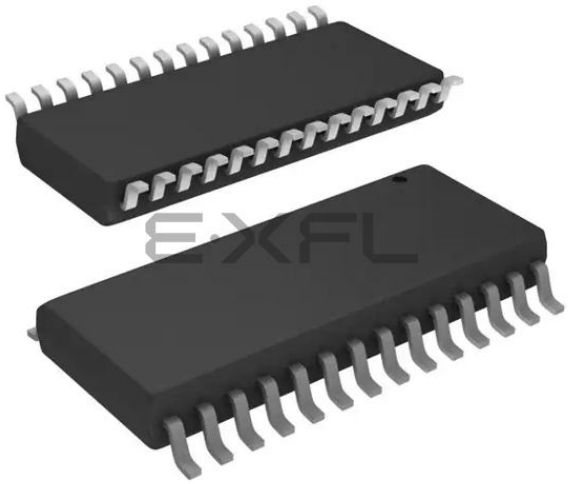

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## What is "Embedded - Microcontrollers"?

"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 | 32MHz |
| Connectivity | I²C, IrDA, LINbus, SPI, UART/USART |
| Peripherals | Brown-out Detect/Reset, HLVD, POR, PWM, WDT |
| Number of I/O | 24 |
| Program Memory Size | 8KB (2.75K x 24) |
| Program Memory Type | FLASH |
| EEPROM Size | 256 x 8 |
| RAM Size | 1K x 8 |
| Voltage - Supply (Vcc/Vdd) | 1.8V ~ 3.6V |
| Data Converters | - |
| Oscillator Type | Internal |
| Operating Temperature | -40°C ~ 125°C (TA) |
| Mounting Type | Surface Mount |
| Package / Case | 28-SOIC (0.295", 7.50mm Width) |
| Supplier Device Package | 28-SOIC |
| Purchase URL | https://www.e-xfl.com/product-detail/microchip-technology/pic24f08kl302-e-so |

**TABLE 1-5: PIC24F16KL20X/10X FAMILY PINOUT DESCRIPTIONS (CONTINUED)**

| Function | Pin Number | | | I/O | Buffer | Description |
|---|---|---|---|---|---|---|
| | 20-Pin PDIP/ SSOP/ SOIC | 20-Pin QFN | 14-Pin PDIP/ TSSOP | | | |
| SCK1 | 15 | 12 | 8 | I/O | ST | MSSP1 SPI Serial Input/Output Clock |
| SCL1 | 12 | 9 | 8 | I/O | $I^2C$ | MSSP1 $I^2C$ Clock Input/Output |
| SCLKI | 10 | 7 | 12 | I | ST | Digital Secondary Clock Input |
| SDA1 | 13 | 10 | 9 | I/O | $I^2C$ | MSSP1 $I^2C$ Data Input/Output |
| SDI1 | 17 | 14 | 11 | I | ST | MSSP1 SPI Serial Data Input |
| SDO1 | 16 | 13 | 9 | O | — | MSSP1 SPI Serial Data Output |
| SOSCI | 9 | 6 | 11 | I | ANA | Secondary Oscillator Input |
| SOSCO | 10 | 7 | 12 | O | ANA | Secondary Oscillator Output |
| $\overline{SS1}$ | 12 | 9 | 12 | O | — | SPI1 Slave Select |
| T1CK | 13 | 10 | 9 | I | ST | Timer1 Clock |
| T3CK | 18 | 15 | 12 | I | ST | Timer3 Clock |
| T3G | 6 | 3 | 11 | I | ST | Timer3 External Gate Input |
| $\overline{U1CTS}$ | 12 | 9 | 8 | I | ST | UART1 Clear-to-Send Input |
| $\overline{U1RTS}$ | 13 | 10 | 9 | O | — | UART1 Request-to-Send Output |
| U1RX | 6 | 3 | 12 | I | ST | UART1 Receive |
| U1TX | 11 | 8 | 11 | O | — | UART1 Transmit |
| ULPWU | 3 | 1 | 3 | I | ANA | Ultra Low-Power Wake-up Input |
| $V_{DD}$ | 20 | 17 | 14 | P | — | Positive Supply for Peripheral Digital Logic and I/O Pins |
| $V_{REF+}$ | 2 | 19 | 2 | I | ANA | A/D Reference Voltage Input (+) |
| $V_{REF-}$ | 3 | 20 | 3 | I | ANA | A/D Reference Voltage Input (-) |
| $V_{SS}$ | 19 | 16 | 13 | P | — | Ground Reference for Logic and I/O Pins |

**Legend:** TTL = TTL input buffer ST = Schmitt Trigger input buffer
ANA = Analog level input/output $I^2C$ = $I^2C$™/SMBus input buffer

## 2.4 ICSP Pins

The PGC and PGD pins are used for In-Circuit Serial Programming™ (ICSP™) and debugging purposes. It is recommended to keep the trace length between the ICSP connector and the ICSP pins on the device as short as possible. If the ICSP connector is expected to experience an ESD event, a series resistor is recommended, with the value in the range of a few tens of ohms, not to exceed 100Ω.

Pull-up resistors, series diodes and capacitors on the PGC and PGD pins are not recommended as they will interfere with the programmer/debugger communications to the device. If such discrete components are an application requirement, they should be removed from the circuit during programming and debugging. Alternatively, refer to the AC/DC characteristics and timing requirements information in the respective device Flash programming specification for information on capacitive loading limits, and pin Input Voltage High ($V_{IH}$) and Input Voltage Low ($V_{IL}$) requirements.

For device emulation, ensure that the "Communication Channel Select" (i.e., PGCx/PGDx) pins, programmed into the device, matches the physical connections for the ICSP to the Microchip debugger/emulator tool.

For more information on available Microchip development tools connection requirements, refer to **Section 24.0 "Development Support"**.

