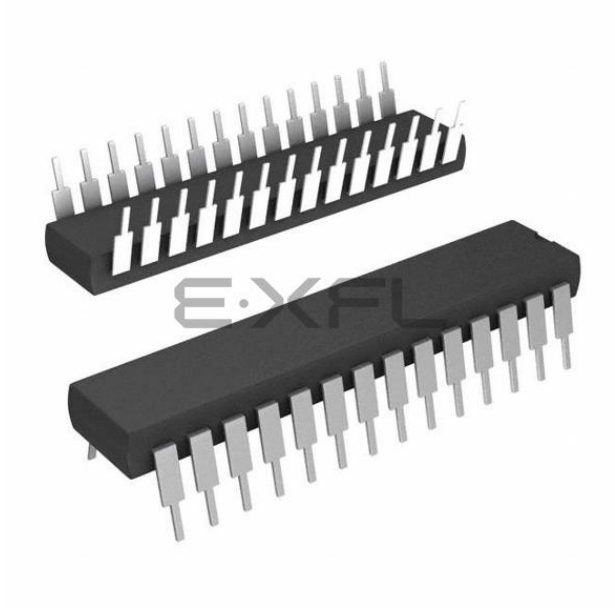

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## What is "Embedded - Microcontrollers"?

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

## Applications of "Embedded - Microcontrollers"

| Details | |
|---|---|
| Product Status | Active |
| Core Processor | PIC |
| Core Size | 16-Bit |
| Speed | 70 MIPs |
| Connectivity | I²C, IrDA, LINbus, QEI, SPI, UART/USART |
| Peripherals | Brown-out Detect/Reset, DMA, Motor Control PWM, POR, PWM, WDT |
| Number of I/O | 21 |
| Program Memory Size | 32KB (10.7K x 24) |
| Program Memory Type | FLASH |
| EEPROM Size | - |
| RAM Size | 2K x 16 |
| Voltage - Supply (Vcc/Vdd) | 3V ~ 3.6V |
| Data Converters | A/D 6x10b/12b |
| Oscillator Type | Internal |
| Operating Temperature | -40°C ~ 85°C (TA) |
| Mounting Type | Through Hole |
| Package / Case | 28-DIP (0.300", 7.62mm) |
| Supplier Device Package | 28-SPDIP |
| Purchase URL | https://www.e-xfl.com/product-detail/microchip-technology/pic24ep32mc202-i-sp |

**TABLE 4-12: PWM 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PTCON | 0C00 | PTEN | — | PTSIDL | SESTAT | SEIEN | EIPU | SYNCPOL | SYNCOEN | SYNCEN | SYNCSRC<2:0> | | | SEVTPS<3:0> | | | | 0000 |
| PTCON2 | 0C02 | — | — | — | — | — | — | — | — | — | — | — | — | — | PCLKDIV<2:0> | | | 0000 |
| PTPER | 0C04 | PTPER<15:0> | | | | | | | | | | | | | | | | 00F8 |
| SEVTCMP | 0C06 | SEVTCMP<15:0> | | | | | | | | | | | | | | | | 0000 |
| MDC | 0C0A | MDC<15:0> | | | | | | | | | | | | | | | | 0000 |
| CHOP | 0C1A | CHPCLKEN | — | — | — | — | — | CHOPCLK<9:0> | | | | | | | | | | 0000 |
| PWMKEY | 0C1E | PWMKEY<15:0> | | | | | | | | | | | | | | | | 0000 |

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

**TABLE 4-13: PWM GENERATOR 1 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PWMCON1 | 0C20 | FLTSTAT | CLSTAT | TRGSTAT | FLTIEN | CLIEN | TRGIEN | ITB | MDCS | DTC<1:0> | | DTCP | — | MTBS | CAM | XPRES | IUE | 0000 |
| IOCON1 | 0C22 | PENH | PENL | POLH | POLL | PMOD<1:0> | | OVRENH | OVRENL | OVRDAT<1:0> | | FLTDAT<1:0> | | CLDAT<1:0> | | SWAP | OSYNC | C000 |
| FCLCON1 | 0C24 | — | CLSRC<4:0> | | | | | CLPOL | CLMOD | FLTSRC<4:0> | | | | | FLTPOL | FLTMOD<1:0> | | 0000 |
| PDC1 | 0C26 | PDC1<15:0> | | | | | | | | | | | | | | | | FFF8 |
| PHASE1 | 0C28 | PHASE1<15:0> | | | | | | | | | | | | | | | | 0000 |
| DTR1 | 0C2A | — | — | DTR1<13:0> | | | | | | | | | | | | | | 0000 |
| ALTDTR1 | 0C2C | — | — | ALTDTR1<13:0> | | | | | | | | | | | | | | 0000 |
| TRIG1 | 0C32 | TRGCMP<15:0> | | | | | | | | | | | | | | | | 0000 |
| TRGCON1 | 0C34 | TRGDIV<3:0> | | | | — | — | — | — | — | — | TRGSTRT<5:0> | | | | | | 0000 |
| LEBCON1 | 0C3A | PHR | PHF | PLR | PLF | FLTLEBEN | CLLEBEN | — | — | — | — | BCH | BCL | BPHH | BPHL | BPLH | BPLL | 0000 |
| LEBDLY1 | 0C3C | — | — | — | — | LEB<11:0> | | | | | | | | | | | | 0000 |
| AUXCON1 | 0C3E | — | — | — | — | BLANKSEL<3:0> | | | | — | — | CHOPSEL<3:0> | | | | CHOPHEN | CHOPLEN | 0000 |

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

### 4.5.3 MOVE AND ACCUMULATOR INSTRUCTIONS

Move instructions, which apply to dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X and PIC24EPXXXGP/MC20X devices, and the DSP accumulator class of instructions, which apply to the dsPIC33EPXXXMC20X/50X and dsPIC33EPXXXGP50X devices, provide a greater degree of addressing flexibility than other instructions. In addition to the addressing modes supported by most MCU instructions, move and accumulator instructions also support Register Indirect with Register Offset Addressing mode, also referred to as Register Indexed mode.

