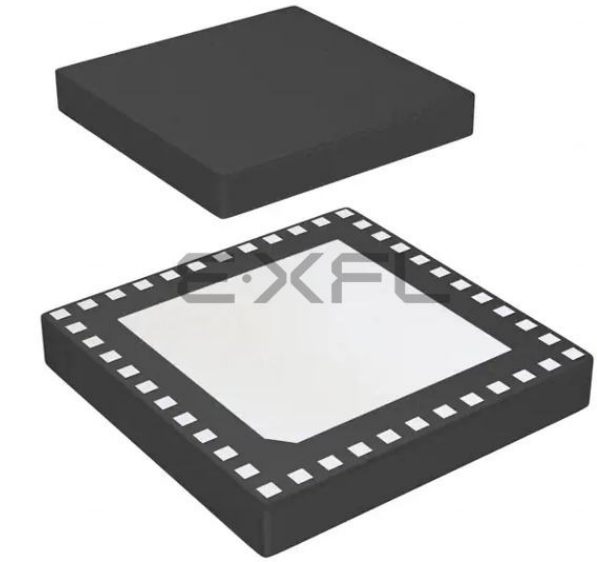

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## What is "Embedded - Microcontrollers"?

"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.

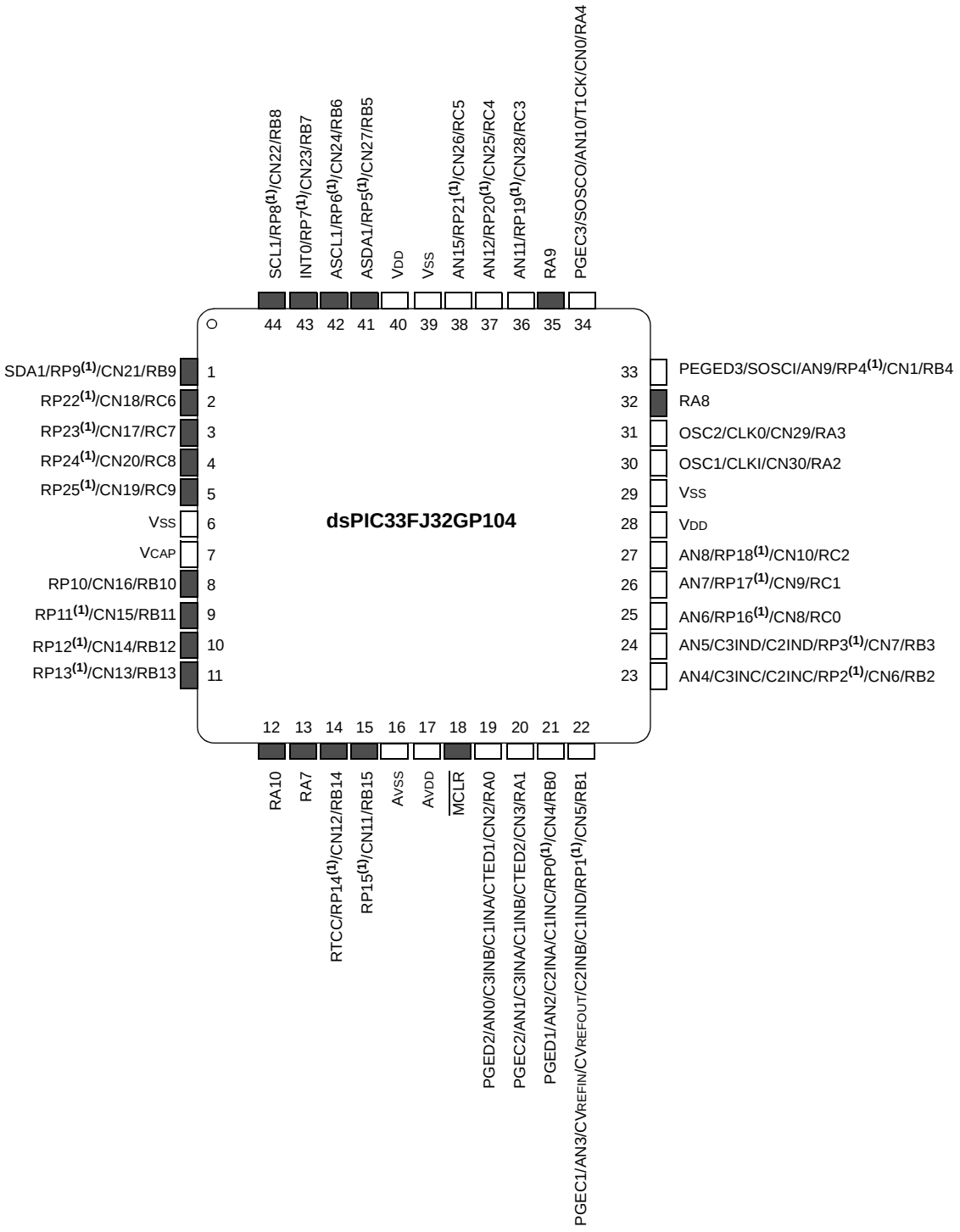
## Applications of "Embedded - Microcontrollers"

| Details | |
|---|---|
| Product Status | Obsolete |
| Core Processor | dsPIC |
| Core Size | 16-Bit |
| Speed | 16 MIPs |
| Connectivity | I²C, IrDA, LINbus, SPI, UART/USART |
| Peripherals | Brown-out Detect/Reset, Motor Control PWM, POR, PWM, WDT |
| Number of I/O | 35 |
| Program Memory Size | 32KB (11K x 24) |
| Program Memory Type | FLASH |
| EEPROM Size | - |
| RAM Size | 1K x 16 |
| Voltage - Supply (Vcc/Vdd) | 3V ~ 3.6V |
| Data Converters | A/D 14x10b |
| Oscillator Type | Internal |
| Operating Temperature | -40°C ~ 125°C (TA) |
| Mounting Type | Surface Mount |
| Package / Case | 44-VFTLA Exposed Pad |
| Supplier Device Package | 44-VTLA (6x6) |
| Purchase URL | https://www.e-xfl.com/product-detail/microchip-technology/dspic33fj32mc104t-e-tl |

## Pin Diagrams (Continued)

**44-Pin TQFP**

■ = Pins are up to 5V tolerant




**Note 1:** The RPn pins can be used by any remappable peripheral. See Table 1 for the list of available peripherals.

## 4.2 Data Address Space

The dsPIC33FJ16(GP/MC)101/102 and dsPIC33FJ32(GP/MC)101/102/104 family CPU has a separate 16-bit-wide data memory space. The data space is accessed using separate Address Generation Units (AGUs) for read and write operations. The data memory maps is shown in Figure 4-4.