## 2.5 External Oscillator Pins

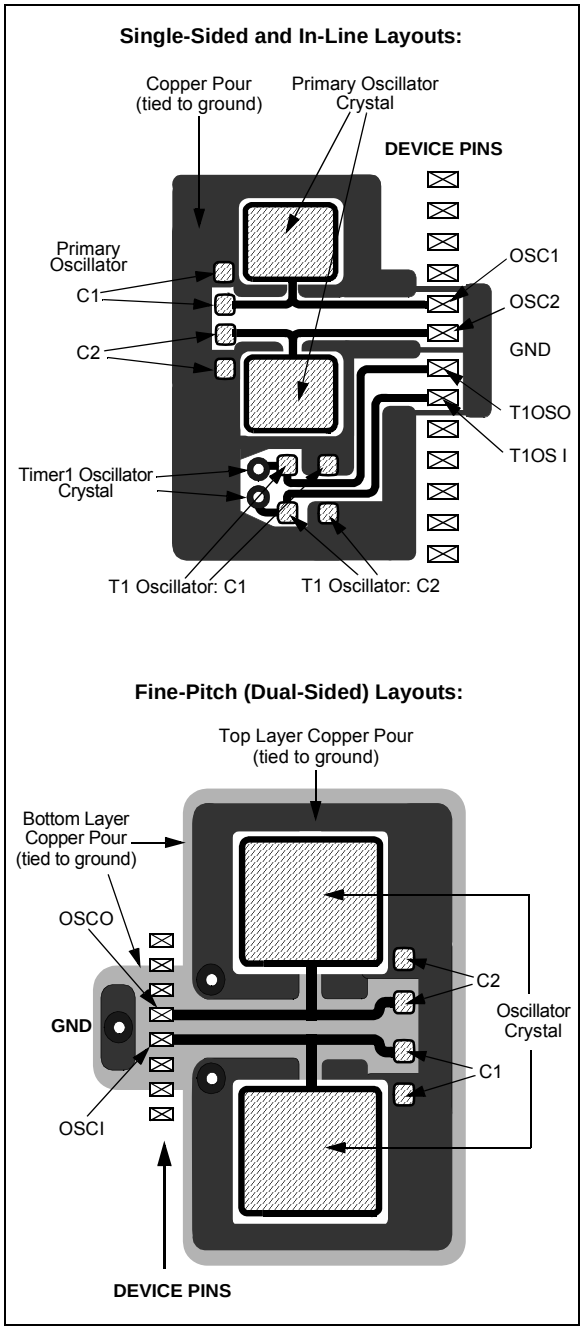
Many microcontrollers have options for at least two oscillators: a high-frequency primary oscillator and a low-frequency secondary oscillator (refer to **Section 9.0 "Oscillator Configuration"** for details).

The oscillator circuit should be placed on the same side of the board as the device. Place the oscillator circuit close to the respective oscillator pins with no more than 0.5 inch (12 mm) between the circuit components and the pins. The load capacitors should be placed next to the oscillator itself, on the same side of the board.

Use a grounded copper pour around the oscillator circuit to isolate it from surrounding circuits. The grounded copper pour should be routed directly to the MCU ground. Do not run any signal traces or power traces inside the ground pour. Also, if using a two-sided board, avoid any traces on the other side of the board where the crystal is placed.

Layout suggestions are shown in Figure 2-3. In-line packages may be handled with a single-sided layout that completely encompasses the oscillator pins. With fine-pitch packages, it is not always possible to completely surround the pins and components. A suitable solution is to tie the broken guard sections to a mirrored ground layer. In all cases, the guard trace(s) must be returned to ground.

**FIGURE 2-3: SUGGESTED PLACEMENT OF THE OSCILLATOR CIRCUIT**




In planning the application's routing and I/O assignments, ensure that adjacent port pins and other signals, in close proximity to the oscillator, are benign (i.e., free of high frequencies, short rise and fall times, and other similar noise).

**REGISTER 7-1: RCON: RESET CONTROL REGISTER(1)**

| R/W-0 | R/W-0 | R/W-0(3) | U-0 | U-0 | U-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| TRAPR | IOPUWR | SBOREN | — | — | — | CM | PMSLP |
| bit 15 | | | | | | | bit 8 |

| R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-1 | R/W-1 |
|---|---|---|---|---|---|---|---|
| EXTR | SWR | SWDTEN(2) | WDTO | SLEEP | IDLE | BOR | POR |
| 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 **TRAPR:** Trap Reset Flag bit
1 = A Trap Conflict Reset has occurred
0 = A Trap Conflict Reset has not occurred

bit 14 **IOPUWR:** Illegal Opcode or Uninitialized W Access Reset Flag bit
1 = An illegal opcode detection, an illegal address mode or an Uninitialized W register is used as an Address Pointer and caused a Reset
0 = An illegal opcode or Uninitialized W register Reset has not occurred

bit 13 **SBOREN:** Software Enable/Disable of BOR bit(3)
1 = BOR is turned on in software
0 = BOR is turned off in software

bit 12-10 **Unimplemented:** Read as '0'

bit 9 **CM:** Configuration Word Mismatch Reset Flag bit
1 = A Configuration Word Mismatch Reset has occurred
0 = A Configuration Word Mismatch Reset has not occurred

bit 8 **PMSLP:** Program Memory Power During Sleep bit
1 = Program memory bias voltage remains powered during Sleep
0 = Program memory bias voltage is powered down during Sleep

bit 7 **EXTR:** External Reset ($\overline{MCLR}$) Pin bit
1 = A Master Clear (pin) Reset has occurred
0 = A Master Clear (pin) Reset has not occurred

bit 6 **SWR:** Software Reset (Instruction) Flag bit
1 = A RESET instruction has been executed
0 = A RESET instruction has not been executed

bit 5 **SWDTEN:** Software Enable/Disable of WDT bit(2)
1 = WDT is enabled
0 = WDT is disabled