| | |
|---|---|
| **Note:** | For the MOV instructions, the addressing mode specified in the instruction can differ for the source and destination EA. However, the 4-bit Wb (Register Offset) field is shared by both source and destination (but typically only used by one). |

In summary, the following addressing modes are supported by move and accumulator instructions:

- Register Direct
- Register Indirect
- Register Indirect Post-modified
- Register Indirect Pre-modified
- Register Indirect with Register Offset (Indexed)
- Register Indirect with Literal Offset
- 8-Bit Literal
- 16-Bit Literal

| | |
|---|---|
| **Note:** | Not all instructions support all the addressing modes given above. Individual instructions may support different subsets of these addressing modes. |

### 4.5.4 MAC INSTRUCTIONS (dsPIC33EPXXXMC20X/50X and dsPIC33EPXXXGP50X DEVICES ONLY)

The dual source operand DSP instructions (CLR, ED, EDAC, MAC, MPY, MPY.N, MOVSAC and MSC), also referred to as MAC instructions, use a simplified set of addressing modes to allow the user application to effectively manipulate the Data Pointers through register indirect tables.

The Two-Source Operand Prefetch registers must be members of the set: {W8, W9, W10, W11}. For data reads, W8 and W9 are always directed to the X RAGU, and W10 and W11 are always directed to the Y AGU. The Effective Addresses generated (before and after modification) must therefore, be valid addresses within X Data Space for W8 and W9, and Y Data Space for W10 and W11.

| | |
|---|---|
| **Note:** | Register Indirect with Register Offset Addressing mode is available only for W9 (in X space) and W11 (in Y space). |

In summary, the following addressing modes are supported by the MAC class of instructions:

- Register Indirect
- Register Indirect Post-Modified by 2
- Register Indirect Post-Modified by 4
- Register Indirect Post-Modified by 6
- Register Indirect with Register Offset (Indexed)

### 4.5.5 OTHER INSTRUCTIONS

Besides the addressing modes outlined previously, some instructions use literal constants of various sizes. For example, BRA (branch) instructions use 16-bit signed literals to specify the branch destination directly, whereas the DISI instruction uses a 14-bit unsigned literal field. In some instructions, such as ULNK, the source of an operand or result is implied by the opcode itself. Certain operations, such as a NOP, do not have any operands.

### 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.

## 7.3 Interrupt 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 |

### 7.3.1 KEY RESOURCES

- **"Interrupts"** (DS70600) in the *"dsPIC33/PIC24 Family Reference Manual"*
- Code Samples
- Application Notes
- Software Libraries
- Webinars
- All Related *"dsPIC33/PIC24 Family Reference Manual"* Sections
- Development Tools

## 7.4 Interrupt Control and Status Registers

dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X and PIC24EPXXXGP/MC20X devices implement the following registers for the interrupt controller:

- INTCON1
- INTCON2
- INTCON3
- INTCON4
- INTTREG

### 7.4.1 INTCON1 THROUGH INTCON4

Global interrupt control functions are controlled from INTCON1, INTCON2, INTCON3 and INTCON4.

INTCON1 contains the Interrupt Nesting Disable bit (NSTDIS), as well as the control and status flags for the processor trap sources.

The INTCON2 register controls external interrupt request signal behavior and also contains the Global Interrupt Enable bit (GIE).

INTCON3 contains the status flags for the DMA and D0 stack overflow status trap sources.

The INTCON4 register contains the software generated hard trap status bit (SGHT).

### 7.4.2 IFSx

The IFSx registers maintain all of the interrupt request flags. Each source of interrupt has a status bit, which is set by the respective peripherals or external signal and is cleared via software.

### 7.4.3 IECx

The IECx registers maintain all of the interrupt enable bits. These control bits are used to individually enable interrupts from the peripherals or external signals.

### 7.4.4 IPCx

The IPCx registers are used to set the Interrupt Priority Level (IPL) for each source of interrupt. Each user interrupt source can be assigned to one of eight priority levels.

### 7.4.5 INTTREG

The INTTREG register contains the associated interrupt vector number and the new CPU Interrupt Priority Level, which are latched into the Vector Number bits (VECNUM<7:0>) and Interrupt Priority Level bits (ILR<3:0>) fields in the INTTREG register. The new Interrupt Priority Level is the priority of the pending interrupt.

The interrupt sources are assigned to the IFSx, IECx and IPCx registers in the same sequence as they are listed in Table 7-1. For example, the INT0 (External Interrupt 0) is shown as having Vector Number 8 and a natural order priority of 0. Thus, the INT0IF bit is found in IFS0<0>, the INT0IE bit in IEC0<0> and the INT0IP bits in the first position of IPC0 (IPC0<2:0>).

### 7.4.6 STATUS/CONTROL REGISTERS

Although these registers are not specifically part of the interrupt control hardware, two of the CPU Control registers contain bits that control interrupt functionality. For more information on these registers refer to **"CPU"** (DS70359) in the *"dsPIC33/PIC24 Family Reference Manual"*.

- The CPU STATUS Register, SR, contains the IPL<2:0> bits (SR<7:5>). These bits indicate the current CPU Interrupt Priority Level. The user software can change the current CPU Interrupt Priority Level by writing to the IPLx bits.
- The CORCON register contains the IPL3 bit which, together with IPL<2:0>, also indicates the current CPU priority level. IPL3 is a read-only bit so that trap events cannot be masked by the user software.

All Interrupt registers are described in Register 7-3 through Register 7-7 in the following pages.

