TRGCMP<12:5>							
bit 15							bit 8

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	U-0	U-0	U-0
TRGCMP<4:0>					—	—	—
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 15-3 **TRGCMP<12:0>:** Trigger Compare Value bits

When the primary PWMx functions in the local time base, this register contains the compare values that can trigger the ADC module.

bit 2-0 **Unimplemented:** Read as ‘0’

16.3 SPI Control Registers

REGISTER 16-1: SPIxSTAT: SPIx STATUS AND CONTROL REGISTER

R/W-0	U-0	R/W-0	U-0	U-0	R/W-0	R/W-0	R/W-0
SPIEN	—	SPISIDL	—	—	SPIBEC2	SPIBEC1	SPIBEC0
bit 15							bit 8

R/W-0	R/C-0, HS	R/W-0	R/W-0	R/W-0	R/W-0	R-0, HS, HC	R-0, HS, HC
SRMPT	SPIROV	SRXMPT	SISEL2	SISEL1	SISEL0	SPITBF	SPIRBF
bit 7							bit 0

Legend:	C = Clearable bit	U = Unimplemented bit, read as '0'	
R = Readable bit	W = Writable bit	HS = Hardware Settable bit	HC = Hardware Clearable bit
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

bit 15 **SPIEN:** SPIx Enable bit
1 = Enables the module and configures SCKx, SDOx, SDIx and $\overline{\text{SSx}}$ as serial port pins
0 = Disables the module

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

bit 13 **SPISIDL:** SPIx Stop in Idle Mode bit
1 = Discontinues the module operation when device enters Idle mode
0 = Continues the module operation in Idle mode

bit 12-11 **Unimplemented:** Read as '0'

bit 10-8 **SPIBEC<2:0>:** SPIx Buffer Element Count bits (valid in Enhanced Buffer mode)
Master Mode:
Number of SPIx transfers that are pending.
Slave Mode:
Number of SPIx transfers that are unread.

bit 7 **SRMPT:** SPIx Shift Register (SPIxSR) Empty bit (valid in Enhanced Buffer mode)
1 = SPIx Shift register is empty and ready to send or receive the data
0 = SPIx Shift register is not empty

bit 6 **SPIROV:** SPIx Receive Overflow Flag bit
1 = A new byte/word is completely received and discarded; the user application has not read the previous data in the SPIxBUF register
0 = No overflow has occurred

bit 5 **SRXMPT:** SPIx Receive FIFO Empty bit (valid in Enhanced Buffer mode)
1 = RX FIFO is empty
0 = RX FIFO is not empty

bit 4-2 **SISEL<2:0>:** SPIx Buffer Interrupt Mode bits (valid in Enhanced Buffer mode)
111 = Interrupt when the SPIx transmit buffer is full (SPITBF bit is set)
110 = Interrupt when the last bit is shifted into SPIxSR, and as a result, the TX FIFO is empty
101 = Interrupt when the last bit is shifted out of SPIxSR and the transmit is complete
100 = Interrupt when one data is shifted into the SPIxSR, and as a result, the TX FIFO has one open memory location
011 = Interrupt when the SPIx receive buffer is full (SPIRBF bit is set)
010 = Interrupt when the SPIx receive buffer is 3/4 or more full
001 = Interrupt when data is available in the receive buffer (SRMPT bit is set)
000 = Interrupt when the last data in the receive buffer is read, and as a result, the buffer is empty (SRXMPT bit is set)

REGISTER 16-2: SPIxCON1: SPIx CONTROL REGISTER 1 (CONTINUED)

bit 4-2	**SPRE<2:0>:** Secondary Prescale bits (Master mode)(3) 111 = Secondary prescale 1:1 110 = Secondary prescale 2:1 • • • 000 = Secondary prescale 8:1
bit 1-0	**PPRE<1:0>:** Primary Prescale bits (Master mode)(3) 11 = Primary prescale 1:1 10 = Primary prescale 4:1 01 = Primary prescale 16:1 00 = Primary prescale 64:1

Note 1: The CKE bit is not used in Framed SPI modes. Program this bit to '0' for Framed SPI modes (FRMEN = 1).

2: This bit must be cleared when FRMEN = 1.

3: Do not set both primary and secondary prescalers to the value of 1:1.