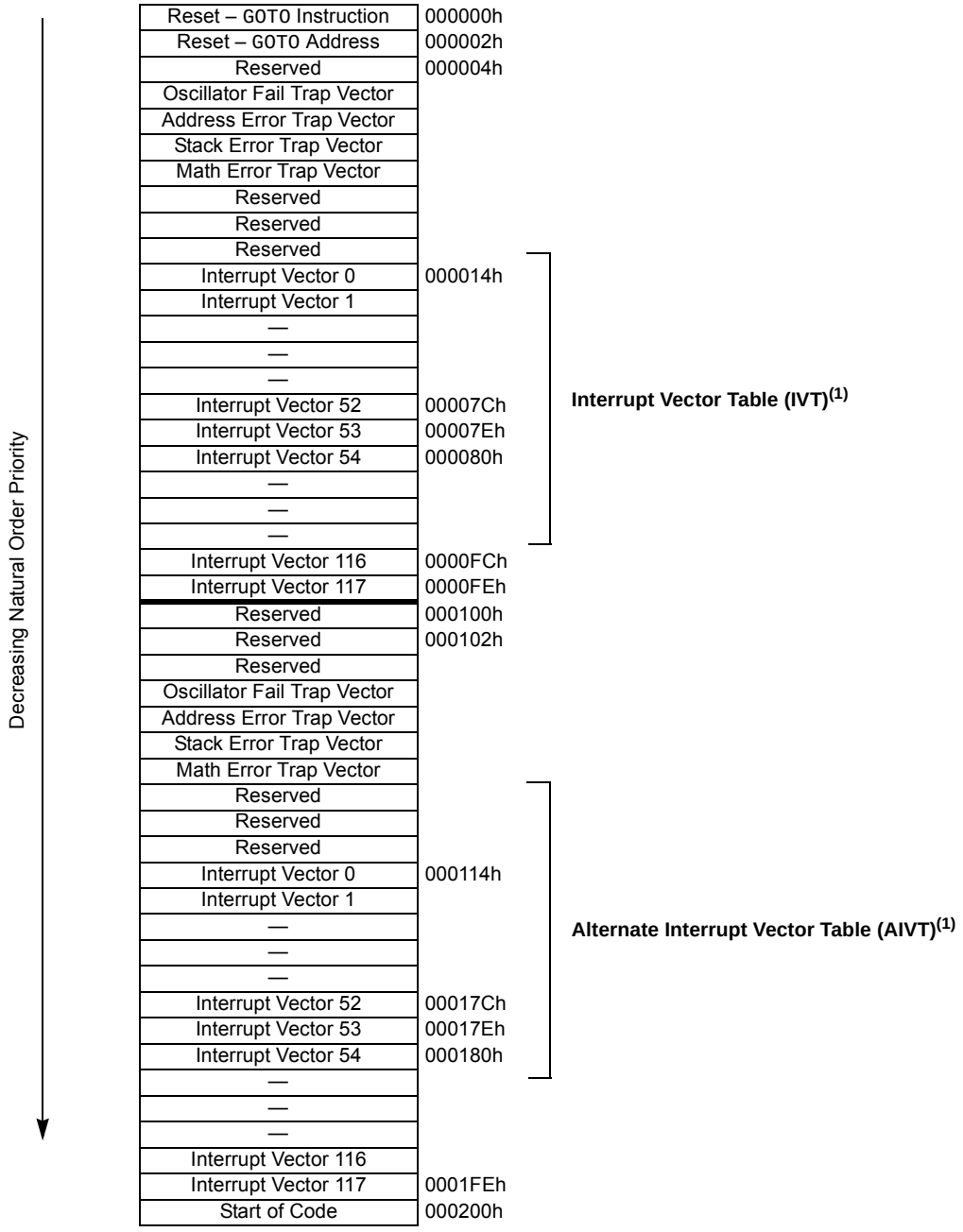
bit 4 **WDTO:** Watchdog Timer Time-out Flag bit
1 = WDT time-out has occurred
0 = WDT time-out has not occurred

**Note 1:** All of the Reset status bits may be set or cleared in software. Setting one of these bits in software does not cause a device Reset.

**2:** If the FWDTEN Configuration bit is '1' (unprogrammed), the WDT is always enabled, regardless of the SWDTEN bit setting.

**3:** The SBOREN bit is forced to '0' when disabled by the Configuration bits, BOREN<1:0> (FPOR<1:0>). When the Configuration bits are set to enable SBOREN, the default Reset state will be '1'.

**FIGURE 8-1: PIC24F INTERRUPT VECTOR TABLE**




**Note 1:** See Table 8-2 for the interrupt vector list.

**TABLE 8-1: TRAP VECTOR DETAILS**

| Vector Number | IVT Address | AIVT Address | Trap Source |
|---|---|---|---|
| 0 | 000004h | 000104h | Reserved |
| 1 | 000006h | 000106h | Oscillator Failure |
| 2 | 000008h | 000108h | Address Error |
| 3 | 00000Ah | 00010Ah | Stack Error |
| 4 | 00000Ch | 00010Ch | Math Error |
| 5 | 00000Eh | 00010Eh | Reserved |
| 6 | 000010h | 000110h | Reserved |
| 7 | 000012h | 000112h | Reserved |

