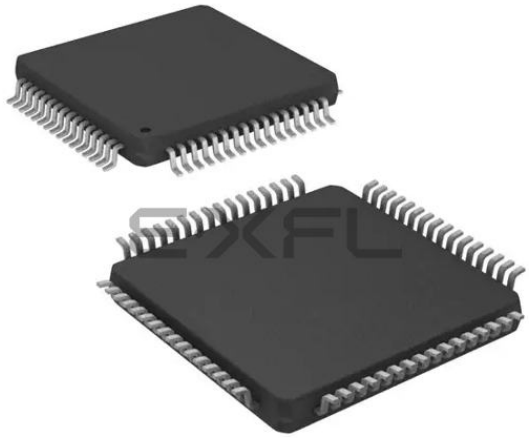
# Microchip Technology - DSPIC33EV128GM106T-I/PT Datasheet



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## Applications of "Embedded - Microcontrollers"

| Details | |
|---|---|
| Product Status | Active |
| Core Processor | dsPIC |
| Core Size | 16-Bit |
| Speed | 70 MIPs |
| Connectivity | CANbus, I²C, IrDA, LINbus, SPI, UART/USART |
| Peripherals | Brown-out Detect/Reset, DMA, Motor Control PWM, POR, PWM, WDT |
| Number of I/O | 53 |
| Program Memory Size | 128KB (43K x 24) |
| Program Memory Type | FLASH |
| EEPROM Size | - |
| RAM Size | 8K x 8 |
| Voltage - Supply (Vcc/Vdd) | 4.5V ~ 5.5V |
| Data Converters | A/D 36x10/12b |
| Oscillator Type | Internal |
| Operating Temperature | -40°C ~ 85°C (TA) |
| Mounting Type | Surface Mount |
| Package / Case | 64-TQFP |
| Supplier Device Package | 64-TQFP (10x10) |
| Purchase URL | https://www.e-xfl.com/product-detail/microchip-technology/dspic33ev128gm106t-i-pt |

**REGISTER 5-1: NVMCON: NONVOLATILE MEMORY (NVM) CONTROL REGISTER**

| R/SO-0 | R/W-0 | R/W-0 | R/W-0 | U-0 | U-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| WR(1) | WREN(1) | WRERR(1) | NVMSIDL(2) | — | — | RPDF | URERR |
| bit 15 | | | | | | | bit 8 |

| U-0 | U-0 | U-0 | U-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | — | NVMOP3(1,3,4) | NVMOP2(1,3,4) | NVMOP1(1,3,4) | NVMOP0(1,3,4) |
| bit 7 | | | | | | | bit 0 |

| **Legend:** | SO = Settable Only 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 **WR:** Write Control bit(1)
- 1 = Initiates a Flash memory program or erase operation; the operation is self-timed and the bit is cleared by hardware once the operation is complete
- 0 = Program or erase operation is complete and inactive

bit 14 **WREN:** Write Enable bit(1)
- 1 = Flash program or erase operations are enabled
- 0 = Flash program or erase operations are inhibited

bit 13 **WRERR:** Write Sequence Error Flag bit(1)
- 1 = An improper program or erase sequence attempt, or termination has occurred (bit is set automatically on any set attempt of the WR bit)
- 0 = The program or erase operation completed normally

bit 12 **NVMSIDL:** NVM Stop in Idle Control bit(2)
- 1 = Primary Flash operation discontinues when the device enters Idle mode
- 0 = Primary Flash operation continues when the device enters Idle mode.

bit 11-10 **Unimplemented:** Read as '0'

bit 9 **RPDF:** Row Programming Data Format Control bit
- 1 = Row data to be stored in RAM is in a compressed format
- 0 = Row data to be stored in RAM is in an uncompressed format

bit 8 **URERR:** Row Programming Data Underrun Error Flag bit
- 1 = Row programming operation has been terminated due to a data underrun error
- 0 = No data underrun has occurred

bit 7-4 **Unimplemented:** Read as '0'

**Note 1:** These bits can only be reset on a POR.

**2:** If this bit is set, there will be minimal power savings ($I_{IDLE}$), and upon exiting Idle mode, there is a delay ($T_{VREG}$) before Flash memory becomes operational.

**3:** All other combinations of NVMOP<3:0> are unimplemented.

**4:** Execution of the PWRSAV instruction is ignored while any of the NVM operations are in progress.

**5:** Two adjacent words on a 4-word boundary are programmed during execution of this operation.

## 9.0 OSCILLATOR CONFIGURATION

**Note 1:** This data sheet summarizes the features of the dsPIC33EVXXXGM00X/10X family of devices. It is not intended to be a comprehensive reference source. To complement the information in this data sheet, refer to **"Oscillator"** (DS70580) in the *"dsPIC33/PIC24 Family Reference Manual"*, which is available from the Microchip web site (www.microchip.com).

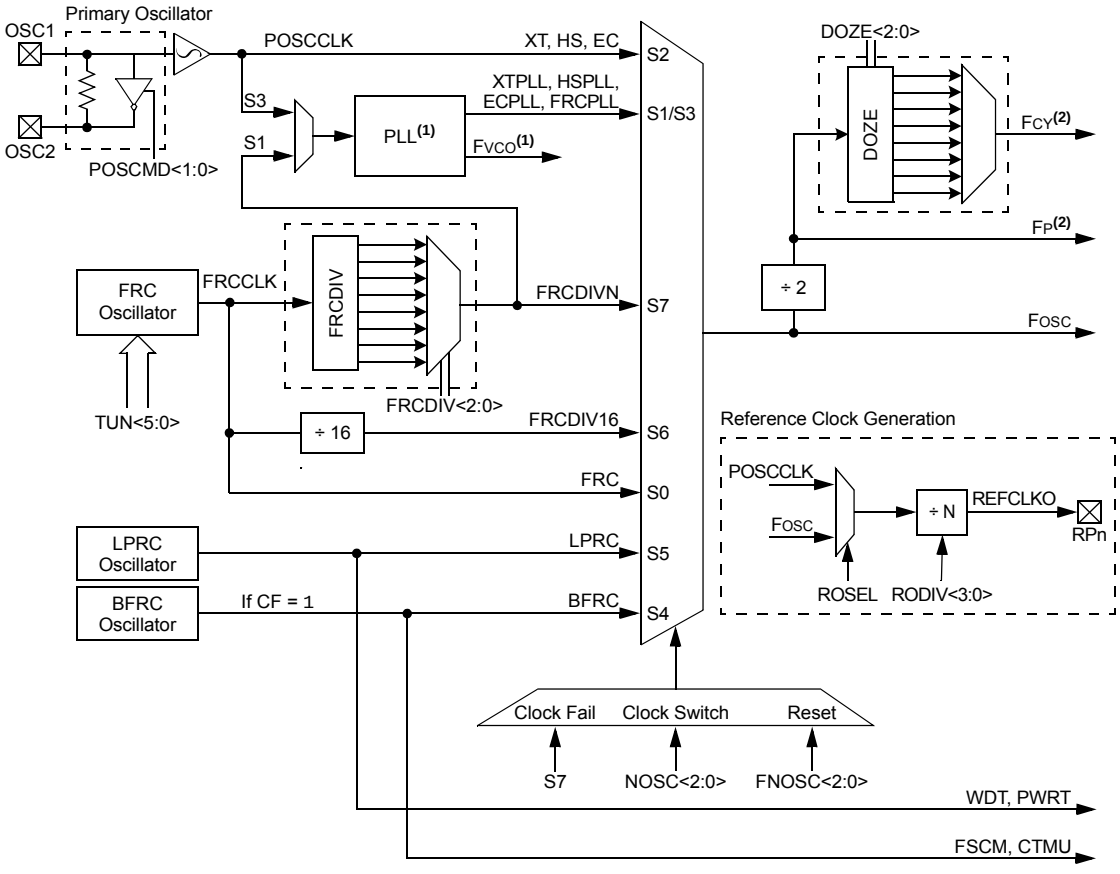
**2:** Some registers and associated bits described in this section may not be available on all devices. Refer to **Section 4.0 "Memory Organization"** in this data sheet for device-specific register and bit information.