REGISTER 19-5: ADCON3L: ADC CONTROL REGISTER 3 LOW

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R-0, HSC	R/W-0	R-0, HSC
REFSEL2	REFSEL1	REFSEL0	SUSPEND	SUSPCIE	SUSPRDY	SHRSAMP	CNVRTCH
bit 15							bit 8

R/W-0	R-0, HSC	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
SWLCTRG	SWCTRG	CNVCHSEL5	CNVCHSEL4	CNVCHSEL3	CNVCHSEL2	CNVCHSEL1	CNVCHSEL0
bit 7							bit 0

Legend:	U = Unimplemented bit, read as ‘0’		
R = Readable bit	W = Writable bit	HSC = Hardware Settable/Clearable bit	
-n = Value at POR	‘1’ = Bit is set	‘0’ = Bit is cleared	x = Bit is unknown

bit 15-13 **REFSEL<2:0>:** ADC Reference Voltage Selection bits

Value	V_{REFH}	V_{REFL}
000	AV_{DD}	AV_{SS}

001-111 = **Unimplemented:** Do not use

bit 12 **SUSPEND:** All ADC Cores Triggers Disable bit

1 = All new trigger events for all ADC cores are disabled
0 = All ADC cores can be triggered

bit 11 **SUSPCIE:** Suspend All ADC Cores Common Interrupt Enable bit

1 = Common interrupt will be generated when ADC core triggers are suspended (SUSPEND bit = 1) and all previous conversions are finished (SUSPRDY bit becomes set)
0 = Common interrupt is not generated for suspend ADC cores event

bit 10 **SUSPRDY:** All ADC Cores Suspended Flag bit

1 = All ADC cores are suspended (SUSPEND bit = 1) and have no conversions in progress
0 = ADC cores have previous conversions in progress

bit 9 **SHRSAMP:** Shared ADC Core Sampling Direct Control bit

This bit should be used with the individual channel conversion trigger controlled by the CNVRTCH bit. It connects an analog input, specified by the CNVCHSEL<5:0> bits, to the shared ADC core and allows extending the sampling time. This bit is not controlled by hardware and must be cleared before the conversion starts (setting CNVRTCH to ‘1’).
1 = Shared ADC core samples an analog input specified by the CNVCHSEL<5:0> bits
0 = Sampling is controlled by the shared ADC core hardware

bit 8 **CNVRTCH:** Software Individual Channel Conversion Trigger bit

1 = Single trigger is generated for an analog input specified by the CNVCHSEL<5:0> bits; when the bit is set, it is automatically cleared by hardware on the next instruction cycle
0 = Next individual channel conversion trigger can be generated

bit 7 **SWLCTRG:** Software Level-Sensitive Common Trigger bit

1 = Triggers are continuously generated for all channels with the software, level-sensitive common trigger selected as a source in the ADTRIGxL and ADTRIGxH registers
0 = No software, level-sensitive common triggers are generated

bit 6 **SWCTRG:** Software Common Trigger bit

1 = Single trigger is generated for all channels with the software, common trigger selected as a source in the ADTRIGxL and ADTRIGxH registers; when the bit is set, it is automatically cleared by hardware on the next instruction cycle
0 = Ready to generate the next software, common trigger

bit 5-0 **CNVCHSEL <5:0>:** Channel Number Selection for Software Individual Channel Conversion Trigger bits

These bits define a channel to be converted when the CNVRTCH bit is set.

23.2 Device Calibration and Identification

The PGAx and current source modules on the dsPIC33EPXXGS50X family devices require Calibration Data registers to improve performance of the module over a wide operating range. These Calibration registers are read-only and are stored in configuration memory space. Prior to enabling the module, the calibration data must be read (TBLPAG and Table Read instruction) and loaded into their respective SFR registers. The device calibration addresses are shown in Table 23-3.

The dsPIC33EPXXGS50X devices have two identification registers near the end of configuration memory space that store the Device ID (DEVID) and Device Revision (DEVREV). These registers are used to determine the mask, variant and manufacturing information about the device. These registers are read-only and are shown in Register 23-1 and Register 23-2.