**TABLE 8-2: IMPLEMENTED INTERRUPT VECTORS**

| Interrupt Source | Vector Number | IVT Address | AIVT Address | Interrupt Bit Locations | | |
|---|---|---|---|---|---|---|
| | | | | Flag | Enable | Priority |
| ADC1 Conversion Done | 13 | 00002Eh | 00012Eh | IFS0<13> | IEC0<13> | IPC3<6:4> |
| Comparator Event | 18 | 000038h | 000138h | IFS1<2> | IEC1<2> | IPC4<10:8> |
| External Interrupt 0 | 0 | 000014h | 000114h | IFS0<0> | IEC0<0> | IPC0<2:0> |
| External Interrupt 1 | 20 | 00003Ch | 00013Ch | IFS1<4> | IEC1<4> | IPC5<2:0> |
| External Interrupt 2 | 29 | 00004Eh | 00014Eh | IFS1<13> | IEC1<13> | IPC7<6:4> |
| MSSP1 Bus Collision Event | 17 | 000036h | 000136h | IFS1<1> | IEC1<1> | IPC4<6:4> |
| MSSP1 SPI or $I^2C$™ Event | 16 | 000034h | 000134h | IFS1<0> | IEC1<0> | IPC4<2:0> |
| MSSP2 Bus Collision Event | 50 | 000078h | 000178h | IFS3<2> | IEC3<2> | IPC12<10:8> |
| MSSP2 SPI or $I^2C$ Event | 49 | 000076h | 000176h | IFS3<1> | IEC3<1> | IPC12<6:4> |
| Input Change Notification | 19 | 00003Ah | 00013Ah | IFS1<3> | IEC1<3> | IPC4<14:12> |
| HLVD (High/Low-Voltage Detect) | 72 | 0000A4h | 0001A4h | IFS4<8> | IEC4<8> | IPC17<2:0> |
| NVM (NVM Write Complete) | 15 | 000032h | 000132h | IFS0<15> | IEC0<15> | IPC3<14:12> |
| CCP1/ECCP1 | 2 | 000018h | 000118h | IFS0<2> | IEC0<2> | IPC0<10:8> |
| CCP2 | 6 | 000020h | 000120h | IFS0<6> | IEC0<6> | IPC1<10:8> |
| CCP3 | 25 | 000046h | 000146h | IFS1<9> | IEC1<9> | IPC6<6:4> |
| Timer1 | 3 | 00001Ah | 00011Ah | IFS0<3> | IEC0<3> | IPC0<14:12> |
| Timer2 | 7 | 000022h | 000122h | IFS0<7> | IEC0<7> | IPC1<14:12> |
| Timer3 | 8 | 000024h | 000124h | IFS0<8> | IEC0<8> | IPC2<2:0> |
| Timer4 | 27 | 00004Ah | 00014Ah | IFS1<11> | IEC1<11> | IPC6<14:12> |
| Timer3 Gate External Count | 37 | 00005Eh | 00015Eh | IFS2<5> | IEC2<5> | IPC9<6:4> |
| UART1 Error | 65 | 000096h | 000196h | IFS4<1> | IEC4<1> | IPC16<6:4> |
| UART1 Receiver | 11 | 00002Ah | 00012Ah | IFS0<11> | IEC0<11> | IPC2<14:12> |
| UART1 Transmitter | 12 | 00002Ch | 00012Ch | IFS0<12> | IEC0<12> | IPC3<2:0> |
| UART2 Error | 66 | 000098h | 000198h | IFS4<2> | IEC4<2> | IPC16<10:8> |
| UART2 Receiver | 30 | 000050h | 000150h | IFS1<14> | IEC1<14> | IPC7<10:8> |
| UART2 Transmitter | 31 | 000052h | 000152h | IFS1<15> | IEC1<15> | IPC7<14:12> |
| ULPW (Ultra Low-Power Wake-up) | 80 | 0000B4h | 0001B4h | IFS5<0> | IEC5<0> | IPC20<2:0> |

**REGISTER 8-3: INTCON1: INTERRUPT CONTROL REGISTER 1**

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

| U-0 | U-0 | U-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | U-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | MATHERR | ADDRERR | STKERR | OSCFAIL | — |
| 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 **NSTDIS:** Interrupt Nesting Disable bit
1 = Interrupt nesting is disabled
0 = Interrupt nesting is enabled

bit 14-5 **Unimplemented:** Read as ‘0’

bit 4 **MATHERR:** Arithmetic Error Trap Status bit
1 = Overflow trap has occurred
0 = Overflow trap has not occurred

bit 3 **ADDRERR:** Address Error Trap Status bit
1 = Address error trap has occurred
0 = Address error trap has not occurred

bit 2 **STKERR:** Stack Error Trap Status bit
1 = Stack error trap has occurred
0 = Stack error trap has not occurred

bit 1 **OSCFAIL:** Oscillator Failure Trap Status bit
1 = Oscillator failure trap has occurred
0 = Oscillator failure trap has not occurred

bit 0 **Unimplemented:** Read as ‘0’

**REGISTER 8-5: IFS0: INTERRUPT FLAG STATUS REGISTER 0**

| R/W-0 | U-0 | R/W-0 | R/W-0 | R/W-0 | U-0 | U-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| NVMIF | — | AD1IF | U1TXIF | U1RXIF | — | — | T3IF |
| bit 15 | | | | | | | bit 8 |

| R/W-0 | R/W-0 | U-0 | U-0 | R/W-0 | R/W-0 | U-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| T2IF | CCP2IF | — | — | T1IF | CCP1IF | — | INT0IF |
| 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 **NVMIF:** NVM Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

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

bit 13 **AD1IF:** A/D Conversion Complete Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 12 **U1TXIF:** UART1 Transmitter Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 11 **U1RXIF:** UART1 Receiver Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 10-9 **Unimplemented:** Read as '0'

bit 8 **T3IF:** Timer3 Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 7 **T2IF:** Timer2 Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 6 **CCP2IF:** Capture/Compare/PWM2 Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 5-4 **Unimplemented:** Read as '0'

bit 3 **T1IF:** Timer1 Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 2 **CCP1IF:** Capture/Compare/PWM1 Interrupt Flag Status bit (ECCP1 on PIC24FXXKL40X devices)
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 1 **Unimplemented:** Read as '0'

bit 0 **INT0IF:** External Interrupt 0 Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

**REGISTER 8-22: IPC5: INTERRUPT PRIORITY CONTROL REGISTER 5**

| 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 | U-0 | R/W-1 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | — | — | INT1IP2 | INT1IP1 | INT1IP0 |
| 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 **Unimplemented:** Read as ‘0’

bit 2-0 **INT1IP<2:0>:** External Interrupt 1 Priority bits

111 = Interrupt is Priority 7 (highest priority interrupt)

•

•

•

001 = Interrupt is Priority 1

000 = Interrupt source is disabled

**REGISTER 8-28: IPC18: INTERRUPT PRIORITY CONTROL REGISTER 18**

| 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 | U-0 | R/W-1 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | — | — | HLVDIP2 | HLVDIP1 | HLVDIP0 |
| 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 **Unimplemented:** Read as ‘0’

bit 2-0 **HLVDIP<2:0>:** High/Low-Voltage Detect Interrupt Priority bits
111 = Interrupt is Priority 7 (highest priority interrupt)
•
•
•
001 = Interrupt is Priority 1
000 = Interrupt source is disabled

**REGISTER 8-29: IPC20: INTERRUPT PRIORITY CONTROL REGISTER 20**

| 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 | U-0 | R/W-1 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | — | — | ULPWUIP2 | ULPWUIP1 | ULPWUIP0 |
| 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 **Unimplemented:** Read as ‘0’

bit 6-4 **ULPWUIP<2:0>:** Ultra Low-Power Wake-up Interrupt Priority bits
111 = Interrupt is Priority 7 (highest priority interrupt)
•
•
•
001 = Interrupt is Priority 1
000 = Interrupt source is disabled