All Effective Addresses (EAs) in the data memory space are 16 bits wide and point to bytes within the data space. This arrangement gives a data space address range of 64 Kbytes or 32K words. The lower half of the data memory space (that is, when EA<15> = 0) is used for implemented memory addresses, while the upper half (EA<15> = 1) is reserved for the Program Space Visibility area (see **Section 4.6.3 "Reading Data from Program Memory Using Program Space Visibility"**).

Microchip dsPIC33FJ16(GP/MC)101/102 and dsPIC33FJ32(GP/MC)101/102/104 devices implement up to 2 Kbytes of data memory. Should an EA point to a location outside of this area, an all-zero word or byte will be returned.

### 4.2.1 DATA SPACE WIDTH

The data memory space is organized in byte-addressable, 16-bit wide blocks. Data is aligned in data memory and registers as 16-bit words, but all data space EAs resolve to bytes. The Least Significant Bytes (LSBs) of each word have even addresses, while the Most Significant Bytes (MSBs) have odd addresses.

### 4.2.2 DATA MEMORY ORGANIZATION AND ALIGNMENT

To maintain backward compatibility with PIC® MCU devices and improve data space memory usage efficiency, the dsPIC33FJ16(GP/MC)101/102 and dsPIC33FJ32(GP/MC)101/102/104 family instruction set supports both word and byte operations. As a consequence of byte accessibility, all Effective Address calculations are internally scaled to step through word-aligned memory. For example, the core recognizes that Post-Modified Register Indirect Addressing mode [Ws++] will result in a value of Ws + 1 for byte operations and Ws + 2 for word operations.

Data byte reads will read the complete word that contains the byte, using the LSB of any EA to determine which byte to select. The selected byte is placed onto the LSB of the data path. That is, data memory and registers are organized as two parallel byte-wide entities with shared (word) address decoding but separate write lines. Data byte writes only write to the corresponding side of the array or register that matches the byte address.

All word accesses must be aligned to an even address. Misaligned word data fetches are not supported, so care must be taken when mixing byte and word operations, or translating from 8-bit MCU code. If a misaligned read or write is attempted, an address error trap is generated. If the error occurred on a read, the instruction in progress is completed. If the error occurred on a write, the instruction is executed but the write does not occur. In either case, a trap is then executed, allowing the system and/or user application to examine the machine state prior to execution of the address Fault.

All byte loads into any W register are loaded into the LSB. The MSB is not modified.

A Sign-Extend (SE) instruction is provided to allow user applications to translate 8-bit signed data to 16-bit signed values. Alternately, for 16-bit unsigned data, user applications can clear the MSB of any W register by executing a Zero-Extend (ZE) instruction on the appropriate address.

### 4.2.3 SFR SPACE

The first 2 Kbytes of the Near Data Space, from 0x0000 to 0x07FF, is primarily occupied by Special Function Registers (SFRs). These are used by the dsPIC33FJ16(GP/MC)101/102 and dsPIC33FJ32(GP/MC)101/102/104 family core and peripheral modules for controlling the operation of the device.

SFRs are distributed among the modules that they control and are generally grouped together by module. Much of the SFR space contains unused addresses; these are read as '0'.

| | |
|---|---|
| **Note:** | The actual set of peripheral features and interrupts varies by the device. Refer to the corresponding device tables and pinout diagrams for device-specific information. |

### 4.2.4 NEAR DATA SPACE

The 8-Kbyte area, between 0x0000 and 0x1FFF, is referred to as the Near Data Space. Locations in this space are directly addressable via a 13-bit absolute address field within all memory direct instructions. Additionally, the whole data space is addressable using the MOV class of instructions, which support Memory Direct Addressing mode with a 16-bit address field or by using Indirect Addressing mode with a Working register as an Address Pointer.

**REGISTER 7-7: IFS2: INTERRUPT FLAG STATUS REGISTER 2**

| U-0 | U-0 | U-0 | U-0 | U-0 | U-0 | U-0 | U-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | — | — | — | — | — |
| bit 15 | | | | | | | bit 8 |

| U-0 | U-0 | R/W-0 | U-0 | U-0 | U-0 | U-0 | U-0 |
|---|---|---|---|---|---|---|---|
| — | — | IC3IF | — | — | — | — | — |
| 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 15-6 **Unimplemented:** Read as '0'

bit 5 **IC3IF:** Input Capture Channel 3 Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

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

**REGISTER 7-8: IFS3: INTERRUPT FLAG STATUS REGISTER 3**

| R/W-0 | R/W-0 | U-0 | U-0 | U-0 | U-0 | R/W-0 | U-0 |
|---|---|---|---|---|---|---|---|
| FLTA1IF(1) | RTCIF | — | — | — | — | PWM1IF(1) | — |
| 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 **FLTA1IF:** PWM1 Fault A Interrupt Flag Status bit(1)
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 14 **RTCIF:** RTCC Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 13-10 **Unimplemented:** Read as '0'

bit 9 **PWM1IF:** PWM1 Interrupt Flag Status bit(1)
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 8-0 **Unimplemented:** Read as '0'

**Note 1:** These bits are available in dsPIC(16/32)MC10X devices only.

**REGISTER 7-14: IEC4: INTERRUPT ENABLE CONTROL REGISTER 4**

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

| U-0 | U-0 | U-0 | U-0 | U-0 | U-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | — | — | — | U1EIE | FLTB1IE(1) |
| 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 15-14 **Unimplemented:** Read as '0'

bit 13 **CTMUIE:** CTMU Interrupt Enable bit
1 = Interrupt request is enabled
0 = Interrupt request is not enabled

bit 12-2 **Unimplemented:** Read as '0'

bit 1 **U1EIE:** UART1 Error Interrupt Enable bit
1 = Interrupt request is enabled
0 = Interrupt request is not enabled

bit 0 **FLTB1IE:** PWM1 Fault B Interrupt Enable bit(1)
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