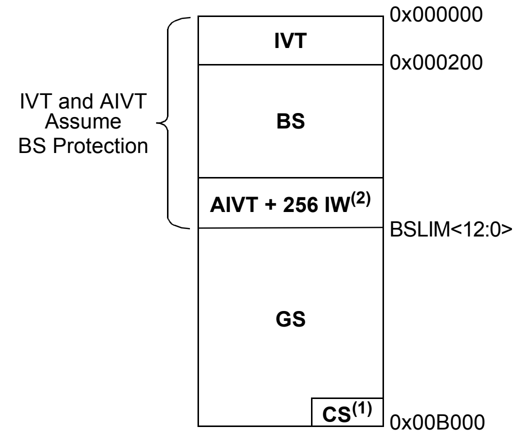
TABLE 23-3: DEVICE CALIBRATION ADDRESSES(1)

Calibration Name	Address	Bits 23-16	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
PGA1CAL	800E48	—	—	—	—	—	—	—	—	—	—	—	PGA1 Calibration Data					
PGA2CAL	800E4C	—	—	—	—	—	—	—	—	—	—	—	PGA2 Calibration Data					
ISRCCAL	800E78	—	—	—	—	—	—	—	—	—	—	—	Current Source Calibration Data					

Note 1: The calibration data must be copied into its respective registers prior to enabling the module.

The different device security segments are shown in Figure 23-3. Here, all three segments are shown but are not required. If only basic code protection is required, then GS can be enabled independently or combined with CS, if desired.

FIGURE 23-3: SECURITY SEGMENTS EXAMPLE FOR dsPIC33EP64GS50X DEVICES



Note 1: If CS is write-protected, the last page (GS + CS) of program memory will be protected from an erase condition.

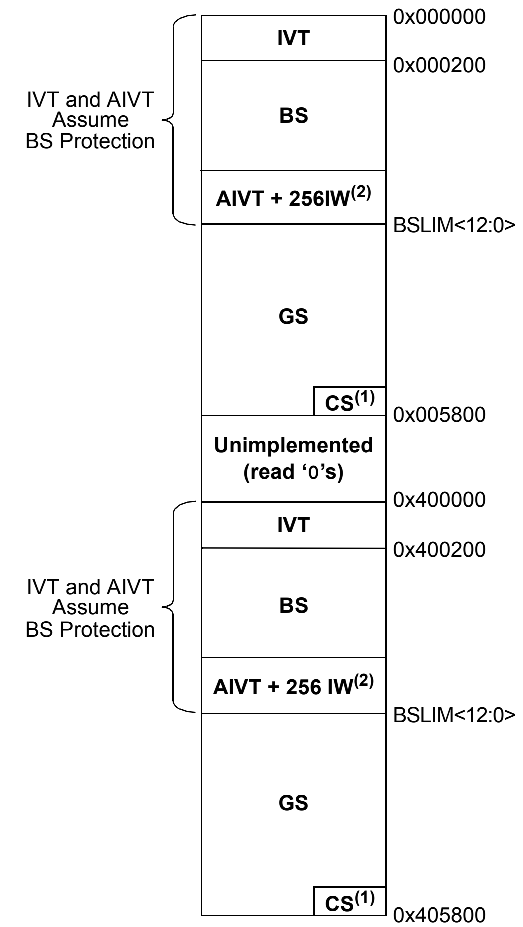
2: The last half (256 IW) of the last page of BS is unusable program memory.

dsPIC33EP64GS50X family devices can be operated in Dual Partition mode, where security is required for each partition. When operating in Dual Partition mode, the Active and Inactive Partitions both contain unique copies of the Reset vector, Interrupt Vector Tables (IVT and AIVT, if enabled) and the Flash Configuration Words. Both partitions have the three security segments described previously. Code may not be executed from the Inactive Partition, but it may be programmed by, and read from, the Active Partition, subject to defined code protection. Figure 23-4 shows the different security segments for a device operating in Dual Partition mode.

The device may also operate in a Protected Dual Partition mode or in Privileged Dual Partition mode. In Protected Dual Partition mode, Partition 1 is permanently erase/write-protected. This implementation allows for a "Factory Default" mode, which provides a fail-safe backup image to be stored in Partition 1. For example, a fail-safe bootloader can be placed in Partition 1, along with a fail-safe backup code image, which can be used or rewritten into Partition 2 in the event of a failed Flash update to Partition 2.

Privileged Dual Partition mode performs the same function as Protected Dual Partition mode, except additional constraints are applied in an effort to prevent code in the Boot Segment and General Segment from being used against each other.

FIGURE 23-4: SECURITY SEGMENTS EXAMPLE FOR dsPIC33EP64GS50X DEVICES (DUAL PARTITION MODES)



Note 1: If CS is write-protected, the last page (GS + CS) of program memory will be protected from an erase condition.