**REGISTER 14-1: T3CON: TIMER3 CONTROL REGISTER**

| 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 | U-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| TMR3CS1 | TMR3CS0 | T3CKPS1 | T3CKPS0 | T3OSCEN | $\overline{\text{T3SYNC}}$ | — | TMR3ON |
| 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 7-6 **TMR3CS<1:0>:** Timer3 Clock Source Select bits
11 = Low-Power RC Oscillator (LPRC)
10 = External clock source (selected by T3CON<3>)
01 = Instruction clock (FOSC/2)
00 = System clock (FOSC)**(1)**

bit 5-4 **T3CKPS<1:0>**: Timer3 Input Clock Prescale Select bits
11 = 1:8 Prescale value
10 = 1:4 Prescale value
01 = 1:2 Prescale value
00 = 1:1 Prescale value

bit 3 **T3OSCEN**: Timer3 Oscillator Enable bit
1 = SOSC (Secondary Oscillator) is used as a clock source
0 = T3CK digital input pin is used as a clock source

bit 2 **$\overline{\text{T3SYNC}}$:** Timer3 External Clock Input Synchronization Control bit
When TMR3CS<1:0> = 1x:
1 = Does not synchronize the external clock input
0 = Synchronizes the external clock input**(2)**
When TMR3CS<1:0> = 0x:
This bit is ignored; Timer3 uses the internal clock.

bit 1 **Unimplemented:** Read as '0'

bit 0 **TMR3ON:** Timer3 On bit
1 = Enables Timer3
0 = Stops Timer3

**Note 1:** The FOSC clock source should not be selected if the timer will be used with the ECCP capture or compare features.
**2:** This option must be selected when the timer will be used with ECCP/CCP.

**REGISTER 17-10: PADCFG1: PAD CONFIGURATION CONTROL REGISTER**

| U-0 | U-0 | U-0 | U-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | — | SDO2DIS(1) | SCK2DIS(1) | SDO1DIS | SCK1DIS |
| 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 15-12 **Unimplemented:** Read as '0'

bit 11 **SDO2DIS:** MSSP2 SDO2 Pin Disable bit(1)
- 1 = The SPI output data (SDO2) of MSSP2 to the pin is disabled
- 0 = The SPI output data (SDO2) of MSSP2 is output to the pin

bit 10 **SCK2DIS:** MSSP2 SCK2 Pin Disable bit(1)
- 1 = The SPI clock (SCK2) of MSSP2 to the pin is disabled
- 0 = The SPI clock (SCK2) of MSSP2 is output to the pin

bit 9 **SDO1DIS:** MSSP1 SDO1 Pin Disable bit
- 1 = The SPI output data (SDO1) of MSSP1 to the pin is disabled
- 0 = The SPI output data (SDO1) of MSSP1 is output to the pin

bit 8 **SCK1DIS:** MSSP1 SCK1 Pin Disable bit
- 1 = The SPI clock (SCK1) of MSSP1 to the pin is disabled
- 0 = The SPI clock (SCK1) of MSSP1 is output to the pin

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

**Note 1:** These bits are implemented only on PIC24FXXKL40X/30X devices.

**REGISTER 18-1: UxMODE: UARTx MODE REGISTER**

| R/W-0 | U-0 | R/W-0 | R/W-0 | R/W-0 | U-0 | R/W-0(2) | R/W-0(2) |
|---|---|---|---|---|---|---|---|
| UARTEN | — | USIDL | IREN(1) | RTSMD | — | UEN1 | UEN0 |
| bit 15 | | | | | | | bit 8 |

| R/C-0, HC | R/W-0 | R/W-0, HC | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| WAKE | LPBACK | ABAUD | RXINV | BRGH | PDSEL1 | PDSEL0 | STSEL |
| bit 7 | | | | | | | bit 0 |

| **Legend:** | C = Clearable bit | HC = Hardware 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 **UARTEN:** UARTx Enable bit
- 1 = UARTx is enabled; all UARTx pins are controlled by UARTx as defined by UEN<1:0>
- 0 = UARTx is disabled; all UARTx pins are controlled by port latches, UARTx power consumption is minimal

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

bit 13 **USIDL:** UARTx Stop in Idle Mode bit
- 1 = Discontinues module operation when device enters Idle mode
- 0 = Continues module operation in Idle mode

bit 12 **IREN:** IrDA® Encoder and Decoder Enable bit(1)
- 1 = IrDA encoder and decoder are enabled
- 0 = IrDA encoder and decoder are disabled

bit 11 **RTSMD:** Mode Selection for $\overline{\text{UxRTS}}$ Pin bit
- 1 = $\overline{\text{UxRTS}}$ pin is in Simplex mode
- 0 = $\overline{\text{UxRTS}}$ pin is in Flow Control mode

bit 10 **Unimplemented:** Read as '0'

bit 9-8 **UEN<1:0>:** UARTx Enable bits(2)
- 11 = UxTX, UxRX and UxBCLK pins are enabled and used; $\overline{\text{UxCTS}}$ pin is controlled by port latches
- 10 = UxTX, UxRX, $\overline{\text{UxCTS}}$ and $\overline{\text{UxRTS}}$ pins are enabled and used
- 01 = UxTX, UxRX and $\overline{\text{UxRTS}}$ pins are enabled and used; $\overline{\text{UxCTS}}$ pin is controlled by port latches
- 00 = UxTX and UxRX pins are enabled and used; $\overline{\text{UxCTS}}$ and $\overline{\text{UxRTS}}$/UxBCLK pins are controlled by port latches

bit 7 **WAKE:** Wake-up on Start Bit Detect During Sleep Mode Enable bit
- 1 = UARTx will continue to sample the UxRX pin; interrupt is generated on the falling edge, bit is cleared in hardware on the following rising edge
- 0 = No wake-up is enabled

bit 6 **LPBACK:** UARTx Loopback Mode Select bit
- 1 = Enables Loopback mode
- 0 = Loopback mode is disabled

bit 5 **ABAUD:** Auto-Baud Enable bit
- 1 = Enables baud rate measurement on the next character – requires reception of a Sync field (55h); cleared in hardware upon completion
- 0 = Baud rate measurement is disabled or completed

bit 4 **RXINV:** Receive Polarity Inversion bit
- 1 = UxRX Idle state is '0'
- 0 = UxRX Idle state is '1'

**Note 1:** This feature is is only available for the 16x BRG mode (BRGH = 0).
**2:** Bit availability depends on pin availability.