**Note 1:** This bit is available in dsPIC(16/32)MC102/104 devices only.

**REGISTER 10-21: RPOR10: PERIPHERAL PIN SELECT OUTPUT REGISTER 10**

| U-0 | U-0 | U-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | RP21R<4:0>(1) | | | | |
| bit 15 | | | | | | | bit 8 |

| U-0 | U-0 | U-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | RP20R<4:0>(1) | | | | |
| 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 12-8 **RP21R<4:0>:** Peripheral Output Function is Assigned to RP21 Output Pin bits(1)
(see Table 10-2 for peripheral function numbers)

bit 7-5 **Unimplemented:** Read as '0'

bit 4-0 **RP20R<4:0>:** Peripheral Output Function is Assigned to RP20 Output Pin bits(1)
(see Table 10-2 for peripheral function numbers)

**Note 1:** These bits are available in dsPIC33FJ32(GP/MC)104 devices only.

**REGISTER 10-22: RPOR11: PERIPHERAL PIN SELECT OUTPUT REGISTER 11**

| U-0 | U-0 | U-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | RP23R<4:0>(1) | | | | |
| bit 15 | | | | | | | bit 8 |

| U-0 | U-0 | U-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | RP22R<4:0>(1) | | | | |
| 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 12-8 **RP23R<4:0>:** Peripheral Output Function is Assigned to RP23 Output Pin bits(1)
(see Table 10-2 for peripheral function numbers)

bit 7-5 **Unimplemented:** Read as '0'

bit 4-0 **RP22R<4:0>:** Peripheral Output Function is Assigned to RP22 Output Pin bits(1)
(see Table 10-2 for peripheral function numbers)

**Note 1:** These bits are available in dsPIC33FJ32(GP/MC)104 devices only.

**REGISTER 17-1: I2CxCON: I2Cx CONTROL REGISTER (CONTINUED)**

bit 6 **STREN:** SCLx Clock Stretch Enable bit (when operating as $I^2C$ slave)
Used in conjunction with the SCLREL bit.
1 = Enables software or receives clock stretching
0 = Disables software or receives clock stretching

bit 5 **ACKDT:** Acknowledge Data bit (when operating as $I^2C$ master, applicable during master receive)
Value that will be transmitted when the software initiates an Acknowledge sequence.
1 = Sends NACK during Acknowledge
0 = Sends ACK during Acknowledge

bit 4 **ACKEN:** Acknowledge Sequence Enable bit (when operating as $I^2C$ master, applicable during master receive)
1 = Initiates Acknowledge sequence on SDAx and SCLx pins and transmits ACKDT data bit; hardware clears at end of master Acknowledge sequence
0 = Acknowledge sequence is not in progress

bit 3 **RCEN:** Receive Enable bit (when operating as $I^2C$ master)
1 = Enables Receive mode for $I^2C$; hardware clears at end of eighth bit of the master receive data byte
0 = Receive sequence is not in progress

bit 2 **PEN:** Stop Condition Enable bit (when operating as $I^2C$ master)
1 = Initiates Stop condition on SDAx and SCLx pins; hardware clears at end of the master Stop sequence
0 = Stop condition not in progress

bit 1 **RSEN:** Repeated Start Condition Enable bit (when operating as $I^2C$ master)
1 = Initiates Repeated Start condition on SDAx and SCLx pins; hardware clears at end of the master Repeated Start sequence
0 = Repeated Start condition is not in progress

bit 0 **SEN:** Start Condition Enable bit (when operating as $I^2C$ master)
1 = Initiates Start condition on SDAx and SCLx pins; hardware clears at end of master Start sequence
0 = Start condition is not in progress

**NOTES:**

## 23.0 SPECIAL FEATURES

**Note 1:** This data sheet summarizes the features of the dsPIC33FJ16(GP/MC)101/102 and dsPIC33FJ32(GP/MC)101/102/104 devices. It is not intended to be a comprehensive reference source. To complement the information in this data sheet, refer to **"Programming and Diagnostics"** (DS70207) and **"Device Configuration"** (DS70194) in the *"dsPIC33/PIC24 Family Reference Manual"*, which are 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.

dsPIC33FJ16(GP/MC)101/102 and dsPIC33FJ32(GP/MC)101/102/104 devices include several features intended to maximize application flexibility and reliability, and minimize cost through elimination of external components. These are:

- Flexible Configuration
- Watchdog Timer (WDT)
- Code Protection
- In-Circuit Serial Programming™ (ICSP™)
- In-Circuit Emulation

### 23.1 Configuration Bits

The Configuration Shadow register bits can be configured (read as '0') or left unprogrammed (read as '1') to select various device configurations. These read-only bits are mapped starting at program memory location, 0xF80000. A detailed explanation of the various bit functions is provided in Table 23-4.

Note that address, 0xF80000, is beyond the user program memory space and belongs to the configuration memory space (0x800000-0xFFFFFF), which can only be accessed using Table Reads.

In dsPIC33FJ16(GP/MC)101/102 and dsPIC33FJ32(GP/MC)101/102/104 devices, the Configuration bytes are implemented as volatile memory. This means that configuration data must be programmed each time the device is powered up. Configuration data is stored in the two words at the top of the on-chip program memory space, known as the Flash Configuration Words. Their specific locations are shown in Table 23-2. These are packed representations of the actual device Configuration bits, whose actual locations are distributed among several locations in configuration space. The configuration data is automatically loaded from the Flash Configuration Words to the proper Configuration registers during device Resets.

**Note:** Configuration data is reloaded on all types of device Resets.

When creating applications for these devices, users should always specifically allocate the location of the Flash Configuration Word for configuration data. This is to make certain that program code is not stored in this address when the code is compiled.

The upper byte of all Flash Configuration Words in program memory should always be '1111 1111'. This makes them appear to be NOP instructions in the remote event that their locations are ever executed by accident. Since Configuration bits are not implemented in the corresponding locations, writing '1's to these locations has no effect on device operation.

**Note:** Performing a page erase operation on the last page of program memory clears the Flash Configuration Words, enabling code protection as a result. Therefore, users should avoid performing page erase operations on the last page of program memory.

## 23.4 Watchdog Timer (WDT)

For dsPIC33FJ16(GP/MC)101/102 and dsPIC33FJ32(GP/MC)101/102/104 devices, the WDT is driven by the LPRC oscillator. When the WDT is enabled, the clock source is also enabled.

### 23.4.1 PRESCALER/POSTSCALER

The nominal WDT clock source from LPRC is 32 kHz. This feeds a prescaler than can be configured for either 5-bit (divide-by-32) or 7-bit (divide-by-128) operation. The prescaler is set by the WDTPRE Configuration bit. With a 32 kHz input, the prescaler yields a nominal WDT Time-out (TWDT) period of 1 ms in 5-bit mode or 4 ms in 7-bit mode.