**REGISTER 7-2: CORCON: CORE CONTROL REGISTER(1)**

| R/W-0 | U-0 | R/W-0 | R/W-0 | R/W-0 | R-0 | R-0 | R-0 |
|---|---|---|---|---|---|---|---|
| **VAR** | — | US1 | US0 | EDT | DL2 | DL1 | DL0 |
| bit 15 | | | | | | | bit 8 |

| R/W-0 | R/W-0 | R/W-1 | R/W-0 | R/C-0 | R-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| SATA | SATB | SATDW | ACCSAT | **IPL3(2)** | SFA | RND | IF |
| bit 7 | | | | | | | bit 0 |

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

bit 15 **VAR:** Variable Exception Processing Latency Control bit
1 = Variable exception processing is enabled
0 = Fixed exception processing is enabled

bit 3 **IPL3:** CPU Interrupt Priority Level Status bit 3(2)
1 = CPU Interrupt Priority Level is greater than 7
0 = CPU Interrupt Priority Level is 7 or less

**Note 1:** For complete register details, see Register 3-2.
**2:** The IPL3 bit is concatenated with the IPL<2:0> bits (SR<7:5>) to form the CPU Interrupt Priority Level.

**REGISTER 8-14: DMAPPS: DMA PING-PONG 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 |
|---|---|---|---|---|---|---|---|
| — | — | — | — | PPST3 | PPST2 | PPST1 | PPST0 |
| 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 **PPST3:** DMA Channel 3 Ping-Pong Mode Status Flag bit
1 = DMASTB3 register is selected
0 = DMASTA3 register is selected

bit 2 **PPST2:** DMA Channel 2 Ping-Pong Mode Status Flag bit
1 = DMASTB2 register is selected
0 = DMASTA2 register is selected

bit 1 **PPST1:** DMA Channel 1 Ping-Pong Mode Status Flag bit
1 = DMASTB1 register is selected
0 = DMASTA1 register is selected

bit 0 **PPST0:** DMA Channel 0 Ping-Pong Mode Status Flag bit
1 = DMASTB0 register is selected
0 = DMASTA0 register is selected

**REGISTER 11-2: 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 |

| U-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| — | INT2R<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 **INT2R<6:0>:** Assign External Interrupt 2 (INT2) 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 11-3: RPINR3: PERIPHERAL PIN SELECT INPUT REGISTER 3**

| 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 |
|---|---|---|---|---|---|---|---|
| — | T2CKR<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 **T2CKR<6:0>:** Assign Timer2 External Clock (T2CK) 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 14-2: ICxCON2: INPUT CAPTURE x CONTROL REGISTER 2**

| U-0 | U-0 | U-0 | U-0 | U-0 | U-0 | U-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | — | — | — | — | IC32 |
| bit 15 | | | | | | | bit 8 |

| R/W-0 | R/W/HS-0 | U-0 | R/W-0 | R/W-1 | R/W-1 | R/W-0 | R/W-1 |
|---|---|---|---|---|---|---|---|
| ICTRIG(2) | TRIGSTAT(3) | — | SYNCSEL4(4) | SYNCSEL3(4) | SYNCSEL2(4) | SYNCSEL1(4) | SYNCSEL0(4) |
| bit 7 | | | | | | | bit 0 |

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

bit 15-9 **Unimplemented:** Read as '0'

bit 8 **IC32:** Input Capture 32-Bit Timer Mode Select bit (Cascade mode)
1 = Odd IC and Even IC form a single 32-bit input capture module(1)
0 = Cascade module operation is disabled

bit 7 **ICTRIG:** Input Capture Trigger Operation Select bit(2)
1 = Input source used to trigger the input capture timer (Trigger mode)
0 = Input source used to synchronize the input capture timer to a timer of another module (Synchronization mode)

bit 6 **TRIGSTAT:** Timer Trigger Status bit(3)
1 = ICxTMR has been triggered and is running
0 = ICxTMR has not been triggered and is being held clear

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

**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 16-15: FCLCONx: PWMx FAULT CURRENT-LIMIT CONTROL REGISTER(1)**

| U-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| — | CLSRC4 | CLSRC3 | CLSRC2 | CLSRC1 | CLSRC0 | CLPOL(2) | CLMOD |
| bit 15 | | | | | | | bit 8 |

| R/W-1 | R/W-1 | R/W-1 | R/W-1 | R/W-1 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| FLTSRC4 | FLTSRC3 | FLTSRC2 | FLTSRC1 | FLTSRC0 | FLTPOL(2) | FLTMOD1 | FLTMOD0 |
| bit 7 | | | | | | | bit 0 |

| **Legend:** | | | |
|---|---|---|---|
| R = Readable bit | W = Writable bit | U = Unimplemented bit, read as '0' | |
| -n = Value at POR | '1' = Bit is set | '0' = Bit is cleared | x = Bit is unknown |

bit 15 **Unimplemented:** Read as '0'

bit 14-10 **CLSRC<4:0>:** Current-Limit Control Signal Source Select for PWM Generator # bits
11111 = Fault 32
11110 = Reserved
•
•
•
01100 = Reserved
01011 = Comparator 4
01010 = Op Amp/Comparator 3
01001 = Op Amp/Comparator 2
01000 = Op Amp/Comparator 1
00111 = Reserved
00110 = Reserved
00101 = Reserved
00100 = Reserved
00011 = Fault 4
00010 = Fault 3
00001 = Fault 2
00000 = Fault 1 **(default)**

bit 9 **CLPOL:** Current-Limit Polarity for PWM Generator # bit(2)
1 = The selected current-limit source is active-low
0 = The selected current-limit source is active-high

bit 8 **CLMOD:** Current-Limit Mode Enable for PWM Generator # bit
1 = Current-Limit mode is enabled
0 = Current-Limit mode is disabled

**Note 1:** If the PWMLOCK Configuration bit (FOSCSEL<6>) is a '1', the IOCONx register can only be written after the unlock sequence has been executed.

**2:** These bits should be changed only when PTEN = 0. Changing the clock selection during operation will yield unpredictable results.