**NOTES:**

## 21.0 COMPARATOR VOLTAGE REFERENCE

**Note:** This data sheet summarizes the features of this group of PIC24F devices. It is not intended to be a comprehensive reference source. For more information on the Comparator Voltage Reference, refer to the *"dsPIC33/PIC24 Family Reference Manual"*, **"Comparator Voltage Reference Module"** (DS39709).

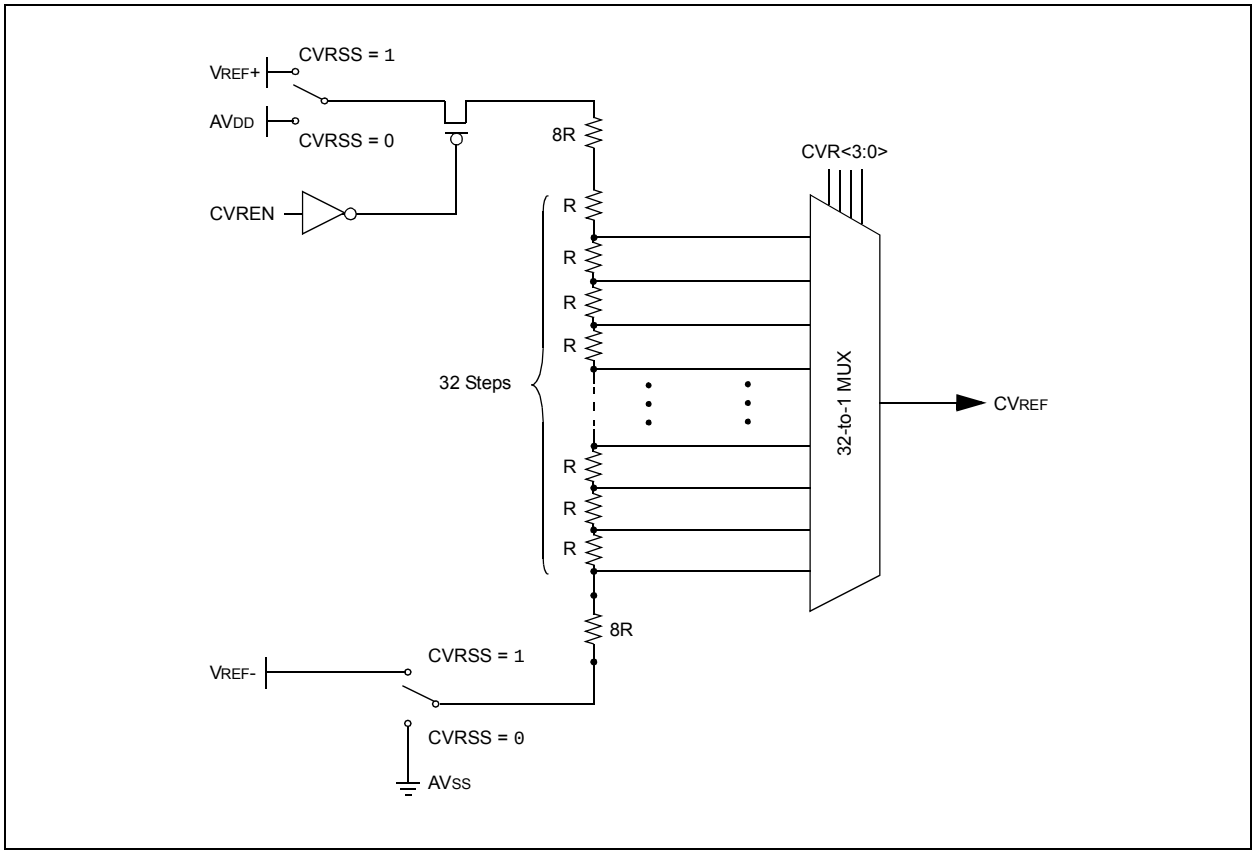
### 21.1 Configuring the Comparator Voltage Reference

The comparator voltage reference module is controlled through the CVRCON register (Register 21-1). The comparator voltage reference provides a range of output voltages, with 32 distinct levels.

The comparator voltage reference supply voltage can come from either VDD and VSS, or the external VREF+ and VREF-. The voltage source is selected by the CVRSS bit (CVRCON<5>).

The settling time of the comparator voltage reference must be considered when changing the CVREF output.

**FIGURE 21-1: COMPARATOR VOLTAGE REFERENCE BLOCK DIAGRAM**



**REGISTER 21-1: CVRCON: COMPARATOR VOLTAGE REFERENCE CONTROL REGISTER**

| 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 |
|---|---|---|---|---|---|---|---|
| CVREN | CVROE | CVRSS | CVR4 | CVR3 | CVR2 | CVR1 | CVR0 |
| 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 **CVREN:** Comparator Voltage Reference Enable bit
1 = CVREF circuit is powered on
0 = CVREF circuit is powered down

bit 6 **CVROE:** Comparator VREF Output Enable bit
1 = CVREF voltage level is output on the CVREF pin
0 = CVREF voltage level is disconnected from the CVREF pin

bit 5 **CVRSS:** Comparator VREF Source Selection bit
1 = Comparator reference source, CVRSRC = VREF+ – VREF-
0 = Comparator reference source, CVRSRC = AVDD – AVSS

bit 4-0 **CVR<4:0>:** Comparator VREF Value Selection 0 ≤ CVR<4:0> ≤ 31 bits
When CVRSS = 1:
CVREF = (VREF-) + (CVR<4:0>/32) • (VREF+ – VREF-)
When CVRSS = 0:
CVREF = (AVSS) + (CVR<4:0>/32) • (AVDD – AVSS)

**REGISTER 23-4: FOSC: OSCILLATOR CONFIGURATION REGISTER**

| R/P-0 | R/P-0 | R/P-1 | R/P-1 | R/P-1 | R/P-0 | R/P-1 | R/P-1 |
|---|---|---|---|---|---|---|---|
| FCKSM1 | FCKSM0 | SOSCSEL | POSCFREQ1 | POSCFREQ0 | OSCIOFNC | POSCMD1 | POSCMD0 |
| bit 7 | | | | | | | bit 0 |

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

bit 7-6 **FCKSM<1:0>:** Clock Switching and Monitor Selection Configuration bits
1x = Clock switching is disabled, Fail-Safe Clock Monitor is disabled
01 = Clock switching is enabled, Fail-Safe Clock Monitor is disabled
00 = Clock switching is enabled, Fail-Safe Clock Monitor is enabled

bit 5 **SOSCSEL:** Secondary Oscillator Power Selection Configuration bit
1 = Secondary oscillator is configured for high-power operation
0 = Secondary oscillator is configured for low-power operation

bit 4-3 **POSCFREQ<1:0>:** Primary Oscillator Frequency Range Configuration bits
11 = Primary oscillator/external clock input frequency is greater than 8 MHz
10 = Primary oscillator/external clock input frequency is between 100 kHz and 8 MHz
01 = Primary oscillator/external clock input frequency is less than 100 kHz
00 = Reserved; do not use

bit 2 **OSCIOFNC:** CLKO Enable Configuration bit
1 = CLKO output signal is active on the OSCO pin; primary oscillator must be disabled or configured for the External Clock mode (EC) for the CLKO to be active (POSCMD<1:0> = 11 or 00)
0 = CLKO output is disabled

bit 1-0 **POSCMD<1:0>:** Primary Oscillator Configuration bits
11 = Primary Oscillator mode is disabled
10 = HS Oscillator mode is selected
01 = XT Oscillator mode is selected
00 = External Clock mode is selected

## 25.0 INSTRUCTION SET SUMMARY

**Note:** This chapter is a brief summary of the PIC24F Instruction Set Architecture (ISA) and is not intended to be a comprehensive reference source.

The PIC24F instruction set adds many enhancements to the previous PIC® MCU instruction sets, while maintaining an easy migration from previous PIC MCU instruction sets. Most instructions are a single program memory word. Only three instructions require two program memory locations.

Each single-word instruction is a 24-bit word divided into an 8-bit opcode, which specifies the instruction type and one or more operands, which further specify the operation of the instruction. The instruction set is highly orthogonal and is grouped into four basic categories:

- Word or byte-oriented operations
- Bit-oriented operations
- Literal operations
- Control operations

Table 25-1 lists the general symbols used in describing the instructions. The PIC24F instruction set summary in Table 25-2 lists all the instructions, along with the status flags affected by each instruction.

Most word or byte-oriented W register instructions (including barrel shift instructions) have three operands:

- The first source operand, which is typically a register ‘Wb’ without any address modifier
- The second source operand, which is typically a register ‘Ws’ with or without an address modifier
- The destination of the result, which is typically a register ‘Wd’ with or without an address modifier

However, word or byte-oriented file register instructions have two operands:

- The file register specified by the value, ‘f’
- The destination, which could either be the file register, ‘f’, or the W0 register, which is denoted as ‘WREG’

Most bit-oriented instructions (including simple rotate/shift instructions) have two operands:

- The W register (with or without an address modifier) or file register (specified by the value of ‘Ws’ or ‘f’)
- The bit in the W register or file register (specified by a literal value or indirectly by the contents of register, ‘Wb’)

The literal instructions that involve data movement may use some of the following operands:

- A literal value to be loaded into a W register or file register (specified by the value of ‘k’)
- The W register or file register where the literal value is to be loaded (specified by ‘Wb’ or ‘f’)

However, literal instructions that involve arithmetic or logical operations use some of the following operands:

- The first source operand, which is a register ‘Wb’ without any address modifier
- The second source operand, which is a literal value
- The destination of the result (only if not the same as the first source operand), which is typically a register ‘Wd’ with or without an address modifier

The control instructions may use some of the following operands:

- A program memory address
- The mode of the Table Read and Table Write instructions

All instructions are a single word, except for certain double-word instructions, which were made double-word instructions so that all of the required information is available in these 48 bits. In the second word, the 8 MSbs are ‘0’s. If this second word is executed as an instruction (by itself), it will execute as a NOP.

Most single-word instructions are executed in a single instruction cycle, unless a conditional test is true or the Program Counter (PC) is changed as a result of the instruction. In these cases, the execution takes two instruction cycles, with the additional instruction cycle(s) executed as a NOP. Notable exceptions are the BRA (unconditional/computed branch), indirect CALL/GOTO, all Table Reads and Table Writes, and RETURN/RETFIE instructions, which are single-word instructions but take two or three cycles.

Certain instructions that involve skipping over the subsequent instruction require either two or three cycles if the skip is performed, depending on whether the instruction being skipped is a single-word or two-word instruction. Moreover, double-word moves require two cycles. The double-word instructions execute in two instruction cycles.

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

| DC CHARACTERISTICS | | | Standard Operating Conditions: 1.8V to 3.6V<br>Operating temperature -40°C ≤ TA ≤ +85°C for Industrial<br>-40°C ≤ TA ≤ +125°C for Extended | | | |
|---|---|---|---|---|---|---|
| **Parameter No.** | **Typical(1)** | **Max** | **Units** | **Conditions** | | |
| **Power-Down Current ($I_{PD}$)** | | | | | | |
| DC60 | 0.01 | 0.20 | µA | -40°C | 1.8V | Sleep Mode(2) |
| | 0.03 | 0.20 | µA | +25°C | | |
| | 0.06 | 0.87 | µA | +60°C | | |
| | 0.20 | 1.35 | µA | +85°C | | |
| | — | 8.00 | µA | +125ºC | | |
| | 0.01 | 0.54 | µA | -40°C | 3.3V | |
| | 0.03 | 0.54 | µA | +25°C | | |
| | 0.08 | 1.68 | µA | +60°C | | |
| | 0.25 | 2.45 | µA | +85°C | | |
| | — | 10.00 | µA | +125ºC | | |

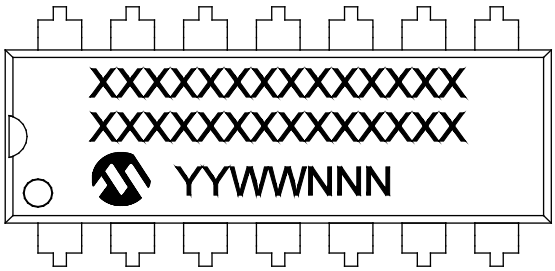
**Note 1:** Data in the Typical column is at 3.3V, +25°C unless otherwise stated.

**2:** Base $I_{PD}$ is measured with all peripherals and clocks disabled. All I/Os are configured as outputs and set low; PMDx bits are set to '1' and WDT, etc., are all disabled

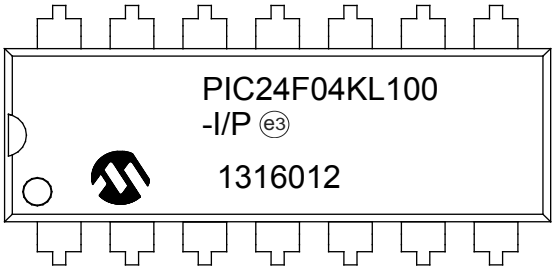
## 27.0 PACKAGING INFORMATION

### 27.1 Package Marking Information

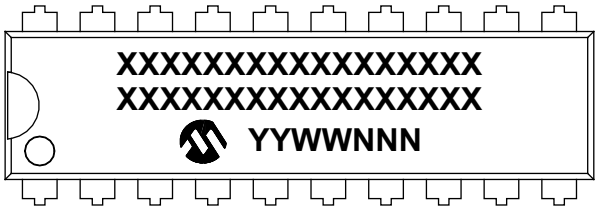
14-Lead PDIP (300 mil)



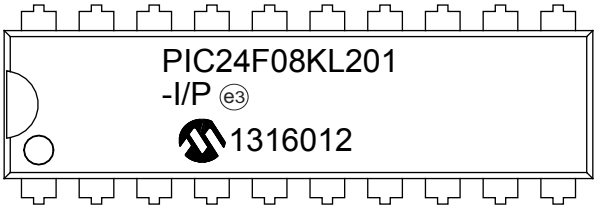

Example



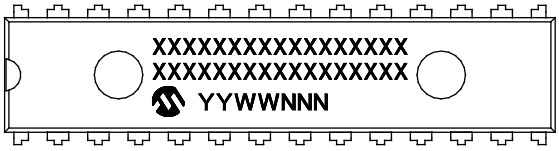

20-Lead PDIP (300 mil)



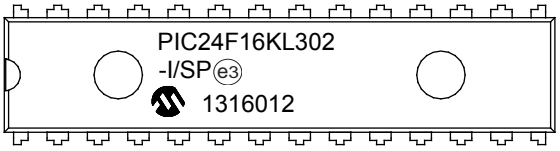

Example




28-Lead SPDIP (.300")




Example

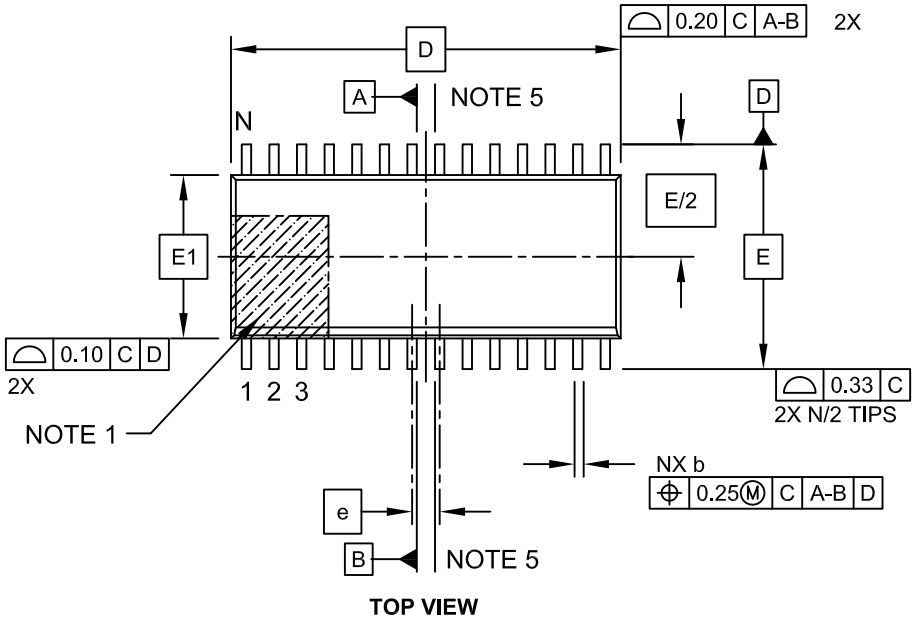



| | | |
|---|---|---|
| **Legend:** | XX...X | Product-specific information |
| | Y | Year code (last digit of calendar year) |
| | YY | Year code (last 2 digits of calendar year) |
| | WW | Week code (week of January 1 is week '01') |
| | NNN | Alphanumeric traceability code |
| | (e3) | Pb-free JEDEC designator for Matte Tin (Sn) |
| | * | This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package. |

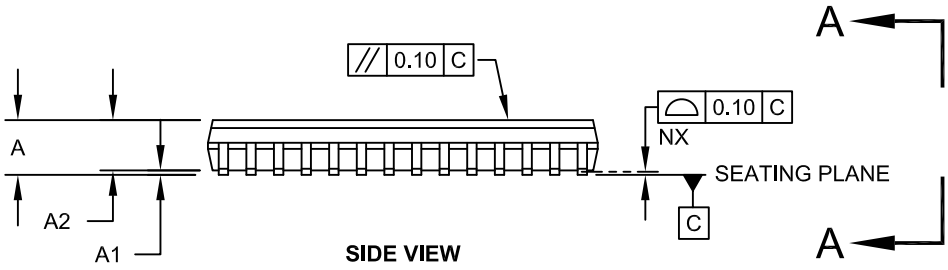
**Note:** In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

### 28-Lead Plastic Small Outline (SO) - Wide, 7.50 mm Body [SOIC]

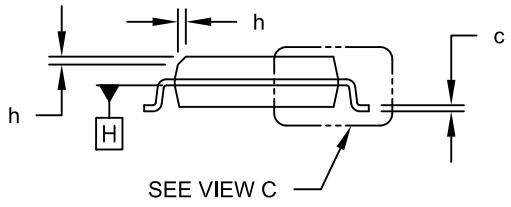
**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging




**TOP VIEW**




**SIDE VIEW**




**VIEW A-A**

Microchip Technology Drawing C04-052C Sheet 1 of 2