The dsPIC33EVXXXGM00X/10X family oscillator system provides:

- On-Chip Phase-Locked Loop (PLL) to Boost Internal Operating Frequency on Select Internal and External Oscillator Sources
- On-the-Fly Clock Switching between Various Clock Sources
- Doze mode for System Power Savings
- Fail-Safe Clock Monitor (FSCM) that Detects Clock Failure and Permits Safe Application Recovery or Shutdown.
- Backup FRC (BFRC) Function that Provides a System Clock when there is a Failure in the FRC Clock
- Configuration bits for Clock Source Selection

A simplified diagram of the oscillator system is shown in Figure 9-1.

**FIGURE 9-1: OSCILLATOR SYSTEM DIAGRAM**




**Note 1:** See Figure 9-2 for PLL and FVCO details.

**2:** The term, FP, refers to the clock source for all peripherals, while FCY refers to the clock source for the CPU. Throughout this document, FCY and FP are used interchangeably, except in the case of Doze mode. FP and FCY will be different when Doze mode is used with a Doze ratio of 1:2 or lower.

**REGISTER 10-1: PMD1: PERIPHERAL MODULE DISABLE CONTROL REGISTER 1**

| R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | U-0 | R/W-0 | U-0 |
|---|---|---|---|---|---|---|---|
| T5MD | T4MD | T3MD | T2MD | T1MD | — | PWMMD | — |
| bit 15 | | | | | | | bit 8 |

| R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | U-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| I2C1MD | U2MD | U1MD | SPI2MD | SPI1MD | — | C1MD(1) | AD1MD |
| 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 **T5MD:** Timer5 Module Disable bit
1 = Timer5 module is disabled
0 = Timer5 module is enabled

bit 14 **T4MD:** Timer4 Module Disable bit
1 = Timer4 module is disabled
0 = Timer4 module is enabled

bit 13 **T3MD:** Timer3 Module Disable bit
1 = Timer3 module is disabled
0 = Timer3 module is enabled

bit 12 **T2MD:** Timer2 Module Disable bit
1 = Timer2 module is disabled
0 = Timer2 module is enabled

bit 11 **T1MD:** Timer1 Module Disable bit
1 = Timer1 module is disabled
0 = Timer1 module is enabled

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

bit 9 **PWMMD:** PWM Module Disable bit
1 = PWM module is disabled
0 = PWM module is enabled

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

bit 7 **I2C1MD:** I2C1 Module Disable bit
1 = I2C1 module is disabled
0 = I2C1 module is enabled

bit 6 **U2MD:** UART2 Module Disable bit
1 = UART2 module is disabled
0 = UART2 module is enabled

bit 5 **U1MD:** UART1 Module Disable bit
1 = UART1 module is disabled
0 = UART1 module is enabled

bit 4 **SPI2MD:** SPI2 Module Disable bit
1 = SPI2 module is disabled
0 = SPI2 module is enabled

bit 3 **SPI1MD:** SPI1 Module Disable bit
1 = SPI1 module is disabled
0 = SPI1 module is enabled

**Note 1:** This bit is available on dsPIC33EVXXXGM10X devices only.

## 17.3 PWMx Control Registers

**REGISTER 17-1: PTCON: PWMx TIME BASE CONTROL REGISTER**

| R/W-0 | U-0 | R/W-0 | HS-0, HC | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| PTEN | — | PTSIDL | SESTAT | SEIEN | EIPU(1) | SYNCPOL(1) | SYNCOEN(1) |
| 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 |
|---|---|---|---|---|---|---|---|
| SYNCEN(1) | SYNCSRC2(1) | SYNCSRC1(1) | SYNCSRC0(1) | SEVTPS3(1) | SEVTPS2(1) | SEVTPS1(1) | SEVTPS0(1) |
| bit 7 | | | | | | | bit 0 |

| **Legend:** | HC = Hardware Clearable bit | 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 **PTEN:** PWMx Module Enable bit
1 = PWMx module is enabled
0 = PWMx module is disabled

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

bit 13 **PTSIDL:** PWMx Time Base Stop in Idle Mode bit
1 = PWMx time base halts in CPU Idle mode
0 = PWMx time base runs in CPU Idle mode

bit 12 **SESTAT:** Special Event Interrupt Status bit
1 = Special event interrupt is pending
0 = Special event interrupt is not pending

bit 11 **SEIEN:** Special Event Interrupt Enable bit
1 = Special event interrupt is enabled
0 = Special event interrupt is disabled

bit 10 **EIPU:** Enable Immediate Period Updates bit(1)
1 = Active Period register is updated immediately
0 = Active Period register updates occur on PWMx cycle boundaries

bit 9 **SYNCPOL:** Synchronize Input and Output Polarity bit(1)
1 = SYNCI1/SYNCO1 polarity is inverted (active-low)
0 = SYNCI1/SYNCO1 is active-high

bit 8 **SYNCOEN:** Primary Time Base Sync Enable bit(1)
1 = SYNCO1 output is enabled
0 = SYNCO1 output is disabled

bit 7 **SYNCEN:** External Time Base Synchronization Enable bit(1)
1 = External synchronization of primary time base is enabled
0 = External synchronization of primary time base is disabled

**Note 1:** These bits should be changed only when PTEN = 0. In addition, when using the SYNCI1 feature, the user application must program the Period register with a value that is slightly larger than the expected period of the external synchronization input signal.

**REGISTER 17-18: AUXCONx: PWMx AUXILIARY CONTROL REGISTER**

| U-0 | U-0 | U-0 | U-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| — | — | — | — | BLANKSEL3 | BLANKSEL2 | BLANKSEL1 | BLANKSEL0 |
| bit 15 | | | | | | | bit 8 |

| U-0 | U-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| — | — | CHOPSEL3 | CHOPSEL2 | CHOPSEL1 | CHOPSEL0 | CHOPHEN | CHOPLEN |
| 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 11-8 **BLANKSEL<3:0>:** PWMx State Blank Source Select bits

The selected state blank signal will block the current-limit and/or Fault input signals (if enabled through the BCH and BCL bits in the LEBCONx register).

1001 = Reserved
•
•
•
0100 = Reserved
0011 = PWM3H is selected as the state blank source
0010 = PWM2H is selected as the state blank source
0001 = PWM1H is selected as the state blank source
0000 = No state blanking

bit 7-6 **Unimplemented:** Read as '0'

bit 5-2 **CHOPSEL<3:0>:** PWMx Chop Clock Source Select bits

The selected signal will enable and disable (Chop) the selected PWMx outputs.