A variable postscaler divides down the WDT prescaler output and allows for a wide range of time-out periods. The postscaler is controlled by the WDTPOST<3:0> Configuration bits (FWDT<3:0>), which allow the selection of 16 settings, from 1:1 to 1:32,768. Using the prescaler and postscaler, time-out periods, ranging from 1 ms to 131 seconds, can be achieved.

The WDT, prescaler and postscaler are reset:

- On any device Reset
- On the completion of a clock switch, whether invoked by software (i.e., setting the OSWEN bit after changing the NOSCx bits) or by hardware (i.e., Fail-Safe Clock Monitor)
- When a PWRSAV instruction is executed (i.e., Sleep or Idle mode is entered)
- When the device exits Sleep or Idle mode to resume normal operation
- By a CLRWDT instruction during normal execution

| **Note:** | The CLRWDT and PWRSAV instructions clear the prescaler and postscaler counts when executed. |
|---|---|

### 23.4.2 SLEEP AND IDLE MODES

If the WDT is enabled, it will continue to run during Sleep or Idle modes. When the WDT time-out occurs, the device will wake the device and code execution will continue from where the PWRSAV instruction was executed. The corresponding SLEEP or IDLE bits (RCON<3:2>) will need to be cleared in software after the device wakes up.

### 23.4.3 ENABLING WDT

The WDT is enabled or disabled by the FWDTEN Configuration bit in the FWDT Configuration register. When the FWDTEN Configuration bit is set, the WDT is always enabled.

The WDT can be optionally controlled in software when the FWDTEN Configuration bit has been programmed to '0'. The WDT is enabled in software by setting the SWDTEN control bit (RCON<5>). The SWDTEN control bit is cleared on any device Reset. The software WDT option allows the user application to enable the WDT for critical code segments and disables the WDT during non-critical segments for maximum power savings.

| **Note:** | If the WINDIS bit (FWDT<6>) is cleared, the CLRWDT instruction should be executed by the application software only during the last 1/4 of the WDT period. This CLRWDT window can be determined by using a timer. If a CLRWDT instruction is executed before this window, a WDT Reset occurs. |
|---|---|

The WDT flag bit, WDTO (RCON<4>), is not automatically cleared following a WDT time-out. To detect subsequent WDT events, the flag must be cleared in software.

**FIGURE 23-2: WDT BLOCK DIAGRAM**

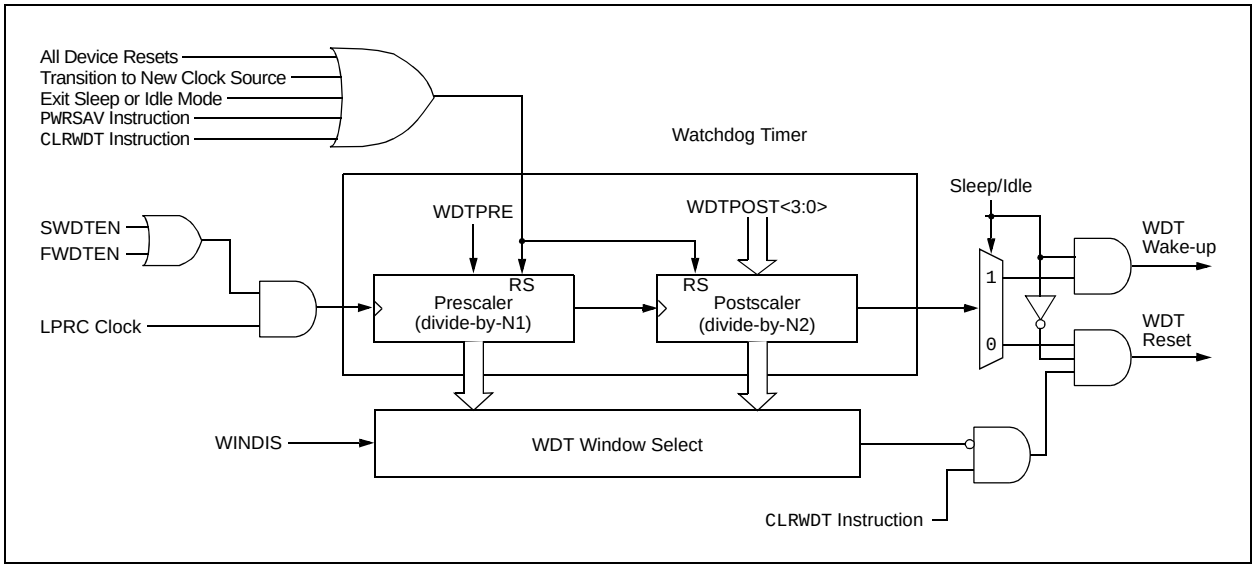
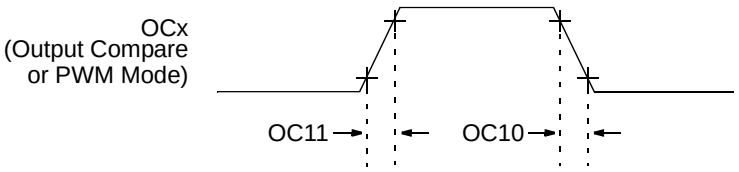


**FIGURE 26-7: OUTPUT COMPARE x (OCx) TIMING CHARACTERISTICS**




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

**TABLE 26-26: OUTPUT COMPARE x (OCx) MODULE TIMING REQUIREMENTS**

| 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 | | | | |
|---|---|---|---|---|---|---|---|
| **Param No.** | **Symbol** | **Characteristic(1)** | **Min** | **Typ** | **Max** | **Units** | **Conditions** |
| OC10 | TccF | OCx Output Fall Time | — | — | — | ns | See Parameter DO32 |
| OC11 | TccR | OCx Output Rise Time | — | — | — | ns | See Parameter DO31 |