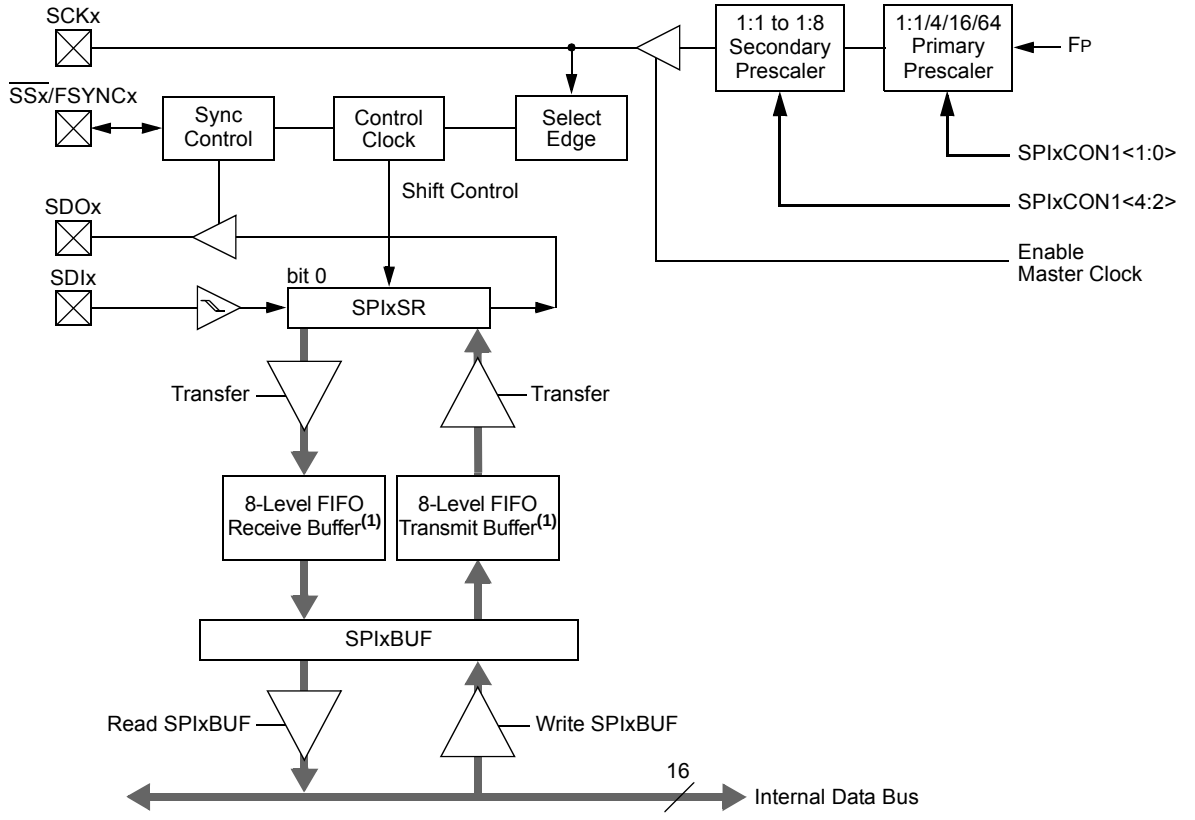
**REGISTER 17-2: QEI1IOC: QEI1 I/O CONTROL REGISTER (CONTINUED)**

bit 2 **INDEX:** Status of INDXx Input Pin After Polarity Control
1 = Pin is at logic '1'
0 = Pin is at logic '0'

bit 1 **QEB:** Status of QEBx Input Pin After Polarity Control And SWPAB Pin Swapping
1 = Pin is at logic '1'
0 = Pin is at logic '0'

bit 0 **QEA:** Status of QEAx Input Pin After Polarity Control And SWPAB Pin Swapping
1 = Pin is at logic '1'
0 = Pin is at logic '0'

**FIGURE 18-1: SPIx MODULE BLOCK DIAGRAM**




**Note 1:** In Standard mode, the FIFO is only one level deep.

## 19.0 INTER-INTEGRATED CIRCUIT™ ($I^2C$™)

**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 **"Inter-Integrated Circuit™ ($I^2C$™)"** (DS70330) 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.

**3:** There are minimum bit rates of approximately FCY/512. As a result, high processor speeds may not support 100 Kbit/second operation. See timing specifications, IM10 and IM11, and the **"Baud Rate Generator"** in the "*dsPIC33/PIC24 Family Reference Manual*".

The dsPIC33EPXXXGP50X, dsPIC33EPXXXMC20X/50X and PIC24EPXXXGP/MC20X family of devices contains two Inter-Integrated Circuit ($I^2C$) modules: I2C1 and I2C2.

The $I^2C$ module provides complete hardware support for both Slave and Multi-Master modes of the $I^2C$ serial communication standard, with a 16-bit interface.

The $I^2C$ module has a 2-pin interface:

- The SCLx pin is clock
- The SDAx pin is data

The $I^2C$ module offers the following key features:

- $I^2C$ interface supporting both Master and Slave modes of operation
- $I^2C$ Slave mode supports 7 and 10-bit addressing
- $I^2C$ Master mode supports 7 and 10-bit addressing
- $I^2C$ port allows bidirectional transfers between master and slaves
- Serial clock synchronization for $I^2C$ port can be used as a handshake mechanism to suspend and resume serial transfer (SCLREL control)
- $I^2C$ supports multi-master operation, detects bus collision and arbitrates accordingly
- Intelligent Platform Management Interface (IPMI) support
- System Management Bus (SMBus) support

**REGISTER 23-2: AD1CON2: ADC1 CONTROL REGISTER 2**

| R/W-0 | R/W-0 | R/W-0 | U-0 | U-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| VCFG2 | VCFG1 | VCFG0 | — | — | CSCNA | CHPS1 | CHPS0 |
| bit 15 | | | | | | | bit 8 |

| R-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| BUFS | SMPI4 | SMPI3 | SMPI2 | SMPI1 | SMPI0 | BUFM | ALTS |
| 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 **VCFG<2:0>:** Converter Voltage Reference Configuration bits

| Value | VREFH | VREFL |
|---|---|---|
| 000 | AVDD | Avss |
| 001 | External VREF+ | Avss |
| 010 | AVDD | External VREF- |
| 011 | External VREF+ | External VREF- |
| 1xx | AVDD | AVSS |

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

bit 10 **CSCNA:** Input Scan Select bit
1 = Scans inputs for CH0+ during Sample MUXA
0 = Does not scan inputs

bit 9-8 **CHPS<1:0>:** Channel Select bits
In 12-bit mode (AD21B = 1), the CHPS<1:0> bits are Unimplemented and are Read as '0':
1x = Converts CH0, CH1, CH2 and CH3
01 = Converts CH0 and CH1
00 = Converts CH0

bit 7 **BUFS:** Buffer Fill Status bit (only valid when BUFM = 1)
1 = ADC is currently filling the second half of the buffer; the user application should access data in the first half of the buffer
0 = ADC is currently filling the first half of the buffer; the user application should access data in the second half of the buffer

bit 6-2 **SMPI<4:0>:** Increment Rate bits
When ADDMAEN = 0:
x1111 = Generates interrupt after completion of every 16th sample/conversion operation
x1110 = Generates interrupt after completion of every 15th sample/conversion operation
•
•
•
x0001 = Generates interrupt after completion of every 2nd sample/conversion operation
x0000 = Generates interrupt after completion of every sample/conversion operation
When ADDMAEN = 1:
11111 = Increments the DMA address after completion of every 32nd sample/conversion operation
11110 = Increments the DMA address after completion of every 31st sample/conversion operation
•
•
•
00001 = Increments the DMA address after completion of every 2nd sample/conversion operation
00000 = Increments the DMA address after completion of every sample/conversion operation

**REGISTER 23-4: AD1CON4: ADC1 CONTROL REGISTER 4**

| U-0 | U-0 | U-0 | U-0 | U-0 | U-0 | U-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | — | — | — | — | ADDMAEN |
| bit 15 | | | | | | | bit 8 |

| U-0 | U-0 | U-0 | U-0 | U-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | — | — | DMABL2 | DMABL1 | DMABL0 |
| 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 **ADDMAEN:** ADC1 DMA Enable bit

1 = Conversion results are stored in the ADC1BUF0 register for transfer to RAM using DMA
0 = Conversion results are stored in ADC1BUF0 through ADC1BUFF registers; DMA will not be used

bit 7-3 **Unimplemented:** Read as ‘0’

bit 2-0 **DMABL<2:0>:** Selects Number of DMA Buffer Locations per Analog Input bits

111 = Allocates 128 words of buffer to each analog input
110 = Allocates 64 words of buffer to each analog input
101 = Allocates 32 words of buffer to each analog input
100 = Allocates 16 words of buffer to each analog input
011 = Allocates 8 words of buffer to each analog input
010 = Allocates 4 words of buffer to each analog input
001 = Allocates 2 words of buffer to each analog input
000 = Allocates 1 word of buffer to each analog input

**REGISTER 24-3: PTGBTE: PTG BROADCAST TRIGGER ENABLE REGISTER(1,2)**

| R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| ADCTS4 | ADCTS3 | ADCTS2 | ADCTS1 | IC4TSS | IC3TSS | IC2TSS | IC1TSS |
| 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 |
|---|---|---|---|---|---|---|---|
| OC4CS | OC3CS | OC2CS | OC1CS | OC4TSS | OC3TSS | OC2TSS | OC1TSS |
| 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 **ADCTS4:** Sample Trigger PTGO15 for ADC bit
1 = Generates Trigger when the broadcast command is executed
0 = Does not generate Trigger when the broadcast command is executed

bit 14 **ADCTS3:** Sample Trigger PTGO14 for ADC bit
1 = Generates Trigger when the broadcast command is executed
0 = Does not generate Trigger when the broadcast command is executed

bit 13 **ADCTS2:** Sample Trigger PTGO13 for ADC bit
1 = Generates Trigger when the broadcast command is executed
0 = Does not generate Trigger when the broadcast command is executed

bit 12 **ADCTS1:** Sample Trigger PTGO12 for ADC bit
1 = Generates Trigger when the broadcast command is executed
0 = Does not generate Trigger when the broadcast command is executed

bit 11 **IC4TSS:** Trigger/Synchronization Source for IC4 bit
1 = Generates Trigger/Synchronization when the broadcast command is executed
0 = Does not generate Trigger/Synchronization when the broadcast command is executed

bit 10 **IC3TSS:** Trigger/Synchronization Source for IC3 bit
1 = Generates Trigger/Synchronization when the broadcast command is executed
0 = Does not generate Trigger/Synchronization when the broadcast command is executed

bit 9 **IC2TSS:** Trigger/Synchronization Source for IC2 bit
1 = Generates Trigger/Synchronization when the broadcast command is executed
0 = Does not generate Trigger/Synchronization when the broadcast command is executed

bit 8 **IC1TSS:** Trigger/Synchronization Source for IC1 bit
1 = Generates Trigger/Synchronization when the broadcast command is executed
0 = Does not generate Trigger/Synchronization when the broadcast command is executed

bit 7 **OC4CS:** Clock Source for OC4 bit
1 = Generates clock pulse when the broadcast command is executed
0 = Does not generate clock pulse when the broadcast command is executed

bit 6 **OC3CS:** Clock Source for OC3 bit
1 = Generates clock pulse when the broadcast command is executed
0 = Does not generate clock pulse when the broadcast command is executed

bit 5 **OC2CS:** Clock Source for OC2 bit
1 = Generates clock pulse when the broadcast command is executed
0 = Does not generate clock pulse when the broadcast command is executed

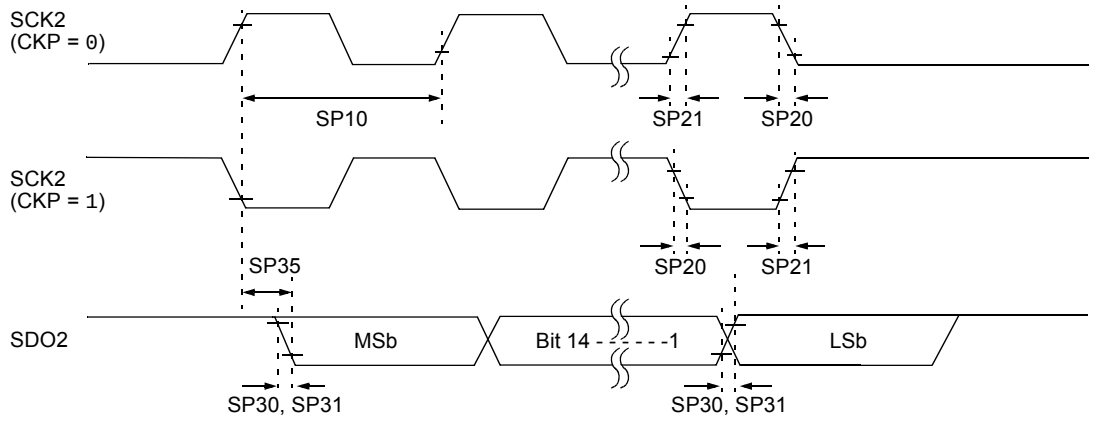
**Note 1:** This register is read-only when the PTG module is executing Step commands (PTGEN = 1 and PTGSTRT = 1).

**2:** This register is only used with the PTGCTRL OPTION = 1111 Step command.

**TABLE 30-33: SPI2 MAXIMUM DATA/CLOCK RATE SUMMARY**

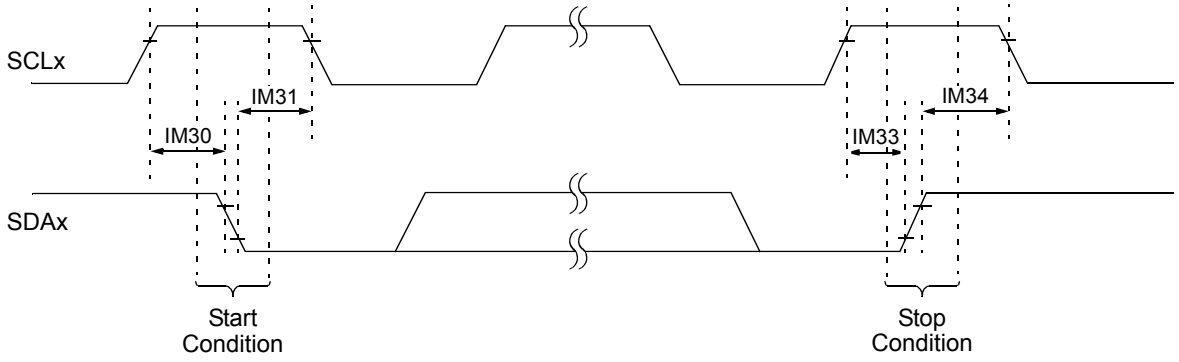
| AC CHARACTERISTICS | | | Standard Operating Conditions: 3.0V to 3.6V (unless otherwise stated)<br>Operating temperature -40°C ≤ TA ≤ +85°C for Industrial<br>-40°C ≤ TA ≤ +125°C for Extended | | | |
|---|---|---|---|---|---|---|
| **Maximum Data Rate** | **Master Transmit Only (Half-Duplex)** | **Master Transmit/Receive (Full-Duplex)** | **Slave Transmit/Receive (Full-Duplex)** | **CKE** | **CKP** | **SMP** |
| 15 MHz | Table 30-33 | — | — | 0,1 | 0,1 | 0,1 |
| 9 MHz | — | Table 30-34 | — | 1 | 0,1 | 1 |
| 9 MHz | — | Table 30-35 | — | 0 | 0,1 | 1 |
| 15 MHz | — | — | Table 30-36 | 1 | 0 | 0 |
| 11 MHz | — | — | Table 30-37 | 1 | 1 | 0 |
| 15 MHz | — | — | Table 30-38 | 0 | 1 | 0 |
| 11 MHz | — | — | Table 30-39 | 0 | 0 | 0 |

**FIGURE 30-14: SPI2 MASTER MODE (HALF-DUPLEX, TRANSMIT ONLY, CKE = 0) TIMING CHARACTERISTICS**




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

**FIGURE 30-30: I2Cx BUS START/STOP BITS TIMING CHARACTERISTICS (MASTER MODE)**




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

**FIGURE 30-31: I2Cx BUS DATA TIMING CHARACTERISTICS (MASTER MODE)**

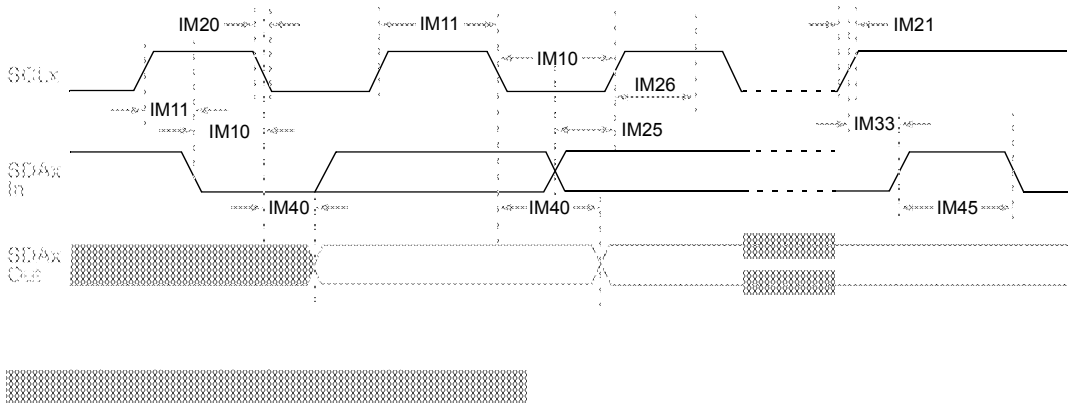
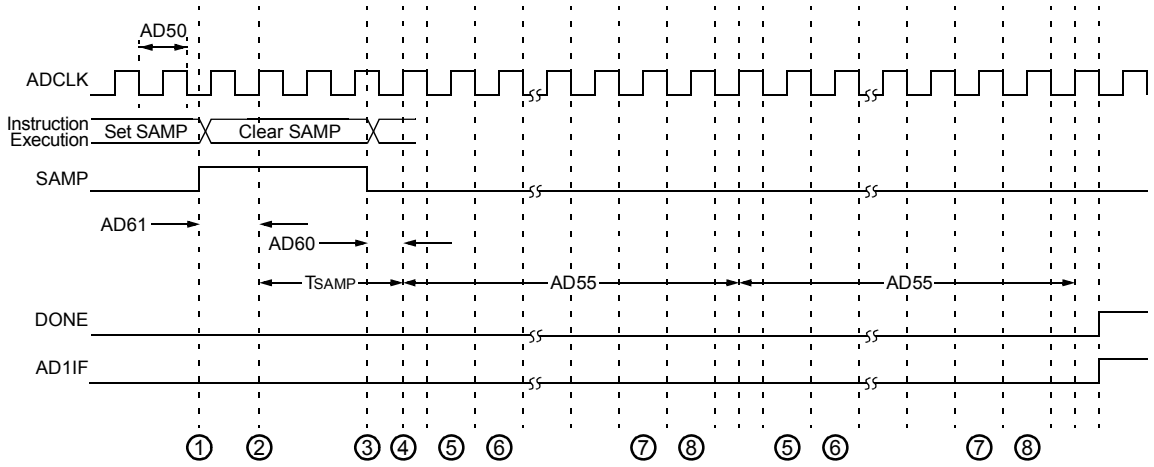


**FIGURE 30-37: ADC CONVERSION (10-BIT MODE) TIMING CHARACTERISTICS (CHPS<1:0> = 01, SIMSAM = 0, ASAM = 0, SSRC<2:0> = 000, SSRCG = 0)**




1 – Software sets AD1CON1. SAMP to start sampling.

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

3 – Software clears AD1CON1. SAMP to start conversion.

4 – Sampling ends, conversion sequence starts.

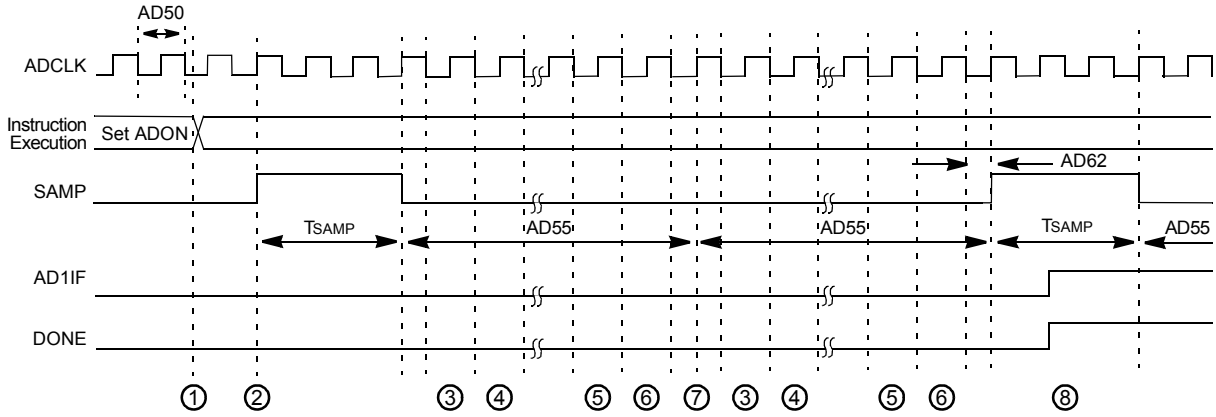
5 – Convert bit 9.

6 – Convert bit 8.

7 – Convert bit 0.

8 – One TAD for end of conversion.

**FIGURE 30-38: ADC CONVERSION (10-BIT MODE) TIMING CHARACTERISTICS (CHPS<1:0> = 01, SIMSAM = 0, ASAM = 1, SSRC<2:0> = 111, SSRCG = 0, SAMC<4:0> = 00010)**




1 – Software sets AD1CON1. ADON to start AD operation.

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

3 – Convert bit 9.

4 – Convert bit 8.

5 – Convert bit 0.

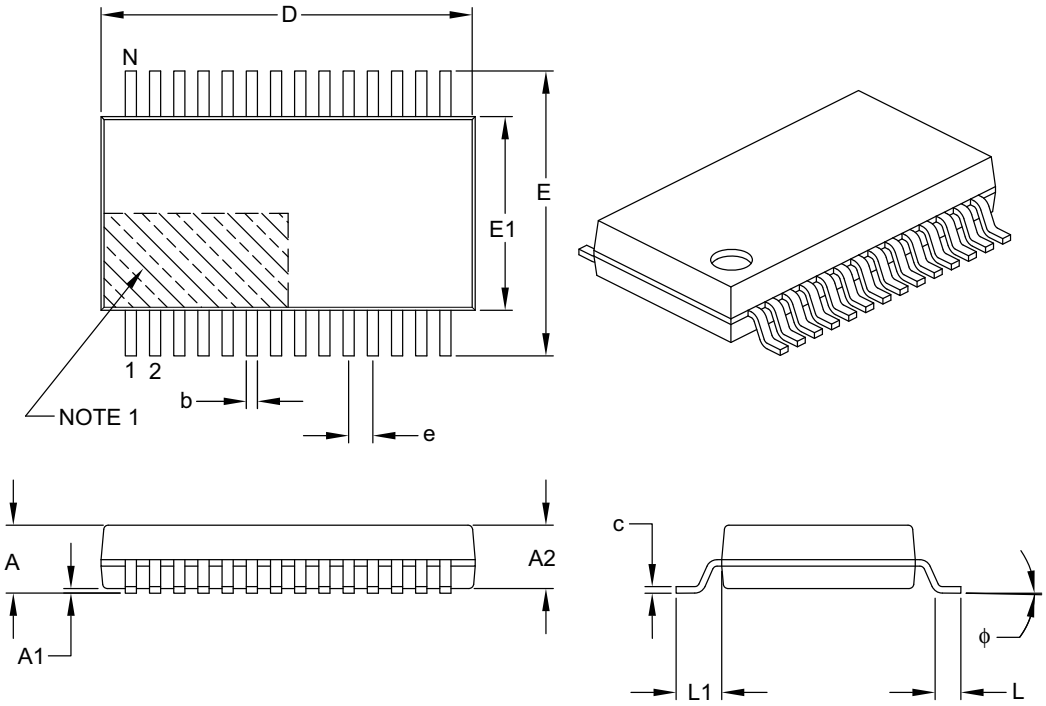
6 – One TAD for end of conversion.

7 – Begin conversion of next channel.

8 – Sample for time specified by SAMC<4:0>.

## 28-Lead Plastic Shrink Small Outline (SS) – 5.30 mm Body [SSOP]

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




| Units | | MILLIMETERS | | |
|---|---|---|---|---|
| Dimension Limits | | MIN | NOM | MAX |
| Number of Pins | N | | 28 | |
| Pitch | e | | 0.65 BSC | |
| Overall Height | A | – | – | 2.00 |
| Molded Package Thickness | A2 | 1.65 | 1.75 | 1.85 |
| Standoff | A1 | 0.05 | – | – |
| Overall Width | E | 7.40 | 7.80 | 8.20 |
| Molded Package Width | E1 | 5.00 | 5.30 | 5.60 |
| Overall Length | D | 9.90 | 10.20 | 10.50 |
| Foot Length | L | 0.55 | 0.75 | 0.95 |
| Footprint | L1 | | 1.25 REF | |
| Lead Thickness | c | 0.09 | – | 0.25 |
| Foot Angle | ϕ | 0° | 4° | 8° |
| Lead Width | b | 0.22 | – | 0.38 |

**Notes:**

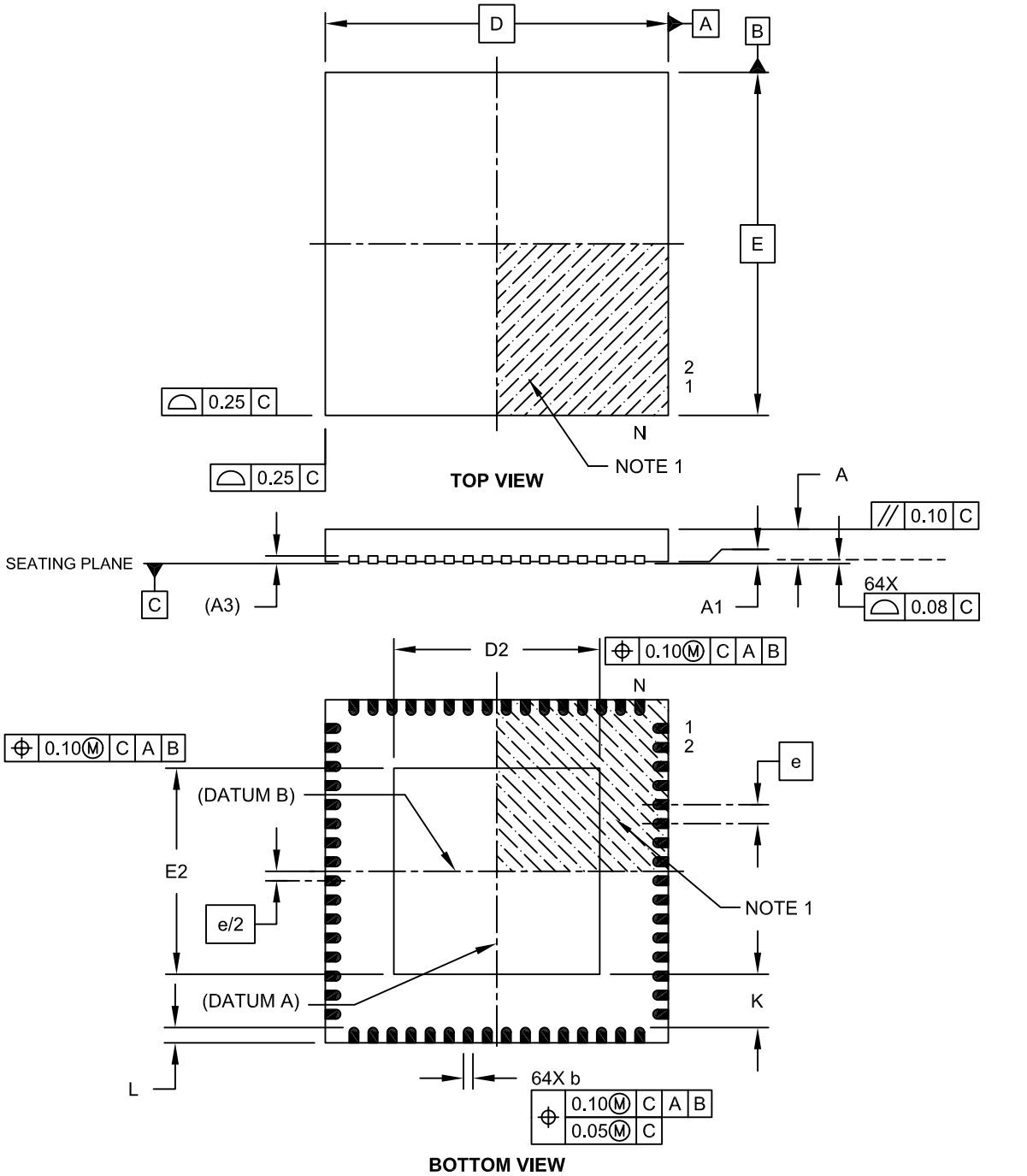
1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.20 mm per side.
3. Dimensioning and tolerancing per ASME Y14.5M.

BSC: Basic Dimension. Theoretically exact value shown without tolerances.
REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-073B

**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




Microchip Technology Drawing C04-154A Sheet 1 of 2