1001 = Reserved
•
•
•
0100 = Reserved
0011 = PWM3H is selected as the chop clock source
0010 = PWM2H is selected as the chop clock source
0001 = PWM1H is selected as the chop clock source
0000 = Chop clock generator is selected as the chop clock source

bit 1 **CHOPHEN:** PWMxH Output Chopping Enable bit

1 = PWMxH chopping function is enabled
0 = PWMxH chopping function is disabled

bit 0 **CHOPLEN:** PWMxL Output Chopping Enable bit

1 = PWMxL chopping function is enabled
0 = PWMxL chopping function is disabled

## 18.1 SPI Helpful Tips

1. In Frame mode, if there is a possibility that the master may not be initialized before the slave:
   a) If FRMPOL (SPIxCON2<13>) = 1, use a pull-down resistor on $\overline{SSx}$.
   b) If FRMPOL = 0, use a pull-up resistor on $\overline{SSx}$.

| **Note:** | This insures that the first frame transmission after initialization is not shifted or corrupted. |
|---|---|

2. In Non-Framed 3-Wire mode (i.e., not using $\overline{SSx}$ from a master):
   a) If CKP (SPIxCON1<6>) = 1, always place a pull-up resistor on $\overline{SSx}$.
   b) If CKP = 0, always place a pull-down resistor on $\overline{SSx}$.

| **Note:** | This will insure that during power-up and initialization, the master/slave will not lose sync due to an errant SCKx transition that would cause the slave to accumulate data shift errors, for both transmit and receive, appearing as corrupted data. |
|---|---|

3. FRMEN (SPIxCON2<15>) = 1 and SSEN (SPIxCON1<7>) = 1 are exclusive and invalid. In Frame mode, SCKx is continuous and the Frame Sync pulse is active on the $\overline{SSx}$ pin, which indicates the start of a data frame.

| **Note:** | Not all third-party devices support Frame mode timing. For more information, refer to the SPI specifications in **Section 30.0 "Electrical Characteristics"**. |
|---|---|

4. In Master mode only, set the SMP bit (SPIxCON1<9>) to a '1' for the fastest SPI data rate possible. The SMP bit can only be set at the same time or after the MSTEN bit (SPIxCON1<5>) is set.

To avoid invalid slave read data to the master, the user's master software must ensure enough time for slave software to fill its write buffer before the user application initiates a master write/read cycle. It is always advisable to preload the SPIxBUF Transmit register in advance of the next master transaction cycle. SPIxBUF is transferred to the SPIx Shift register and is empty once the data transmission begins.

## 20.2 Transmit Mode

By default, the SENTx module is configured for transmit operation. The module can be configured for continuous asynchronous message frame transmission, or alternatively, for Synchronous mode triggered by software. When enabled, the transmitter will send a Sync followed by the appropriate number of data nibbles, an optional CRC and optional pause pulse. The tick period used by the SENTx transmitter is set by writing a value to the TICKTIME<15:0> (SENTxCON2<15:0>) bits. The tick period calculations are shown in Equation 20-1.

**EQUATION 20-1: TICK PERIOD CALCULATION**

$$TICKTIME\langle 15:0\rangle = \frac{T_{TICK}}{T_{CLK}} - 1$$

An optional pause pulse can be used in Asynchronous mode to provide a fixed message frame time period. The frame period used by the SENTx transmitter is set by writing a value to the FRAMETIME<15:0> (SENTxCON3<15:0>) bits. The formulas used to calculate the value of frame time are shown in Equation 20-2.

**EQUATION 20-2: FRAME TIME CALCULATIONS**

$$FRAMETIME\langle 15:0\rangle = T_{TICK}/T_{FRAME}$$

$$FRAMETIME\langle 15:0\rangle \geq 122 + 27N$$

$$FRAMETIME\langle 15:0\rangle \geq 848 + 12N$$

Where:

$T_{FRAME}$ = Total time of the message from ms

$N$ = The number of data nibbles in message, 1-6

**Note:** The module will not produce a pause period with less than 12 ticks, regardless of the FRAMETIME<15:0> value. FRAMETIME<15:0> values beyond 2047 will have no effect on the length of a data frame.

### 20.2.1 TRANSMIT MODE CONFIGURATION

#### 20.2.1.1 Initializing the SENTx Module:

Perform the following steps to initialize the module:

1. Write RCVEN (SENTxCON1<11>) = 0 for Transmit mode.
2. Write TXM (SENTxCON1<10>) = 0 for Asynchronous Transmit mode or TXM = 1 for Synchronous mode.
3. Write NIBCNT<2:0> (SENTxCON1<2:0>) for the desired data frame length.
4. Write CRCEN (SENTxCON1<8>) for hardware or software CRC calculation.
5. Write PPP (SENTxCON1<7>) for optional pause pulse.
6. If PPP = 1, write TFRAME to SENTxCON3.
7. Write SENTxCON2 with the appropriate value for desired tick period.
8. Enable interrupts and set interrupt priority.
9. Write initial status and data values to SENTxDATH/L.
10. If CRCEN = 0, calculate CRC and write the value to CRC<3:0> (SENTxDATL<3:0>).
11. Set the SNTEN (SENTxCON1<15>) bit to enable the module.

User software updates to SENTxDATH/L must be performed after the completion of the CRC and before the next message frame's status nibble. The recommended method is to use the message frame completion interrupt to trigger data writes.

**REGISTER 21-1: UxMODE: UARTx MODE REGISTER (CONTINUED)**

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

bit 4 **URXINV:** UARTx Receive Polarity Inversion bit
1 = UxRX Idle state is '0'
0 = UxRX Idle state is '1'

bit 3 **BRGH:** High Baud Rate Enable bit
1 = BRG generates 4 clocks per bit period (4x baud clock, High-Speed mode)
0 = BRG generates 16 clocks per bit period (16x baud clock, Standard mode)

bit 2-1 **PDSEL<1:0>:** Parity and Data Selection bits
11 = 9-bit data, no parity
10 = 8-bit data, odd parity
01 = 8-bit data, even parity
00 = 8-bit data, no parity

bit 0 **STSEL:** Stop Bit Selection bit
1 = Two Stop bits
0 = One Stop bit

**Note 1:** Refer to **"Universal Asynchronous Receiver Transmitter (UART)"** (DS70000582) in the *"dsPIC33/PIC24 Family Reference Manual"* for information on enabling the UART module for receive or transmit operation.

**2:** This feature is only available for the 16x BRG mode (BRGH = 0).

**3:** This feature is only available on 44-pin and 64-pin devices.

**4:** This feature is only available on 64-pin devices.

**REGISTER 22-14: CxBUFPNT3: CANx FILTERS 8-11 BUFFER POINTER REGISTER 3**

| R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| F11BP3 | F11BP2 | F11BP1 | F11BP0 | F10BP3 | F10BP2 | F10BP1 | F10BP0 |
| 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 |
|---|---|---|---|---|---|---|---|
| F9BP3 | F9BP2 | F9BP1 | F9BP0 | F8BP3 | F8BP2 | F8BP1 | F8BP0 |
| 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 **F11BP<3:0>:** RX Buffer Mask for Filter 11 bits
1111 = Filter hits received in RX FIFO buffer
1110 = Filter hits received in RX Buffer 14
•
•
•
0001 = Filter hits received in RX Buffer 1
0000 = Filter hits received in RX Buffer 0

bit 11-8 **F10BP<3:0>:** RX Buffer Mask for Filter 10 bits (same values as bits 15-12)

bit 7-4 **F9BP<3:0>:** RX Buffer Mask for Filter 9 bits (same values as bits 15-12)

bit 3-0 **F8BP<3:0>:** RX Buffer Mask for Filter 8 bits (same values as bits 15-12)