**Note 1:** These parameters are characterized by similarity, but are not tested in manufacturing.

**FIGURE 26-8: OCx/PWMx MODULE TIMING CHARACTERISTICS**

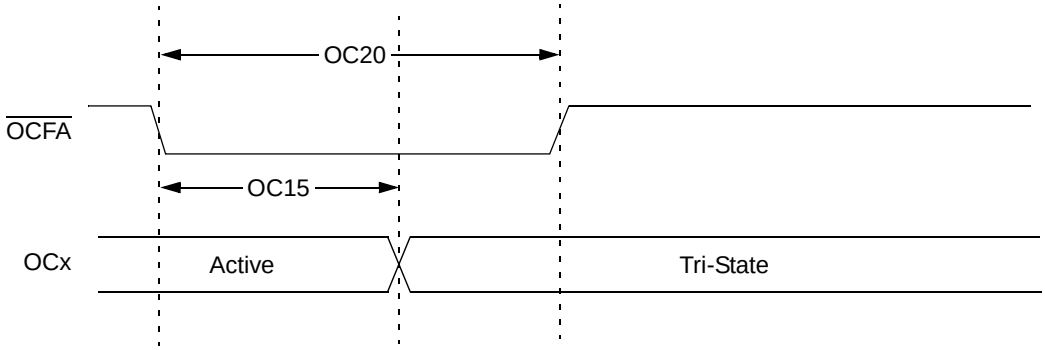



**TABLE 26-27: SIMPLE OCx/PWMx MODE TIMING REQUIREMENTS**

| 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 | | | | |
|---|---|---|---|---|---|---|---|
| **Param No.** | **Symbol** | **Characteristic(1)** | **Min** | **Typ** | **Max** | **Units** | **Conditions** |
| OC15 | TFD | Fault Input to PWMx I/O Change | — | — | TCY + 20 ns | ns | |
| OC20 | TFLT | Fault Input Pulse Width | TCY + 20 ns | — | — | ns | |

**Note 1:** These parameters are characterized by similarity, but are not tested in manufacturing.

**TABLE 26-36: SPIx SLAVE MODE (FULL-DUPLEX, CKE = 0, CKP = 0, SMP = 0) TIMING REQUIREMENTS FOR dsPIC33FJ16(GP/MC)10X**

| AC CHARACTERISTICS | | | Standard Operating Conditions: 2.4V to 3.6V (unless otherwise stated)<br>Operating temperature -40°C ≤ TA ≤ +85°C for Industrial<br>-40°C ≤ TA ≤ +125°C for Extended | | | | |
|---|---|---|---|---|---|---|---|
| **Param No.** | **Symbol** | **Characteristic(1)** | **Min** | **Typ(2)** | **Max** | **Units** | **Conditions** |
| SP70 | TscP | Maximum SCKx Input Frequency | — | — | 11 | MHz | See **Note 3** |
| SP72 | TscF | SCKx Input Fall Time | — | — | — | ns | See Parameter DO32 and **Note 4** |
| SP73 | TscR | SCKx Input Rise Time | — | — | — | ns | See Parameter DO31 and **Note 4** |
| SP30 | TdoF | SDOx Data Output Fall Time | — | — | — | ns | See Parameter DO32 and **Note 4** |
| SP31 | TdoR | SDOx Data Output Rise Time | — | — | — | ns | See Parameter DO31 and **Note 4** |
| SP35 | TscH2doV, TscL2doV | SDOx Data Output Valid after SCKx Edge | — | 6 | 20 | ns | |
| SP36 | TdoV2scH, TdoV2scL | SDOx Data Output Setup to First SCKx Edge | 30 | — | — | ns | |
| SP40 | TdiV2scH, TdiV2scL | Setup Time of SDIx Data Input to SCKx Edge | 30 | — | — | ns | |
| SP41 | TscH2diL, TscL2diL | Hold Time of SDIx Data Input to SCKx Edge | 30 | — | — | ns | |
| SP50 | TssL2scH, TssL2scL | $\overline{SSx}$ ↓ to SCKx ↑ or SCKx Input | 120 | — | — | ns | |
| SP51 | TssH2doZ | $\overline{SSx}$ ↑ to SDOx Output High-Impedance | 10 | — | 50 | ns | See **Note 4** |
| SP52 | TscH2ssH TscL2ssH | $\overline{SSx}$ after SCKx Edge | 1.5 TCY + 40 | — | — | ns | See **Note 4** |

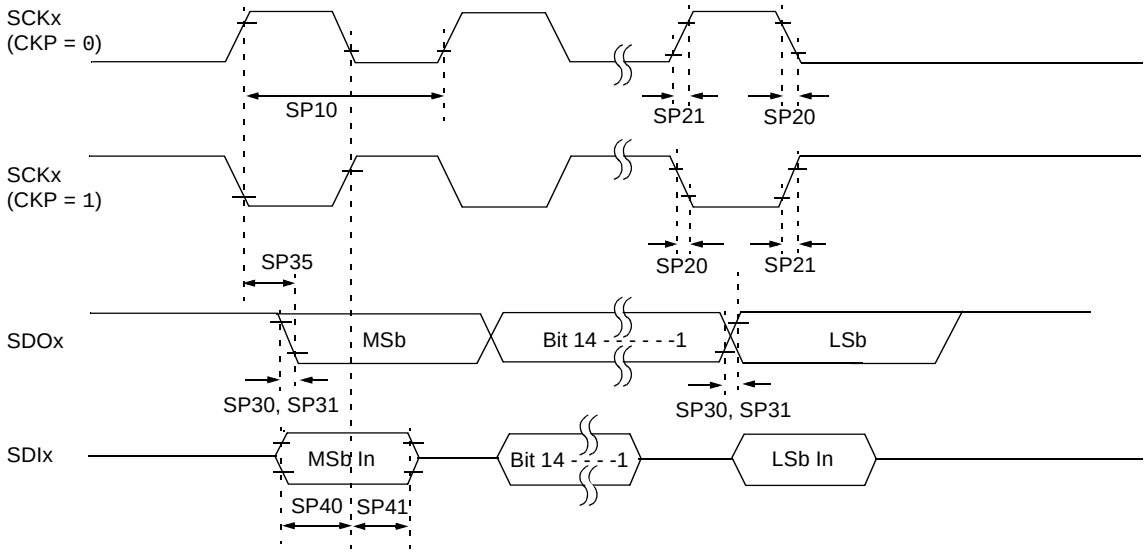
**Note 1:** These parameters are characterized, but are not tested in manufacturing.

**2:** Data in "Typ" column is at 3.3V, +25°C unless otherwise stated.

**3:** The minimum clock period for SCKx is 91 ns. Therefore, the SCKx clock generated by the Master must not violate this specification.

**4:** Assumes 50 pF load on all SPIx pins.

**FIGURE 26-22: SPIx MASTER MODE (FULL-DUPLEX, CKE = 0, CKP = x, SMP = 1) TIMING CHARACTERISTICS FOR dsPIC33FJ32(GP/MC)10X**




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

**TABLE 26-40: SPIx MASTER MODE (FULL-DUPLEX, CKE = 0, CKP = x, SMP = 1) TIMING REQUIREMENTS FOR dsPIC33FJ32(GP/MC)10X**

| 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 | | | | |
|---|---|---|---|---|---|---|---|
| **Param No.** | **Symbol** | **Characteristic(1)** | **Min** | **Typ(2)** | **Max** | **Units** | **Conditions** |
| SP10 | TscP | Maximum SCKx Frequency | — | — | 9 | MHz | -40°C to +125°C, see **Note 3** |
| SP20 | TscF | SCKx Output Fall Time | — | — | — | ns | See Parameter DO32 and **Note 4** |
| SP21 | TscR | SCKx Output Rise Time | — | — | — | ns | See Parameter DO31 and **Note 4** |
| SP30 | TdoF | SDOx Data Output Fall Time | — | — | — | ns | See Parameter DO32 and **Note 4** |
| SP31 | TdoR | SDOx Data Output Rise Time | — | — | — | ns | See Parameter DO31 and **Note 4** |
| SP35 | TscH2doV, TscL2doV | SDOx Data Output Valid after SCKx Edge | — | 6 | 20 | ns | |
| SP36 | TdoV2scH, TdoV2scL | SDOx Data Output Setup to First SCKx Edge | 30 | — | — | ns | |
| SP40 | TdiV2scH, TdiV2scL | Setup Time of SDIx Data Input to SCKx Edge | 30 | — | — | ns | |
| SP41 | TscH2diL, TscL2diL | Hold Time of SDIx Data Input to SCKx Edge | 30 | — | — | ns | |

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

**2:** Data in "Typ" column is at 3.3V, +25°C unless otherwise stated.

**3:** The minimum clock period for SCKx is 111 ns. The clock generated in Master mode must not violate this specification.

**4:** Assumes 50 pF load on all SPIx pins.

**TABLE 26-43: SPIx SLAVE MODE (FULL-DUPLEX, CKE = 0, CKP = 1, SMP = 0) TIMING REQUIREMENTS FOR dsPIC33FJ32(GP/MC)10X**

| 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 | | | | |
|---|---|---|---|---|---|---|---|
| **Param No.** | **Symbol** | **Characteristic(1)** | **Min** | **Typ(2)** | **Max** | **Units** | **Conditions** |
| SP70 | TscP | Maximum SCKx Input Frequency | — | — | 15 | MHz | See **Note 3** |
| SP72 | TscF | SCKx Input Fall Time | — | — | — | ns | See Parameter DO32 and **Note 4** |
| SP73 | TscR | SCKx Input Rise Time | — | — | —w | ns | See Parameter DO31 and **Note 4** |
| SP30 | TdoF | SDOx Data Output Fall Time | — | — | — | ns | See Parameter DO32 and **Note 4** |
| SP31 | TdoR | SDOx Data Output Rise Time | — | — | — | ns | See Parameter DO31 and **Note 4** |
| SP35 | TscH2doV, TscL2doV | SDOx Data Output Valid after SCKx Edge | — | 6 | 20 | ns | |
| SP36 | TdoV2scH, TdoV2scL | SDOx Data Output Setup to First SCKx Edge | 30 | — | — | ns | |
| SP40 | TdiV2scH, TdiV2scL | Setup Time of SDIx Data Input to SCKx Edge | 30 | — | — | ns | |
| SP41 | TscH2diL, TscL2diL | Hold Time of SDIx Data Input to SCKx Edge | 30 | — | — | ns | |
| SP50 | TssL2scH, TssL2scL | $\overline{SSx}$ ↓ to SCKx ↑ or SCKx Input | 120 | — | — | ns | |
| SP51 | TssH2doZ | $\overline{SSx}$ ↑ to SDOx Output High-Impedance | 10 | — | 50 | ns | See **Note 4** |
| SP52 | TscH2ssH TscL2ssH | $\overline{SSx}$ after SCKx Edge | 1.5 TCY + 40 | — | — | ns | See **Note 4** |

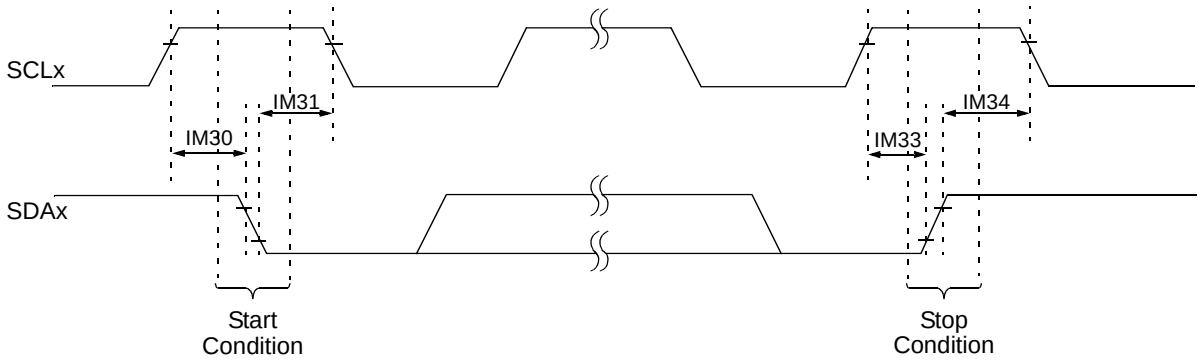
**Note 1:** These parameters are characterized, but are not tested in manufacturing.

**2:** Data in "Typ" column is at 3.3V, +25°C unless otherwise stated.

**3:** The minimum clock period for SCKx is 66.7 ns. Therefore, the SCKx clock generated by the Master must not violate this specification.

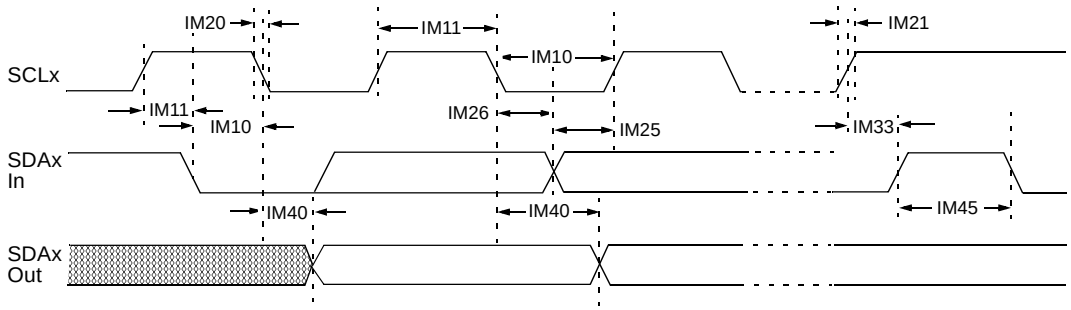
**4:** Assumes 50 pF load on all SPIx pins.

**FIGURE 26-27: I2Cx BUS START/STOP BITS TIMING CHARACTERISTICS (MASTER MODE)**



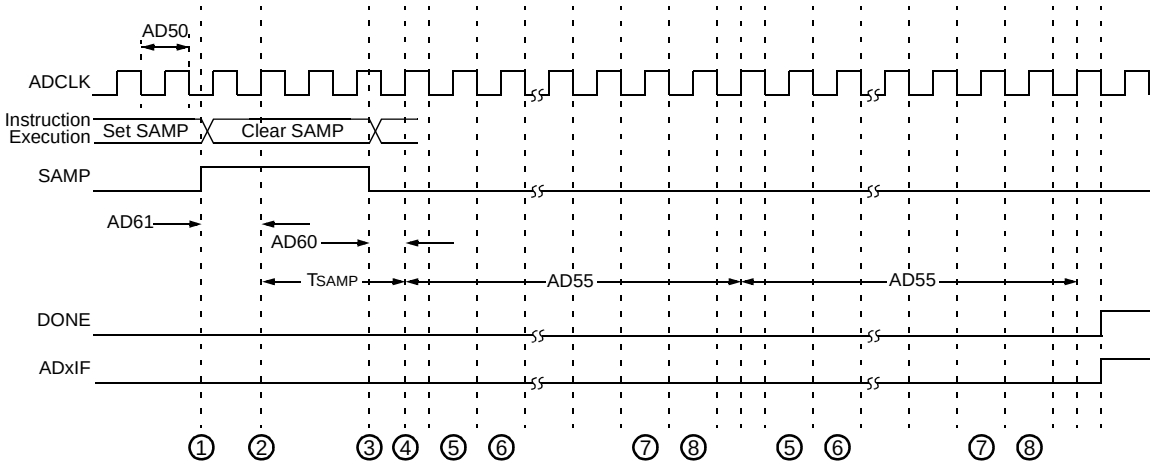

**Note:** Refer to Figure 26-1 for load conditions.

**FIGURE 26-28: I2Cx BUS DATA TIMING CHARACTERISTICS (MASTER MODE)**




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

**FIGURE 26-31: ADC CONVERSION TIMING CHARACTERISTICS (CHPS<1:0> = 01, SIMSAM = 0, ASAM = 0, SSRC<2:0> = 000)**




1 – Software sets ADxCON. SAMP to start sampling.

2 – Sampling starts after discharge period. TSAMP is described in **"Analog-to-Digital Converter (ADC)"** (DS70183) in the "*dsPIC33/PIC24 Family Reference Manual*".

3 – Software clears ADxCON. SAMP to start conversion.

4 – Sampling ends, conversion sequence starts.

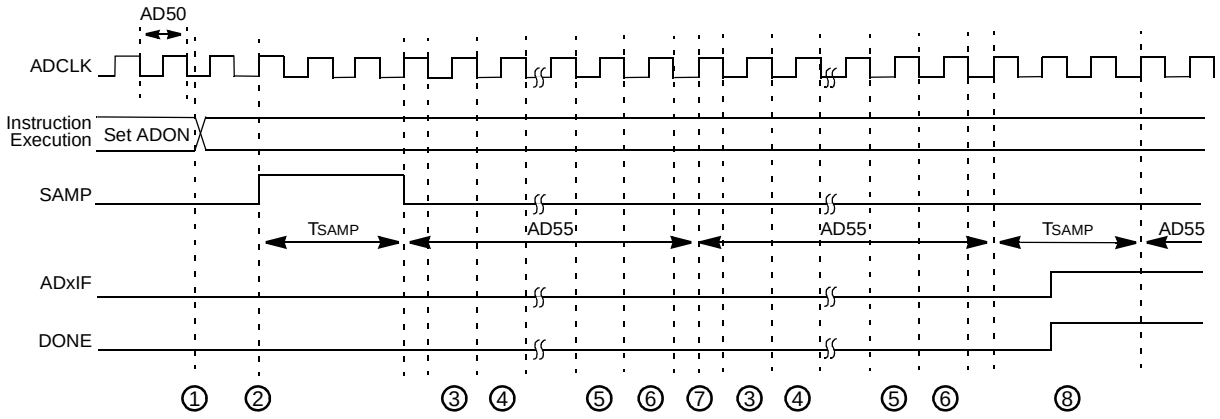
5 – Convert bit 9.

6 – Convert bit 8.

7 – Convert bit 0.

8 – One TAD for end of conversion.

**FIGURE 26-32: ADC CONVERSION TIMING CHARACTERISTICS (CHPS<1:0> = 01, SIMSAM = 0, ASAM = 1, SSRC<2:0> = 111, SAMC<4:0> = 00001)**




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

2 – Sampling starts after discharge period. TSAMP is described in **"Analog-to-Digital Converter (ADC)"** (DS70183) 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>.

**TABLE 26-50: COMPARATOR TIMING SPECIFICATIONS**

| 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 | | | | |
|---|---|---|---|---|---|---|---|
| **Param No.** | **Symbol** | **Characteristic** | **Min.** | **Typ** | **Max.** | **Units** | **Conditions** |
| 300 | TRESP | Response Time(1,2) | — | 150 | 400 | ns | |
| 301 | TMC2OV | Comparator Mode Change to Output Valid(1) | — | — | 10 | µs | |
| 302 | TON2OV | Comparator Enabled to Output Valid(1) | — | — | 10 | µs | |

**Note 1:** Parameters are characterized but not tested.

**2:** Response time is measured with one comparator input at (VDD – 1.5)/2, while the other input transitions from VSS to VDD.

**TABLE 26-51: COMPARATOR MODULE SPECIFICATIONS**

| DC 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 | | | | |
|---|---|---|---|---|---|---|---|
| **Param No.** | **Symbol** | **Characteristic** | **Min.** | **Typ** | **Max.** | **Units** | **Conditions** |
| D300 | VIOFF | Input Offset Voltage(1) | -20 | ±10 | 20 | mV | |
| D301 | VICM | Input Common-Mode Voltage(1) | 0 | — | AVDD – 1.5V | V | |
| D302 | CMRR | Common-Mode Rejection Ratio(1) | -54 | — | — | dB | |
| D305 | IVREF | Internal Voltage Reference(1) | 1.116 | 1.24 | 1.364 | V | |

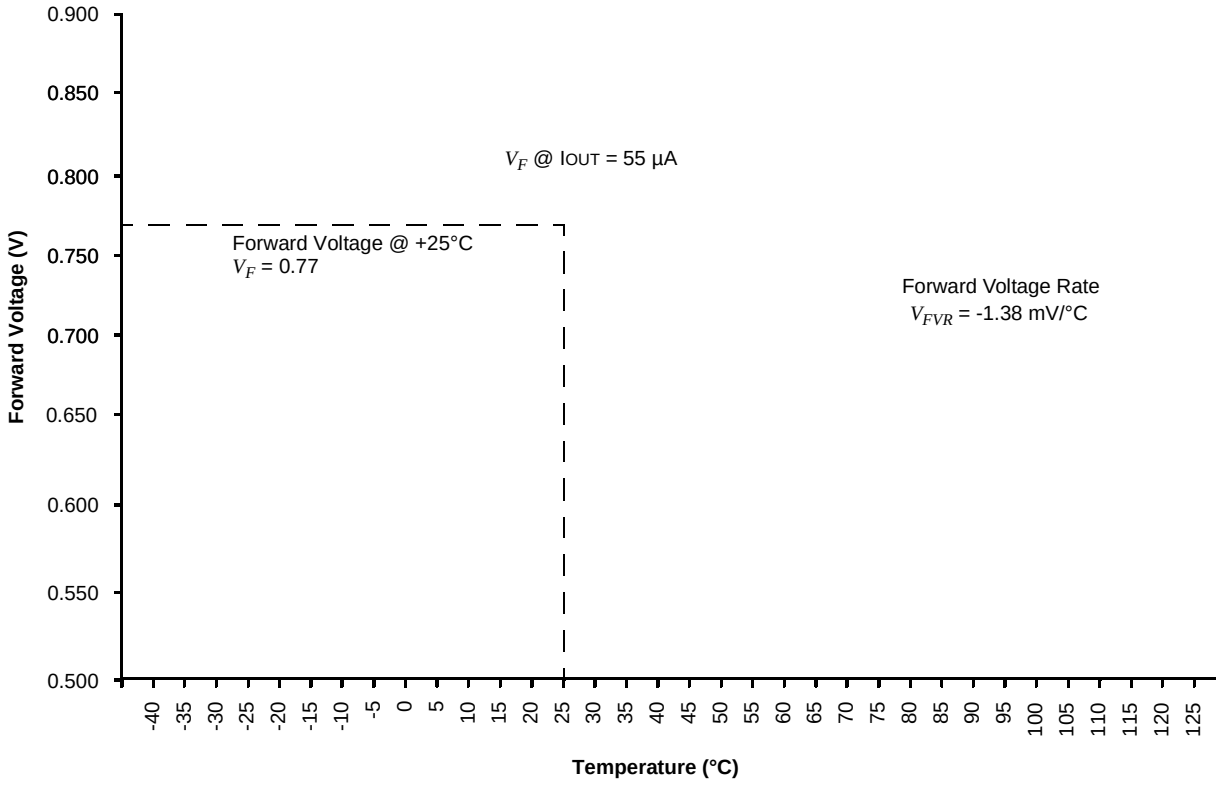
**Note 1:** Parameters are characterized but not tested.

**TABLE 26-52: COMPARATOR VOLTAGE REFERENCE SETTLING TIME SPECIFICATIONS**

| 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 | | | | |
|---|---|---|---|---|---|---|---|
| **Param No.** | **Symbol** | **Characteristic** | **Min.** | **Typ** | **Max.** | **Units** | **Conditions** |
| VR310 | TSET | Settling Time(1) | — | — | 10 | µs | |

**Note 1:** Settling time measured while CVRR = 1 and the CVR<3:0> bits transition from '0000' to '1111'.

**FIGURE 26-33: FORWARD VOLTAGE VERSUS TEMPERATURE**

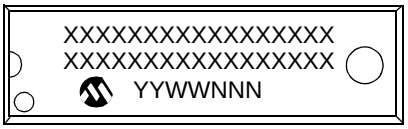



**Note:** This graph is a statistical summary based on a limited number of samples and this data is characterized but not tested in manufacturing.

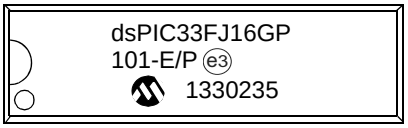
## 28.0 PACKAGING INFORMATION

### 28.1 Package Marking Information

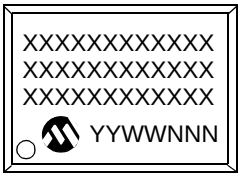
18-Lead PDIP




Example



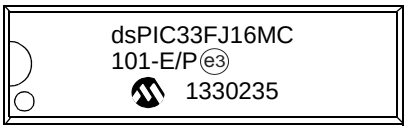

18-Lead SOIC



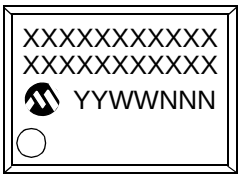

Example


20-Lead PDIP

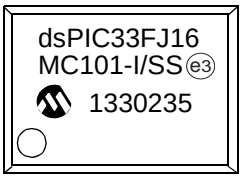

Example



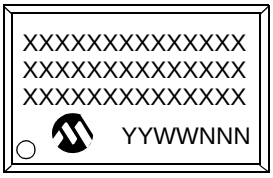

20-Lead SSOP



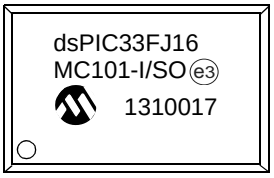

Example




20-Lead SOIC




Example




| | | |
|---|---|---|
| **Legend:** | XX...X | Customer-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:** If the full Microchip part number cannot be marked on one line, it is carried over to the next line, thus limiting the number of available characters for customer-specific information.

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