2: The last half (256 IW) of the last page of BS is unusable program memory.

TABLE 26-6: DC CHARACTERISTICS: OPERATING CURRENT (IDD)

DC 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		
Parameter No.	**Typ.**	**Max.**	**Units**	**Conditions**		
Operating Current (IDD)[1]						
DC20d	7	12	mA	-40°C	3.3V	10 MIPS
DC20a	7	12	mA	+25°C		
DC20b	7	12	mA	+85°C		
DC20c	7	12	mA	+125°C		
DC22d	11	19	mA	-40°C	3.3V	20 MIPS
DC22a	11	19	mA	+25°C		
DC22b	11	19	mA	+85°C		
DC22c	11	19	mA	+125°C		
DC24d	19	30	mA	-40°C	3.3V	40 MIPS
DC24a	19	30	mA	+25°C		
DC24b	19	30	mA	+85°C		
DC24c	19	30	mA	+125°C		
DC25d	26	41	mA	-40°C	3.3V	60 MIPS
DC25a	26	41	mA	+25°C		
DC25b	26	41	mA	+85°C		
DC25c	26	41	mA	+125°C		
DC26d	30	46	mA	-40°C	3.3V	70 MIPS
DC26a	30	46	mA	+25°C		
DC26b	30	46	mA	+85°C		
DC27d	51	81	mA	-40°C	3.3V	70 MIPS (Note 2)
DC27a	51	81	mA	+25°C		
DC27b	52	82	mA	+85°C		
DC27c	53	83	mA	+125°C		

Note 1: IDD is primarily a function of the operating voltage and frequency. Other factors, such as I/O pin loading and switching rate, oscillator type, internal code execution pattern and temperature, also have an impact on the current consumption. The test conditions for all IDD measurements are as follows:

- Oscillator is configured in EC mode with PLL, OSC1 is driven with external square wave from rail-to-rail (EC clock overshoot/undershoot < 250 mV required)
- CLKO is configured as an I/O input pin in the Configuration Word
- All I/O pins are configured as inputs and pulled to VSS
- $\overline{\text{MCLR}}$ = VDD, WDT and FSCM are disabled
- CPU, SRAM, program memory and data memory are operational
- No peripheral modules are operating or being clocked (all defined PMDx bits are set)
- CPU is executing `while(1)` statement
- JTAG is disabled

2: For this specification, the following test conditions apply:

- APLL clock is enabled
- All 5 PWMs enabled and operating at maximum speed (PTCON2<2:0> = `000`), PTPER = 1000h, 50% duty cycle
- All other peripherals are disabled (corresponding PMDx bits are set)

TABLE 26-8: DC CHARACTERISTICS: POWER-DOWN CURRENT (I_{PD})

DC 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		
Parameter No.	Typ.	Max.	Units	Conditions	
Power-Down Current (I_{PD})[1]					
DC60d	12	100	μA	-40°C	3.3V
DC60a	18	100	μA	+25°C	
DC60b	130	400	μA	+85°C	
DC60c	500	1100	μA	+125°C	

Note 1: I_{PD} (Sleep) current is measured as follows:

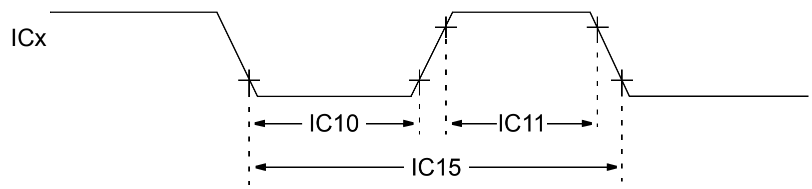
- CPU core is off, oscillator is configured in EC mode and external clock is active; OSC1 is driven with external square wave from rail-to-rail (EC clock overshoot/undershoot < 250 mV required)
- CLKO is configured as an I/O input pin in the Configuration Word
- All I/O pins are configured as inputs and pulled to V_{SS}
- $\overline{MCLR}$ = V_{DD}, WDT and FSCM are disabled
- All peripheral modules are disabled (PMDx bits are all set)
- The VREGS bit (RCON<8>) = 0 (i.e., core regulator is set to standby while the device is in Sleep mode)
- The VREGSF bit (RCON<11>) = 0 (i.e., Flash regulator is set to standby while the device is in Sleep mode)
- JTAG is disabled