**REGISTER 25-5: CMxMSKCON: COMPARATOR x MASK GATING CONTROL REGISTER**

| R/W-0 | U-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |
|---|---|---|---|---|---|---|---|
| HLMS | — | OCEN | OCNEN | OBEN | OBNEN | OAEN | OANEN |
| 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 |
|---|---|---|---|---|---|---|---|
| NAGS | PAGS | ACEN | ACNEN | ABEN | ABNEN | AAEN | AANEN |
| 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 **HLMS:** High or Low-Level Masking Select bit
1 = The masking (blanking) function will prevent any asserted ('0') comparator signal from propagating
0 = The masking (blanking) function will prevent any asserted ('1') comparator signal from propagating

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

bit 13 **OCEN:** OR Gate C Input Enable bit
1 = MCI is connected to OR gate
0 = MCI is not connected to OR gate

bit 12 **OCNEN:** OR Gate C Input Inverted Enable bit
1 = Inverted MCI is connected to OR gate
0 = Inverted MCI is not connected to OR gate

bit 11 **OBEN:** OR Gate B Input Enable bit
1 = MBI is connected to OR gate
0 = MBI is not connected to OR gate

bit 10 **OBNEN:** OR Gate B Input Inverted Enable bit
1 = Inverted MBI is connected to OR gate
0 = Inverted MBI is not connected to OR gate

bit 9 **OAEN:** OR Gate A Input Enable bit
1 = MAI is connected to OR gate
0 = MAI is not connected to OR gate

bit 8 **OANEN:** OR Gate A Input Inverted Enable bit
1 = Inverted MAI is connected to OR gate
0 = Inverted MAI is not connected to OR gate

bit 7 **NAGS:** AND Gate Output Inverted Enable bit
1 = Inverted ANDI is connected to OR gate
0 = Inverted ANDI is not connected to OR gate

bit 6 **PAGS:** AND Gate Output Enable bit
1 = ANDI is connected to OR gate
0 = ANDI is not connected to OR gate

bit 5 **ACEN:** AND Gate C Input Enable bit
1 = MCI is connected to AND gate
0 = MCI is not connected to AND gate

bit 4 **ACNEN:** AND Gate C Input Inverted Enable bit
1 = Inverted MCI is connected to AND gate
0 = Inverted MCI is not connected to AND gate

## 28.0 INSTRUCTION SET SUMMARY

**Note:** This data sheet summarizes the features of the dsPIC33EVXXXGM00X/10X family of devices. It is not intended to be a comprehensive reference source. To complement the information in this data sheet, refer to the related section of the *"dsPIC33/PIC24 Family Reference Manual"*, which is available from the Microchip web site (www.microchip.com).

The dsPIC33EV instruction set is almost identical to that of the dsPIC30F and dsPIC33F.

Most instructions are a single program memory word (24 bits). 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 following five basic categories:

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

Table 28-1 lists the general symbols used in describing the instructions.

The dsPIC33E instruction set summary in Table 28-2 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 the following 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 be either 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 can use some of the following operands:

- A literal value to be loaded into a W register or file register (specified by '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 MAC class of DSP instructions can use some of the following operands:

- The accumulator (A or B) to be used (required operand)
- The W registers to be used as the two operands
- The X and Y address space prefetch operations
- The X and Y address space prefetch destinations
- The accumulator write-back destination

The other DSP instructions do not involve any multiplication and can include:

- The accumulator to be used (required)
- The source or destination operand (designated as Wso or Wdo, respectively) with or without an address modifier
- The amount of shift specified by a W register 'Wn' or a literal value

The control instructions can use some of the following operands:

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

## 30.1 DC Characteristics

**TABLE 30-1: OPERATING MIPS vs. VOLTAGE**

| Characteristic | VDD Range (in Volts) | Temperature Range (in °C) | Maximum MIPS |
|---|---|---|---|
| | | | dsPIC33EVXXXGM00X/10X Family |
| I-Temp | 4.5V to 5.5V(1,2) | -40°C to +85°C | 70 |
| E-Temp | 4.5V to 5.5V(1,2) | -40°C to +125°C | 60 |

**Note 1:** Device is functional at VBORMIN < VDD < VDDMIN. Analog modules: ADC, op amp/comparator and comparator voltage reference will have degraded performance. Device functionality is tested but not characterized. Refer to Parameter BO10 in Table 30-12 for the minimum and maximum BOR values.

**2:** When BOR is enabled, the device will work from 4.7V to 5.5V.

**Note 1:** Customer operating voltage range is specified as: 4.5V to 5.5V.

**TABLE 30-2: THERMAL OPERATING CONDITIONS**

| Rating | Symbol | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Industrial Temperature Devices: | | | | | |
| Operating Junction Temperature Range | TJ | -40 | — | +125 | °C |
| Operating Ambient Temperature Range | TA | -40 | — | +85 | °C |
| Extended Temperature Devices: | | | | | |
| Operating Junction Temperature Range | TJ | -40 | — | +140 | °C |
| Operating Ambient Temperature Range | TA | -40 | — | +125 | °C |
| Power Dissipation:<br>Internal Chip Power Dissipation:<br>PINT = VDD x (IDD – Σ IOH)<br>I/O Pin Power Dissipation:<br>I/O = Σ ({VDD – VOH} x IOH) + Σ (VOL x IOL) | PD | PINT + PI/O | | | W |
| Maximum Allowed Power Dissipation | PDMAX | (TJ – TA)/θJA | | | W |

**TABLE 30-3: THERMAL PACKAGING CHARACTERISTICS**

| Characteristic | Symbol | Typ. | Max. | Unit | Notes |
|---|---|---|---|---|---|
| Package Thermal Resistance, 64-Pin QFN, 9x9x0.9 mm | θJA | 28.0 | — | °C/W | **1** |
| Package Thermal Resistance, 64-Pin TQFP, 10x10x1 mm | θJA | 48.3 | — | °C/W | **1** |
| Package Thermal Resistance, 44-Pin QFN, 8x8 mm | θJA | 29.0 | — | °C/W | **1** |
| Package Thermal Resistance, 44-Pin TQFP, 10x10x1 mm | θJA | 49.8 | — | °C/W | **1** |
| Package Thermal Resistance, 28-Pin QFN-S, 6x6x0.9 mm | θJA | 30.0 | — | °C/W | **1** |
| Package Thermal Resistance, 28-Pin SOIC, 7.50 mm | θJA | 69.7 | — | °C/W | **1** |
| Package Thermal Resistance, 28-Pin SSOP, 5.30 mm | θJA | 71.0 | — | °C/W | **1** |
| Package Thermal Resistance, 28-Pin SPDIP, 300 mil | θJA | 60.0 | — | °C/W | **1** |

**Note 1:** Junction to ambient thermal resistance, Theta-JA (θJA) numbers are achieved by package simulations.

**TABLE 30-50: OP AMP/COMPARATOR x SPECIFICATIONS**

| DC CHARACTERISTICS | | | Standard Operating Conditions (see Note 3): 4.5V to 5.5V (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.(1)** | **Max.** | **Units** | **Conditions** |
| **Comparator AC Characteristics** | | | | | | | |
| CM10 | TRESP | Response Time | — | 19 | 80 | ns | V+ input step of 100 mV, V- input held at VDD/2 |
| CM11 | TMC2OV | Comparator Mode Change to Output Valid | — | — | 10 | µs | |
| **Comparator DC Characteristics** | | | | | | | |
| CM30 | VOFFSET | Comparator Offset Voltage | -80 | ±60 | 80 | mV | |
| CM31 | VHYST | Input Hysteresis Voltage | — | 30 | — | mV | |
| CM32 | TRISE/ TFALL | Comparator Output Rise/Fall Time | — | 20 | — | ns | 1 pF load capacitance on input |
| CM33 | VGAIN | Open-Loop Voltage Gain | — | 90 | — | db | |
| CM34 | VICM | Input Common-Mode Voltage | AVSS | — | AVDD | V | |
| **Op Amp AC Characteristics** | | | | | | | |
| CM20 | SR | Slew Rate | — | 9 | — | V/µs | 10 pF load |
| CM21 | PM | Phase Margin | — | 35 | — | °C | G = 100V/V, 10 pF load |
| CM22 | GM | Gain Margin | — | 20 | — | db | G = 100V/V, 10 pF load |
| CM23 | GBW | Gain Bandwidth | — | 10 | — | MHz | 10 pF load |
| **Op Amp DC Characteristics** | | | | | | | |
| CM40 | VCMR | Common-Mode Input Voltage Range | AVSS | — | AVDD | V | |
| CM41 | CMRR | Common-Mode Rejection Ratio | — | 45 | — | db | VCM = AVDD/2 |
| CM42 | VOFFSET | Op Amp Offset Voltage | -50 | ±6 | 50 | mV | |
| CM43 | VGAIN | Open-Loop Voltage Gain | — | 90 | — | db | |
| CM44 | IOS | Input Offset Current | — | — | — | — | See pad leakage currents in Table 30-10 |
| CM45 | IB | Input Bias Current | — | — | — | — | See pad leakage currents in Table 30-10 |
| CM46 | IOUT | Output Current | — | — | 420 | µA | With minimum value of RFEEDBACK (CM48) |
| CM48 | RFEEDBACK | Feedback Resistance Value | 8 | — | — | kΩ | **Note 2** |
| CM49a | VOUT | Output Voltage | AVSS + 0.075 | — | AVDD – 0.075 | V | IOUT = 420 µA |

**Note 1:** Data in "Typ." column is at 5.0V, +25°C unless otherwise stated.

**2:** Resistances can vary by ±10% between op amps.

**3:** Device is functional at VBORMIN < VDD < VDDMIN, but will have degraded performance. Device functionality is tested, but not characterized. Analog modules: ADC, op amp/comparator and comparator voltage reference, will have degraded performance. Refer to Parameter BO10 in Table 30-12 for the minimum and maximum BOR values.

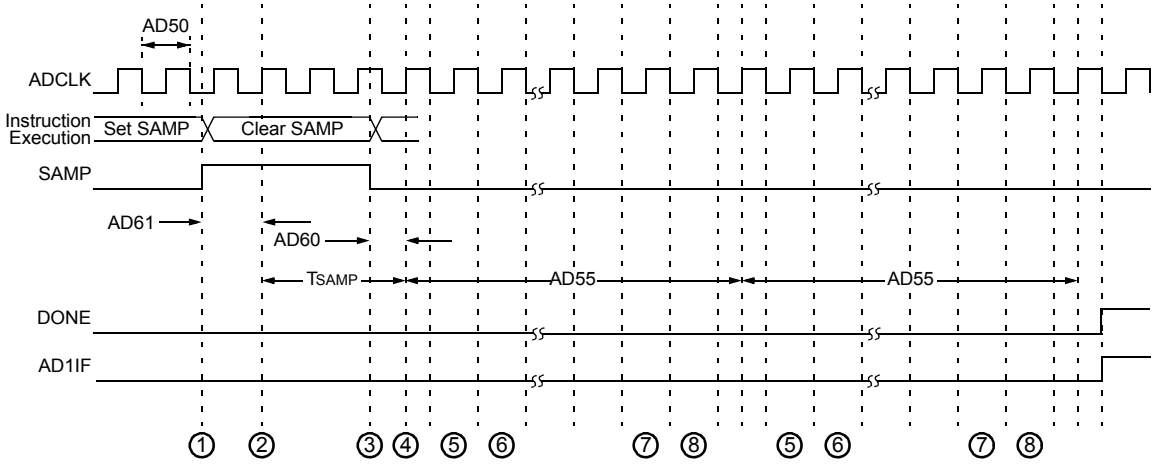
**TABLE 30-55: ADC MODULE SPECIFICATIONS (12-BIT MODE)**

| AC CHARACTERISTICS | | | Standard Operating Conditions (see Note 1): 4.5V to 5.5V (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** |
| **ADC Accuracy (12-Bit Mode)** | | | | | | | |
| AD20a | Nr | Resolution | 12 data bits | | | bits | |
| AD21a | INL | Integral Nonlinearity | -2 | — | +2 | LSb | VINL = AVSS = VREFL = 0V, AVDD = VREFH = 5.5V |
| AD22a | DNL | Differential Nonlinearity | > -1 | — | < 1 | LSb | VINL = AVSS = VREFL = 0V, AVDD = VREFH = 5.5V |
| AD23a | GERR | Gain Error | -10 | 4 | 10 | LSb | VINL = AVSS = VREFL = 0V, AVDD = VREFH = 5.5V |
| AD24a | EOFF | Offset Error | -10 | 1.75 | 10 | LSb | VINL = AVSS = VREFL = 0V, AVDD = VREFH = 5.5V |
| AD25a | — | Monotonicity(2) | — | — | — | — | Guaranteed |
| **Dynamic Performance (12-Bit Mode)** | | | | | | | |
| AD30a | THD | Total Harmonic Distortion | — | — | -75 | dB | |
| AD31a | SINAD | Signal to Noise and Distortion | 68.5 | 69.5 | — | dB | |
| AD32a | SFDR | Spurious Free Dynamic Range | 80 | — | — | dB | |
| AD33a | FNYQ | Input Signal Bandwidth | — | — | 250 | kHz | |
| AD34a | ENOB | Effective Number of Bits | 11.09 | 11.3 | — | bits | |

**Note 1:** Device is functional at VBORMIN < VDD < VDDMIN, but will have degraded performance. Device functionality is tested, but not characterized. Analog modules: ADC, op amp/comparator and comparator voltage reference, will have degraded performance. Refer to Parameter BO10 in Table 30-12 for the minimum and maximum BOR values.

**2:** The conversion result never decreases with an increase in the input voltage.

**FIGURE 30-35: ADC CONVERSION (10-BIT MODE) TIMING CHARACTERISTICS (CHPS<1:0> = 01, SIMSAM = 0, ASAM = 0, SSRC<2:0> = 000, SSRCG = 0)**




① – Software sets ADxCON1. SAMP to start sampling.

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

③ – Software clears ADxCON1. SAMP to start conversion.

④ – Sampling ends, conversion sequence starts.

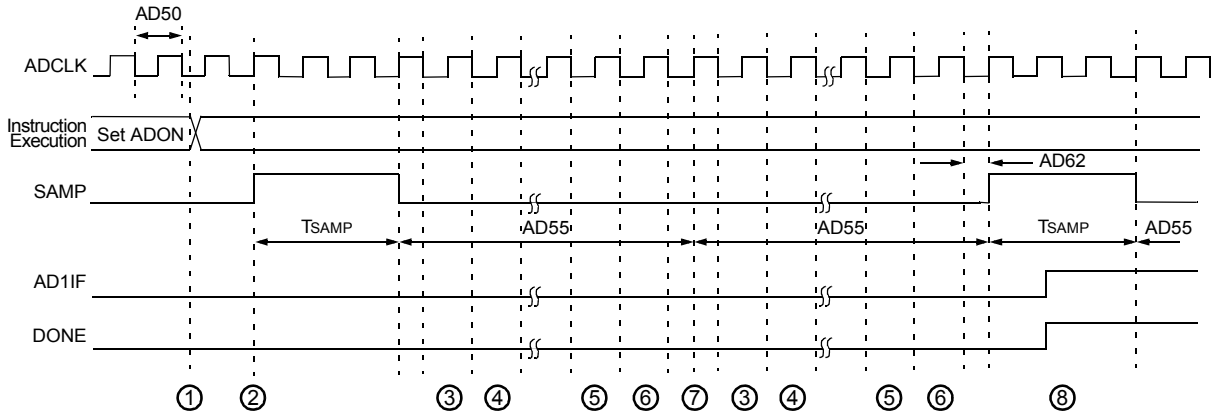
⑤ – Convert bit 9.

⑥ – Convert bit 8.

⑦ – Convert bit 0.

⑧ – One TAD for end of conversion.

**FIGURE 30-36: 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 ADxCON1. ADON to start ADC operation.

② – Sampling starts after discharge period. TSAMP is described in **"Analog-to-Digital Converter (ADC)"** (DS70621) of 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>.

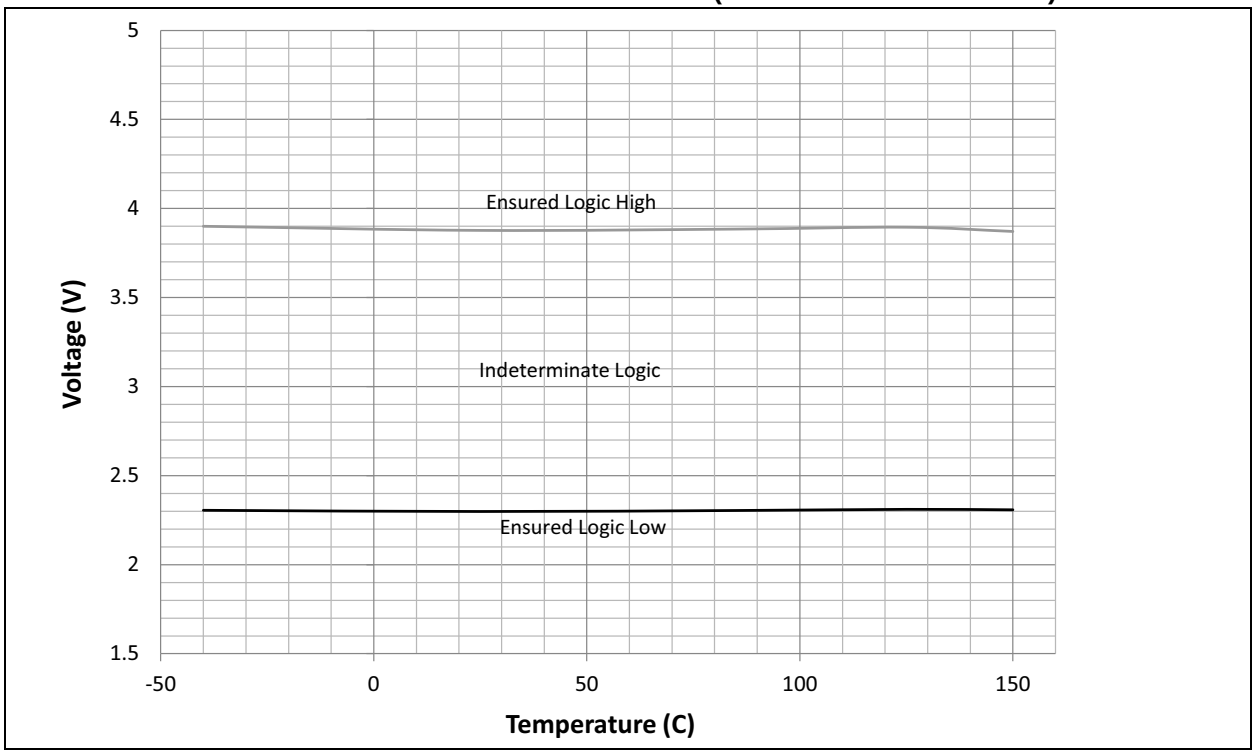
**TABLE 31-19: ADC MODULE SPECIFICATIONS (10-BIT MODE)**

| AC CHARACTERISTICS | | | Standard Operating Conditions (see Note 1): 4.5V to 5.5V (unless otherwise stated)<br>Operating temperature -40°C ≤ TA ≤ +150°C | | | | |
|---|---|---|---|---|---|---|---|
| **Param No.** | **Symbol** | **Characteristic** | **Min.** | **Typ.** | **Max.** | **Units** | **Conditions** |
| **ADC Accuracy (10-Bit Mode)** | | | | | | | |
| HAD20b | Nr | Resolution | 10 data bits | | | bits | |
| HAD21b | INL | Integral Nonlinearity | -1.5 | — | +1.5 | LSb | VINL = AVSS = VREFL = 0V, AVDD = VREFH = 5.5V |
| HAD22b | DNL | Differential Nonlinearity | ≥ 1 | — | < 1 | LSb | VINL = AVSS = VREFL = 0V, AVDD = VREFH = 5.5V |
| HAD23b | GERR | Gain Error | 1 | 3 | 6 | LSb | VINL = AVSS = VREFL = 0V, AVDD = VREFH = 5.5V |
| HAD24b | EOFF | Offset Error | 1 | 2 | 4 | LSb | VINL = AVSS = VREFL = 0V, AVDD = VREFH = 5.5V |

**Note 1:** Device is functional at VBORMIN < VDD < VDDMIN, but will have degraded performance. Device functionality is tested, but is not characterized. Analog modules: ADC, op amp/comparator and comparator voltage reference, will have degraded performance. Refer to Parameter HBO10 in Table 31-10 for the minimum and maximum BOR values.

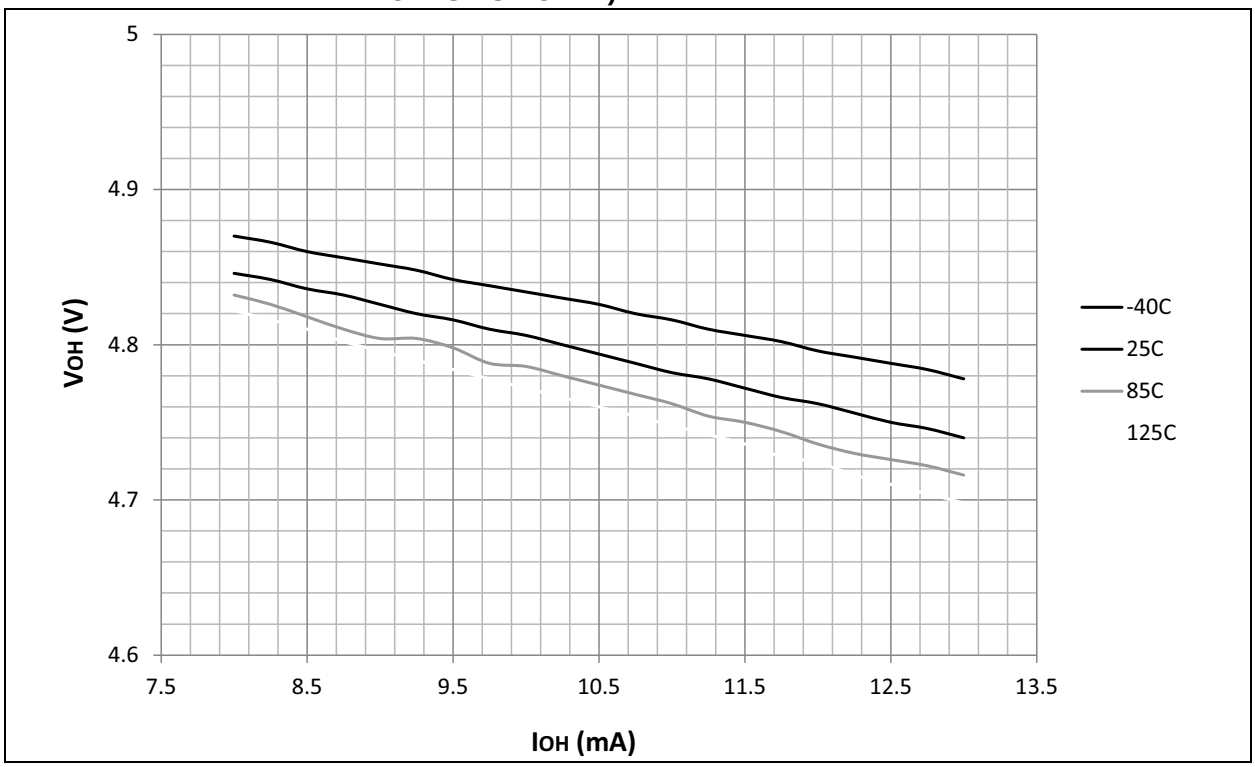
## 32.9 Voltage Input Low (VIL) – Voltage Input High (VIH)

**FIGURE 32-29: TYPICAL VIH/VIL vs. TEMPERATURE (GENERAL PURPOSE I/Os)**




## 32.10 Voltage Output Low (VOL) – Voltage Output High (VOH)

**FIGURE 32-30: TYPICAL VOH 8x DRIVER PINS vs. IOH (GENERAL PURPOSE I/Os, TEMPERATURES AS NOTED)**



## 32.14 Comparator Op Amp Offset

**FIGURE 32-37: TYPICAL COMPARATOR OFFSET vs. VCM**

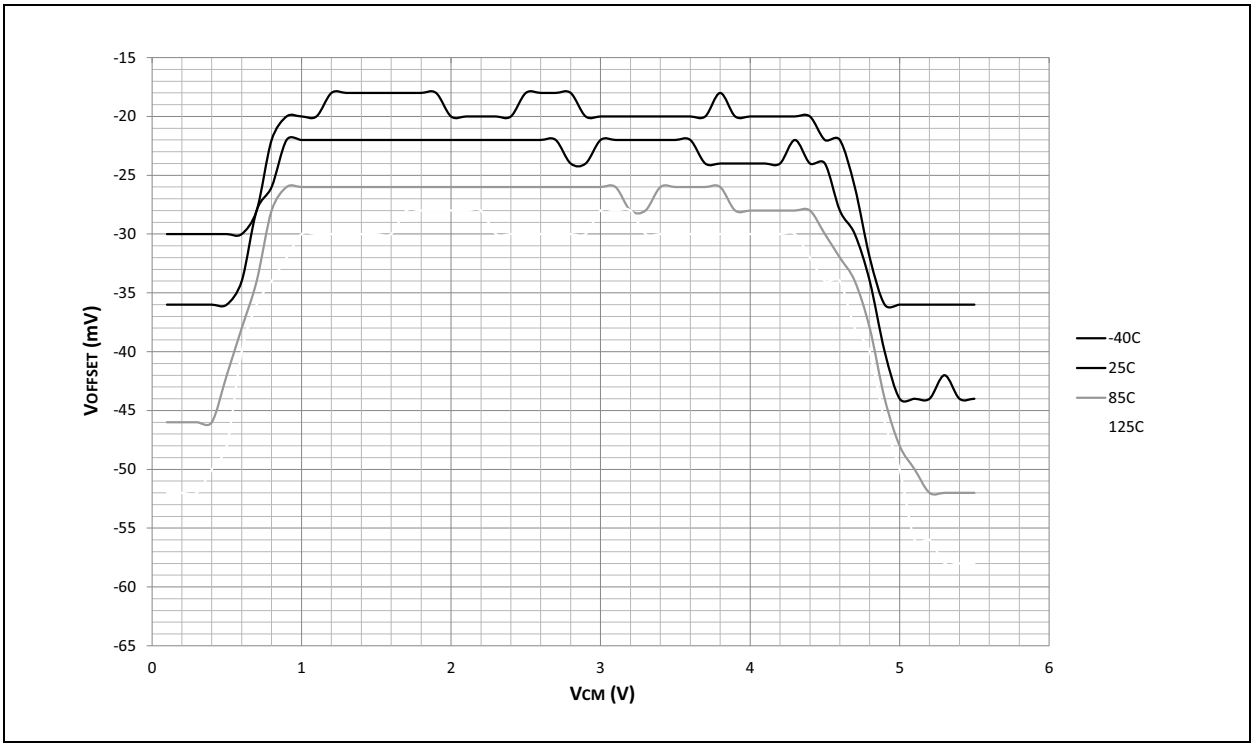



**FIGURE 32-38: TYPICAL OP AMP OFFSET vs. VCM OP AMP OFFSET**

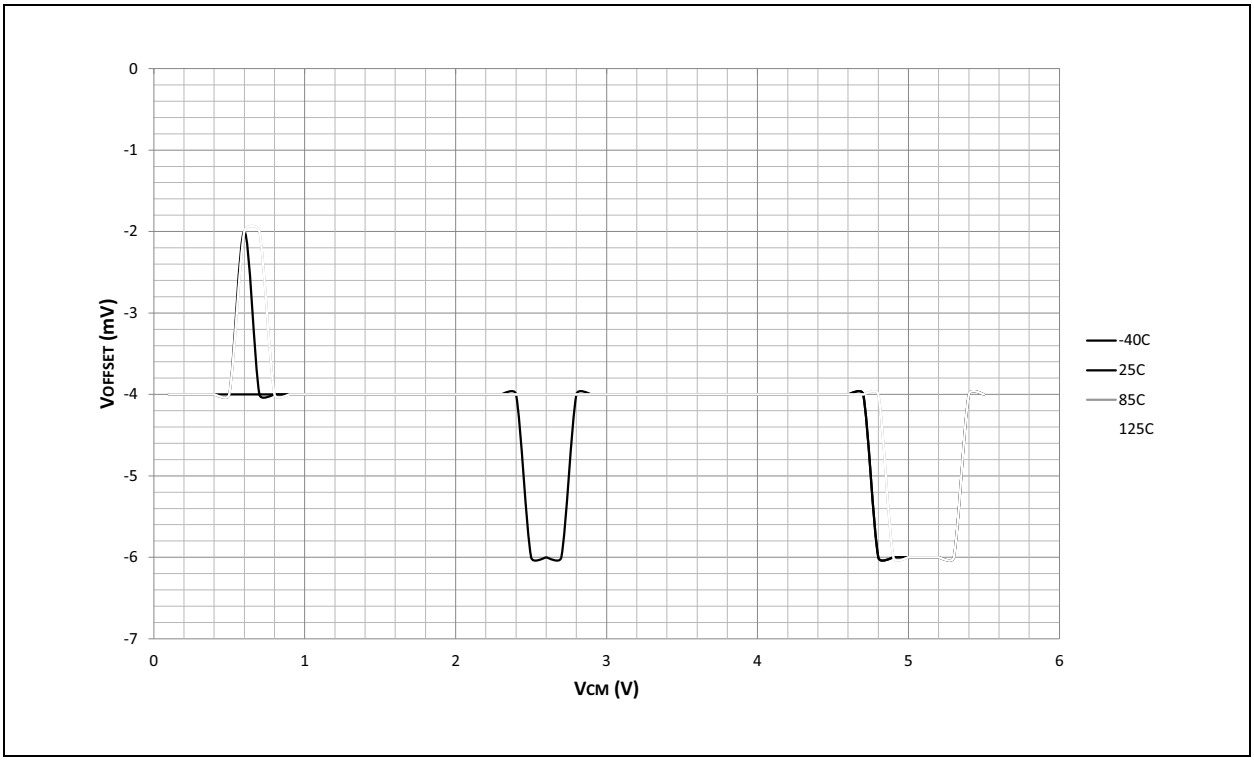


**FIGURE 33-11: TYPICAL IDOZE VS. VDD (DOZE 1:128, 70 MIPS)**

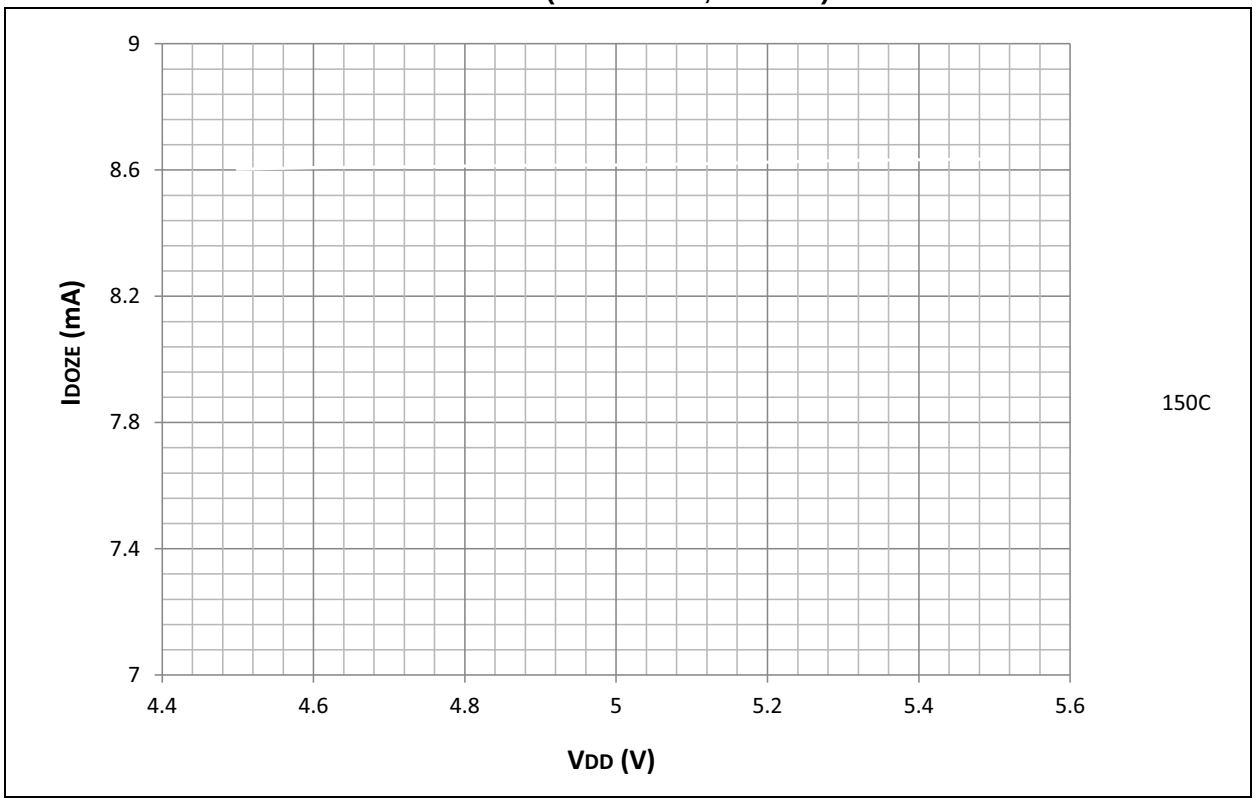
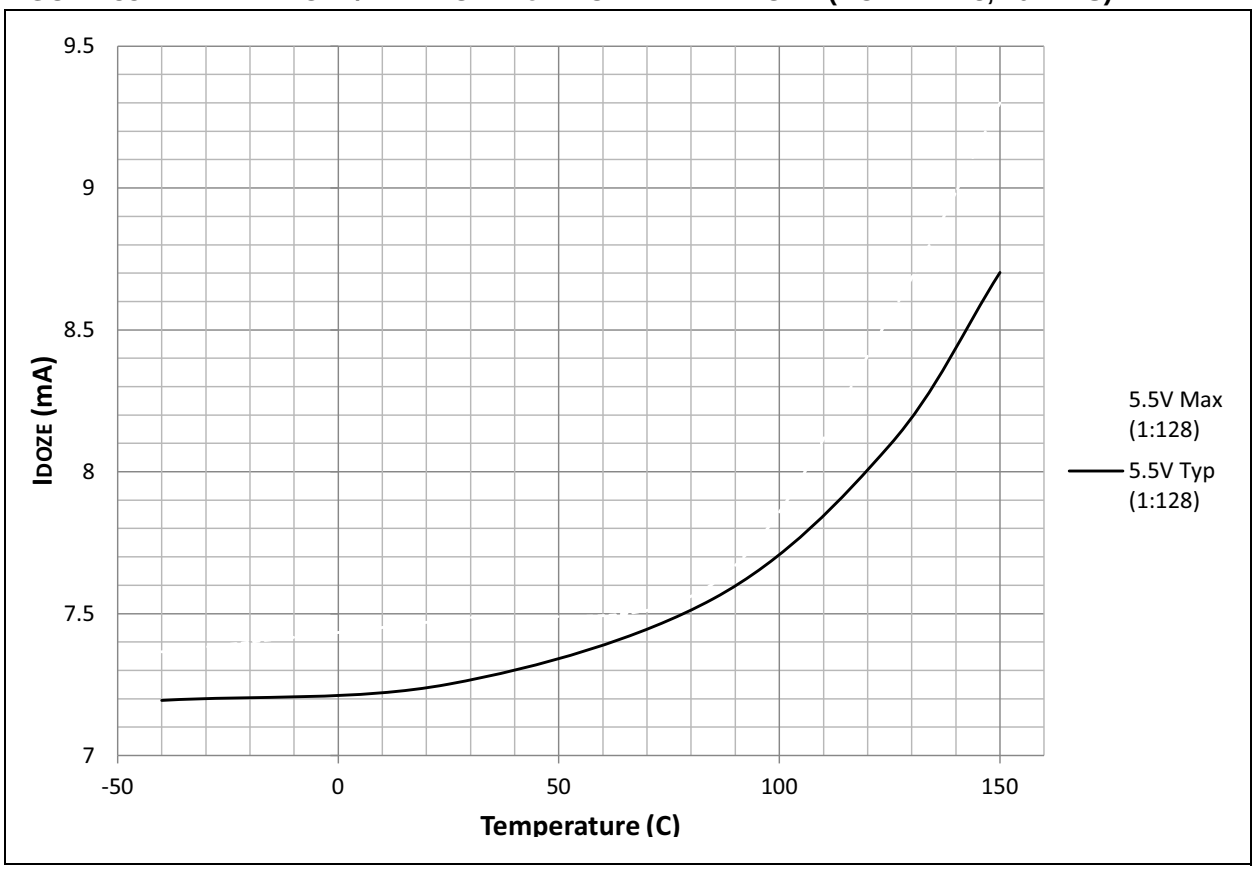



**FIGURE 33-12: TYPICAL/MAXIMUM IDOZE VS. TEMPERATURE (DOZE 1:128, 70 MIPS)**



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