TABLE 26-9: DC CHARACTERISTICS: WATCHDOG TIMER DELTA CURRENT (ΔI_{WDT})[1]

DC 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		
Parameter No.	Typ.	Max.	Units	Conditions	
DC61d	13	50	μA	-40°C	3.3V
DC61a	19	80	μA	+25°C	
DC61b	12	—	μA	+85°C	
DC61c	13	—	μA	+125°C	

Note 1: The ΔI_{WDT} current is the additional current consumed when the module is enabled. This current should be added to the base I_{PD} current. All parameters are characterized but not tested during manufacturing.

FIGURE 26-6: INPUT CAPTURE x (ICx) TIMING CHARACTERISTICS



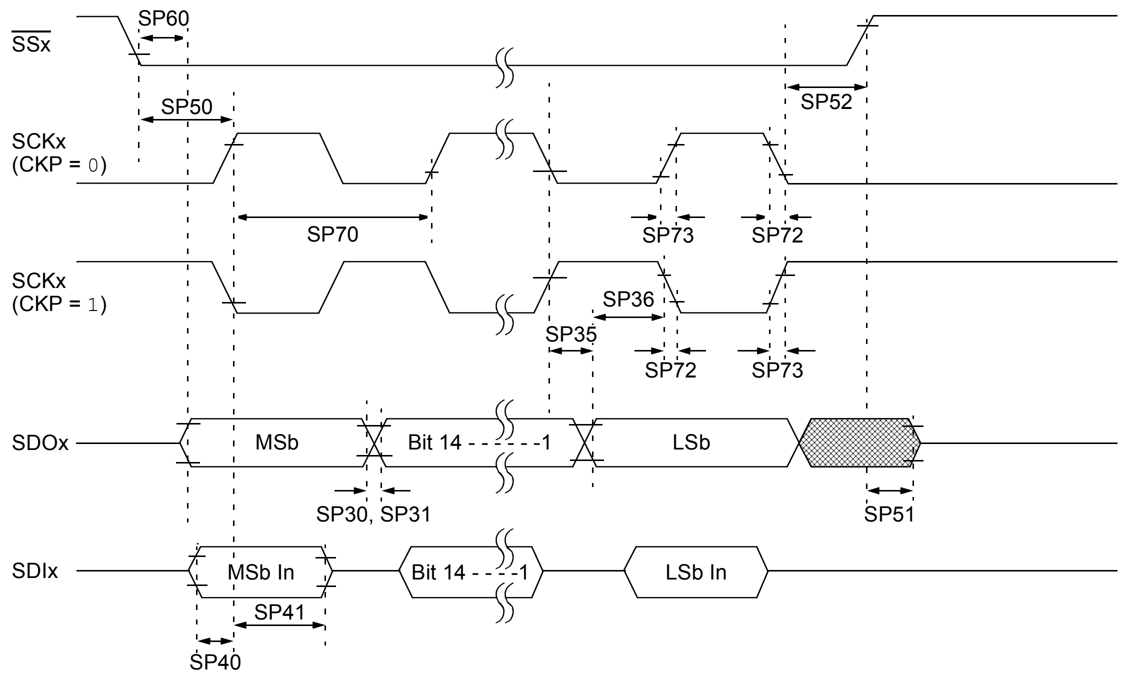
Note: Refer to Figure 26-1 for load conditions.

TABLE 26-27: INPUT CAPTURE x MODULE 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**	**Characteristics[1]**	**Min.**	**Max.**	**Units**	**Conditions**	
IC10	TCCL	ICx Input Low Time	Greater of: 12.5 + 25 or (0.5 TCY/N) + 25	—	ns	Must also meet Parameter IC15	N = Prescale Value (1, 4, 16)
IC11	TCCH	ICx Input High Time	Greater of: 12.5 + 25 or (0.5 TCY/N) + 25	—	ns	Must also meet Parameter IC15	
IC15	TCCP	ICx Input Period	Greater of: 25 + 50 or (1 TCY/N) + 50	—	ns		

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

FIGURE 26-16: SPIx SLAVE MODE (FULL-DUPLEX, CKE = 1, CKP = 1, SMP = 0) TIMING CHARACTERISTICS



Note: Refer to Figure 26-1 for load conditions.

NOTES: