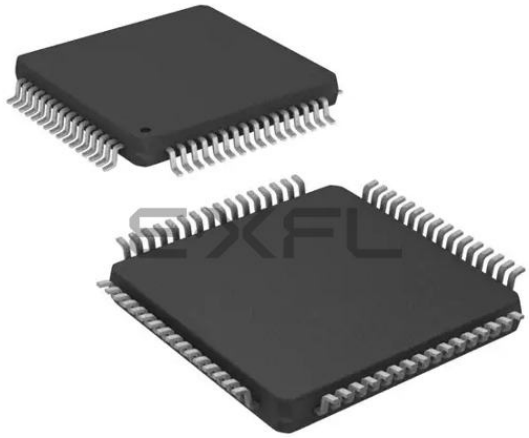
Microchip Technology - DSPIC33EP16GS506T-E/PT Datasheet



Welcome to E-XFL.COM

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	dsPIC
Core Size	16-Bit
Speed	60 MIPs
Connectivity	I²C, IrDA, LINbus, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	53
Program Memory Size	16KB (16K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	2K x 8
Voltage - Supply (Vcc/Vdd)	3V ~ 3.6V
Data Converters	A/D 22x12b; D/A 2x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 125°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/dspic33ep16gs506t-e-pt

REGISTER 7-5: INTCON3: INTERRUPT CONTROL REGISTER 3

U-0	U-0	U-0	U-0	U-0	U-0	U-0	R/W-0
—	—	—	—	—	—	—	NAE
bit 15							bit 8

U-0	U-0	U-0	R/W-0	U-0	U-0	U-0	R/W-0
—	—	—	DOOVR	—	—	—	APLL
bit 7							bit 0

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

bit 15-9 **Unimplemented:** Read as ‘0’

bit 8 **NAE:** NVM Address Error Soft Trap Status bit
1 = NVM address error soft trap has occurred
0 = NVM address error soft trap has not occurred

bit 7-5 **Unimplemented:** Read as ‘0’

bit 4 **DOOVR:** DO Stack Overflow Soft Trap Status bit
1 = DO stack overflow soft trap has occurred
0 = DO stack overflow soft trap has not occurred

bit 3-1 **Unimplemented:** Read as ‘0’

bit 0 **APLL:** Auxiliary PLL Loss of Lock Soft Trap Status bit
1 = APLL lock soft trap has occurred
0 = APLL lock soft trap has not occurred

REGISTER 7-6: INTCON4: INTERRUPT CONTROL REGISTER 4

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	U-0	U-0	R/W-0
—	—	—	—	—	—	—	SGHT
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 15-1 **Unimplemented:** Read as ‘0’

bit 0 **SGHT:** Software Generated Hard Trap Status bit
1 = Software generated hard trap has occurred
0 = Software generated hard trap has not occurred

REGISTER 10-18: RPINR42: PERIPHERAL PIN SELECT INPUT REGISTER 42

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
FLT6R7	FLT6R6	FLT6R5	FLT6R4	FLT6R3	FLT6R2	FLT6R1	FLT6R0
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
FLT5R7	FLT5R6	FLT5R5	FLT5R4	FLT5R3	FLT5R2	FLT5R1	FLT5R0
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 **FLT6R<7:0>:** Assign PWM Fault 6 (FLT6) to the Corresponding RPn Pin bits

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

bit 7-0 **FLT5R<7:0>:** Assign PWM Fault 5 (FLT5) to the Corresponding RPn Pin bits

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

11.0 TIMER1

Note 1: This data sheet summarizes the features of the dsPIC33EPXXGS50X family of devices. It is not intended to be a comprehensive reference source. To complement the information in this data sheet, refer to **"Timers"** (DS70362) 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 Timer1 module is a 16-bit timer that can operate as a free-running interval timer/counter.

The Timer1 module has the following unique features over other timers:

- Can be Operated in Asynchronous Counter mode from an External Clock Source
- The External Clock Input (T1CK) can Optionally be Synchronized to the Internal Device Clock and the Clock Synchronization is Performed after the Prescaler

A block diagram of Timer1 is shown in Figure 11-1.

The Timer1 module can operate in one of the following modes:

- Timer mode
- Gated Timer mode
- Synchronous Counter mode
- Asynchronous Counter mode

In Timer and Gated Timer modes, the input clock is derived from the internal instruction cycle clock (FCY). In Synchronous and Asynchronous Counter modes, the input clock is derived from the external clock input at the T1CK pin.

The Timer modes are determined by the following bits:

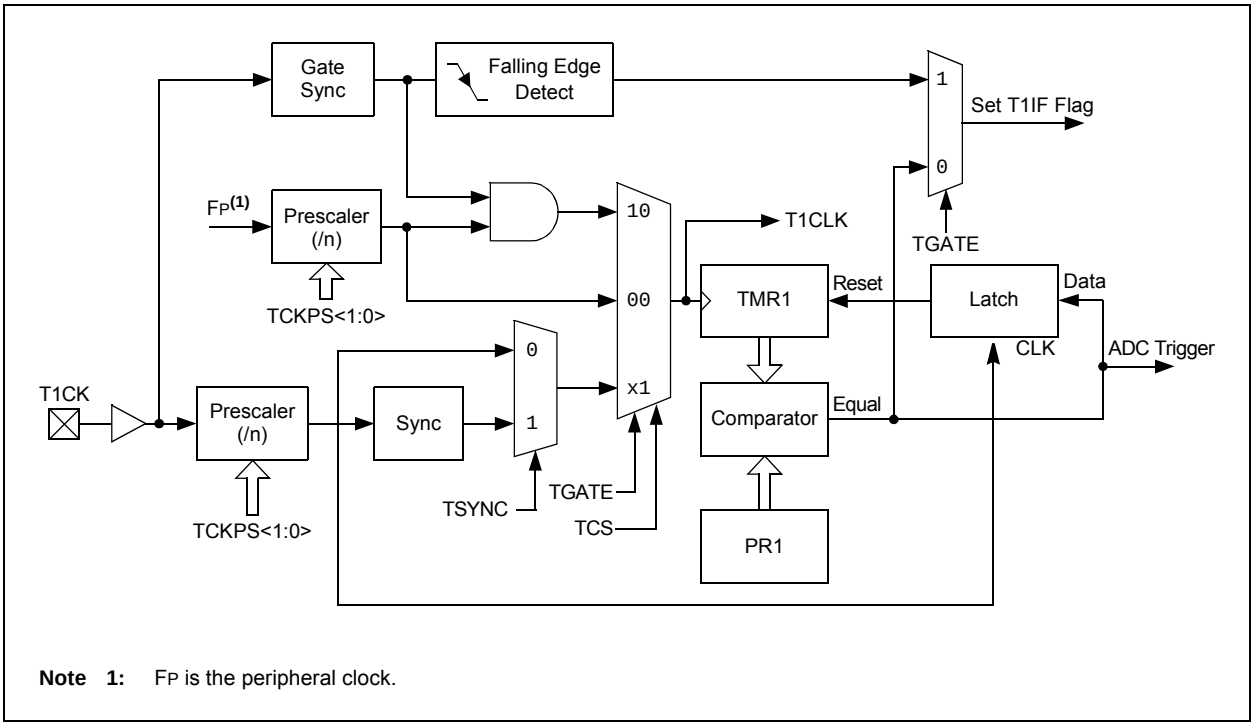
- Timer Clock Source Control bit (TCS): T1CON<1>
- Timer Synchronization Control bit (TSYNC): T1CON<2>
- Timer Gate Control bit (TGATE): T1CON<6>

Timer control bit settings for different operating modes are provided in Table 11-1.

TABLE 11-1: TIMER MODE SETTINGS

Mode	TCS	TGATE	TSYNC
Timer	0	0	x
Gated Timer	0	1	x
Synchronous Counter	1	x	1
Asynchronous Counter	1	x	0

FIGURE 11-1: 16-BIT TIMER1 MODULE BLOCK DIAGRAM



Note 1: FP is the peripheral clock.

REGISTER 15-1: PTCON: PWMx TIME BASE CONTROL REGISTER (CONTINUED)

bit 3-0 **SEVTPS<3:0>:** PWMx Special Event Trigger Output Postscaler Select bits(1)
1111 = 1:16 Postscaler generates a Special Event Trigger on every sixteenth compare match event
•
•
•
0001 = 1:2 Postscaler generates a Special Event Trigger on every second compare match event
0000 = 1:1 Postscaler generates a Special Event Trigger on every compare match event

Note 1: These bits should be changed only when PTEN = 0. In addition, when using the SYNCIx 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 15-2: PTCON2: PWMx CLOCK DIVIDER SELECT 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	U-0	U-0	U-0	R/W-0	R/W-0	R/W-0
—	—	—	—	—	PCLKDIV<2:0>(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 15-3 **Unimplemented:** Read as ‘0’

bit 2-0 **PCLKDIV<2:0>:** PWMx Input Clock Prescaler (Divider) Select bits(1)
111 = Reserved
110 = Divide-by-64, maximum PWM timing resolution
101 = Divide-by-32, maximum PWM timing resolution
100 = Divide-by-16, maximum PWM timing resolution
011 = Divide-by-8, maximum PWM timing resolution
010 = Divide-by-4, maximum PWM timing resolution
001 = Divide-by-2, maximum PWM timing resolution
000 = Divide-by-1, maximum PWM timing resolution (power-on default)

Note 1: These bits should be changed only when PTEN = 0. Changing the clock selection during operation will yield unpredictable results.

16.0 SERIAL PERIPHERAL INTERFACE (SPI)

Note 1: This data sheet summarizes the features of the dsPIC33EPXXGS50X family of devices. It is not intended to be a comprehensive reference source. To complement the information in this data sheet, refer to **"Serial Peripheral Interface (SPI)"** (DS70005185) 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 SPI module is a synchronous serial interface, useful for communicating with other peripherals or microcontroller devices. These peripheral devices can be serial EEPROMs, shift registers, display drivers, ADC Converters, etc. The SPI module is compatible with Motorola® SPI and SIOP interfaces.

The dsPIC33EPXXGS50X device family offers two SPI modules on a single device. These modules, which are designated as SPI1 and SPI2, are functionally identical.

Note: In this section, the SPI modules are referred to together as SPIx, or separately as SPI1 and SPI2. Special Function Registers follow a similar notation. For example, SPIxCON refers to the control register for the SPI1 and SPI2 modules.

The SPIx module takes advantage of the Peripheral Pin Select (PPS) feature to allow for greater flexibility in pin configuration.

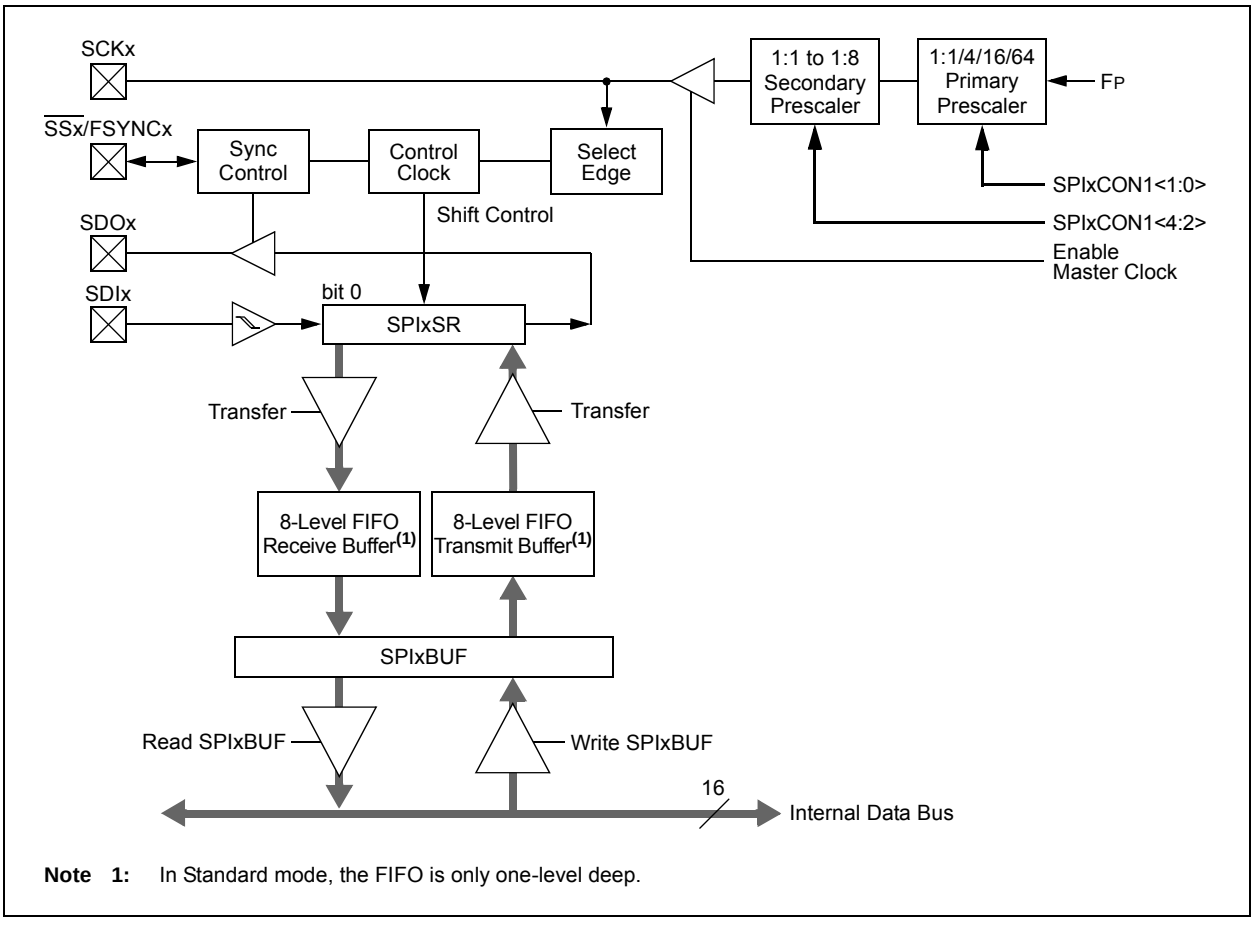
The SPIx serial interface consists of four pins, as follows:

- SDIx: Serial Data Input
- SDOx: Serial Data Output
- SCKx: Shift Clock Input or Output
- $\overline{SS}$x/FSYNCx: Active-Low Slave Select or Frame Synchronization I/O Pulse

The SPIx module can be configured to operate with two, three or four pins. In 3-Pin mode, $\overline{SS}$x is not used. In 2-Pin mode, neither SDOx nor $\overline{SS}$x is used.

Figure 16-1 illustrates the block diagram of the SPIx module in Standard and Enhanced modes.

FIGURE 16-1: SPIx MODULE BLOCK DIAGRAM



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

REGISTER 17-2: I2CxCONH: I2Cx CONTROL REGISTER HIGH

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

U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	PCIE	SCIE	BOEN	SDAHT	SBCDE	AHEN	DHEN
bit 7							bit 0

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

bit 15-7 **Unimplemented:** Read as '0'

bit 6 **PCIE:** Stop Condition Interrupt Enable bit (I^2C Slave mode only)
1 = Enables interrupt on detection of Stop condition
0 = Stop detection interrupts are disabled

bit 5 **SCIE:** Start Condition Interrupt Enable bit (I^2C Slave mode only)
1 = Enables interrupt on detection of Start or Restart conditions
0 = Start detection interrupts are disabled

bit 4 **BOEN:** Buffer Overwrite Enable bit (I^2C Slave mode only)
1 = I2CxRCV is updated and ACK is generated for a received address/data byte, ignoring the state of the I2COV only if the RBF bit = 0
0 = I2CxRCV is only updated when I2COV is clear

bit 3 **SDAHT:** SDAx Hold Time Selection bit
1 = Minimum of 300 ns hold time on SDAx after the falling edge of SCLx
0 = Minimum of 100 ns hold time on SDAx after the falling edge of SCLx

bit 2 **SBCDE:** Slave Mode Bus Collision Detect Enable bit (I^2C Slave mode only)
1 = Enables slave bus collision interrupts
0 = Slave bus collision interrupts are disabled
If the rising edge of SCLx and SDAx is sampled low when the module is in a high state, the BCL bit is set and the bus goes Idle. This Detection mode is only valid during data and ACK transmit sequences.

bit 1 **AHEN:** Address Hold Enable bit (I^2C Slave mode only)
1 = Following the 8th falling edge of SCLx for a matching received address byte, the SCLREL (I2CxCONL<12>) bit will be cleared and SCLx will be held low
0 = Address holding is disabled

bit 0 **DHEN:** Data Hold Enable bit (I^2C Slave mode only)
1 = Following the 8th falling edge of SCLx for a received data byte, the slave hardware clears the SCLREL (I2CxCONL<12>) bit and SCLx is held low
0 = Data holding is disabled

18.1 UART Helpful Tips

1. In multi-node, direct connect UART networks, UART receive inputs react to the complementary logic level defined by the URXINV bit (UxMODE<4>), which defines the Idle state, the default of which is logic high (i.e., URXINV = 0). Because remote devices do not initialize at the same time, it is likely that one of the devices, because the RX line is floating, will trigger a Start bit detection and will cause the first byte received, after the device has been initialized, to be invalid. To avoid this situation, the user should use a pull-up or pull-down resistor on the RX pin depending on the value of the URXINV bit.
   a) If URXINV = 0, use a pull-up resistor on the UxRX pin.
   b) If URXINV = 1, use a pull-down resistor on the UxRX pin.
2. The first character received on a wake-up from Sleep mode, caused by activity on the UxRX pin of the UARTx module, will be invalid. In Sleep mode, peripheral clocks are disabled. By the time the oscillator system has restarted and stabilized from Sleep mode, the baud rate bit sampling clock, relative to the incoming UxRX bit timing, is no longer synchronized, resulting in the first character being invalid; this is to be expected.

18.2 UART Resources

Many useful resources are provided on the main product page of the Microchip web site for the devices listed in this data sheet. This product page contains the latest updates and additional information.

18.2.1 KEY RESOURCES

- Code Samples
- Application Notes
- Software Libraries
- Webinars
- All Related *"dsPIC33/PIC24 Family Reference Manual"* Sections
- Development Tools

18.3 UART Control Registers

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

R/W-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	URXINV	BRGH	PDSEL1	PDSEL0	STSEL
bit 7							bit 0

Legend:	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)
- 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(2)
- 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 Pin Enable bits
- 11 = UxTX, UxRX and BCLKx 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 $\overline{\text{UxRTS}}$/BCLKx pins are controlled by PORT latches

bit 7 **WAKE:** Wake-up on Start Bit Detect During Sleep Mode Enable bit
- 1 = UARTx continues 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

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

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

REGISTER 19-15: ADEIEL: ADC EARLY INTERRUPT ENABLE REGISTER LOW

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
EIEN<15:8>							
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
EIEN<7:0>							
bit 7							bit 0

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

bit 15-0 **EIEN<15:0>:** Early Interrupt Enable for Corresponding Analog Inputs bits
1 = Early interrupt is enabled for the channel
0 = Early interrupt is disabled for the channel

REGISTER 19-16: ADEIEH: ADC EARLY INTERRUPT ENABLE REGISTER HIGH

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	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	—	EIEN<21:16>					
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 5-0 **EIEN<21:16>:** Early Interrupt Enable for Corresponding Analog Inputs bits
1 = Early interrupt is enabled for the channel
0 = Early interrupt is disabled for the channel

REGISTER 19-19: ADMOD0L: ADC INPUT MODE CONTROL REGISTER 0 LOW

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
DIFF7	SIGN7	DIFF6	SIGN6	DIFF5	SIGN5	DIFF4	SIGN4
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
DIFF3	SIGN3	DIFF2	SIGN2	DIFF1	SIGN1	DIFF0	SIGN0
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 15-1(odd) **DIFF<7:0>:** Differential-Mode for Corresponding Analog Inputs bits
1 = Channel is differential
0 = Channel is single-ended

bit 14-0 (even) **SIGN<7:0>:** Output Data Sign for Corresponding Analog Inputs bits
1 = Channel output data is signed
0 = Channel output data is unsigned

REGISTER 19-20: ADMOD0H: ADC INPUT MODE CONTROL REGISTER 0 HIGH

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
DIFF15	SIGN15	DIFF14	SIGN14	DIFF13	SIGN13	DIFF12	SIGN12
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
DIFF11	SIGN11	DIFF10	SIGN10	DIFF9	SIGN9	DIFF8	SIGN8
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 15-1(odd) **DIFF<15:8>:** Differential-Mode for Corresponding Analog Inputs bits
1 = Channel is differential
0 = Channel is single-ended

bit 14-0 (even) **SIGN<15:8>:** Output Data Sign for Corresponding Analog Inputs bits
1 = Channel output data is signed
0 = Channel output data is unsigned

21.0 PROGRAMMABLE GAIN AMPLIFIER (PGA)

Note 1: This data sheet summarizes the features of the dsPIC33EPXXGS50X family of devices. It is not intended to be a comprehensive reference source. To complement the information in this data sheet, refer to **"Programmable Gain Amplifier (PGA)"** (DS70005146) in the *"dsPIC33/PIC24 Family Reference Manual"*, which is available from the Microchip web site (www.microchip.com).

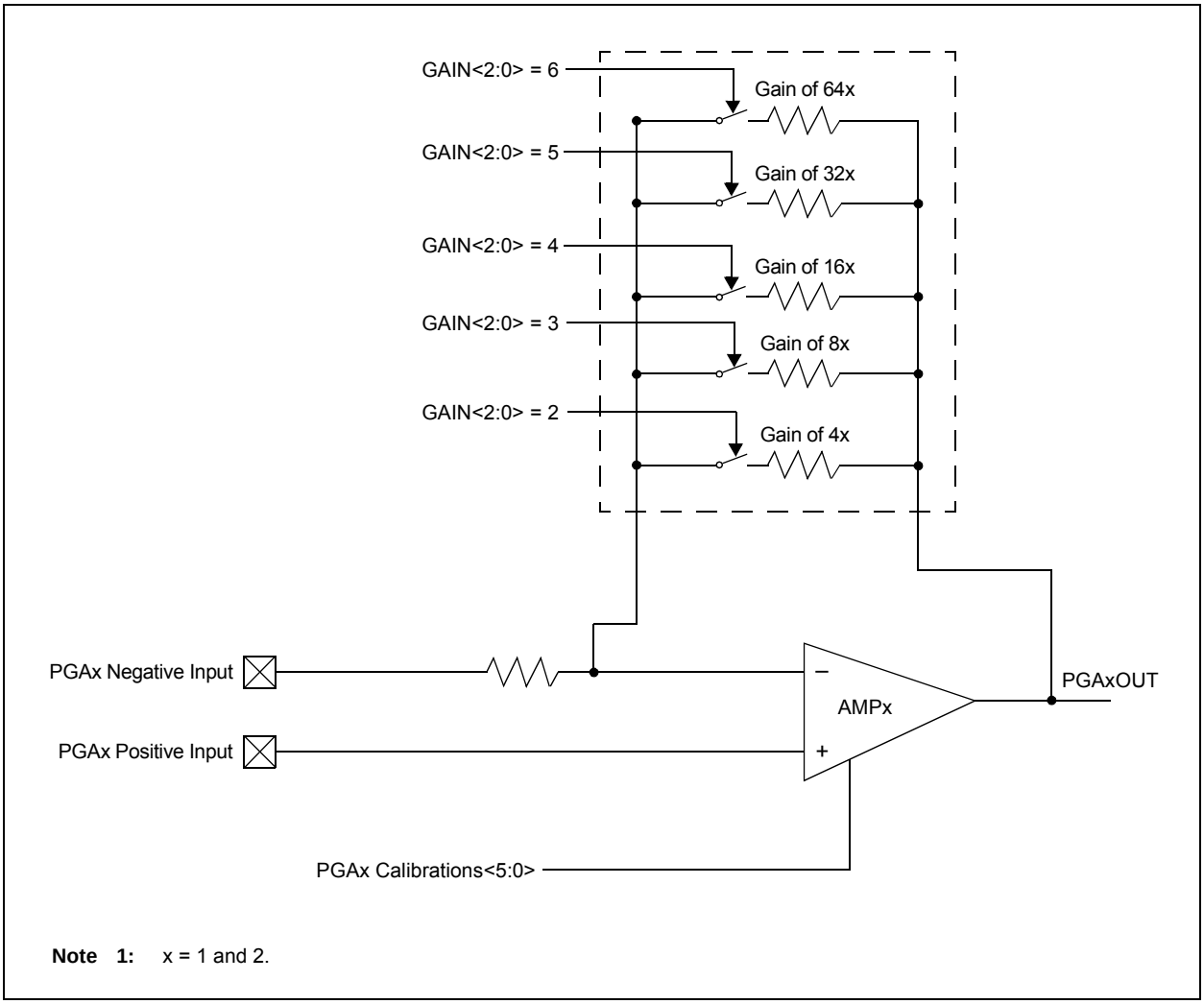
2: Some registers and associated bits described in this section may not be available on all devices. Refer to **Section 4.0 "Memory Organization"** in this data sheet for device-specific register and bit information.

The dsPIC33EPXXGS50X family devices have two Programmable Gain Amplifiers (PGA1, PGA2). The PGA is an op amp-based, non-inverting amplifier with user-programmable gains. The output of the PGA can be connected to a number of dedicated Sample-and-Hold inputs of the Analog-to-Digital Converter and/or to the high-speed analog comparator module. The PGA has five selectable gains and may be used as a ground referenced amplifier (single-ended) or used with an independent ground reference point.

Key features of the PGA module include:

- Single-Ended or Independent Ground Reference
- Selectable Gains: 4x, 8x, 16x, 32x and 64x
- High Gain Bandwidth
- Rail-to-Rail Output Voltage
- Wide Input Voltage Range

FIGURE 21-1: PGAx MODULE BLOCK DIAGRAM



Note 1: x = 1 and 2.

21.1 Module Description

The Programmable Gain Amplifiers are used to amplify small voltages (i.e., voltages across burden/shunt resistors) to improve the signal-to-noise ratio of the measured signal. The PGAx output voltage can be read by any of the four dedicated Sample-and-Hold circuits on the ADC module. The output voltage can also be fed to the comparator module for overcurrent/ voltage protection. Figure 21-2 shows a functional block diagram of the PGAx module. Refer to **Section 19.0 "High-Speed, 12-Bit Analog-to-Digital Converter (ADC)"** and **Section 20.0 "High-Speed Analog Comparator"** for more interconnection details.

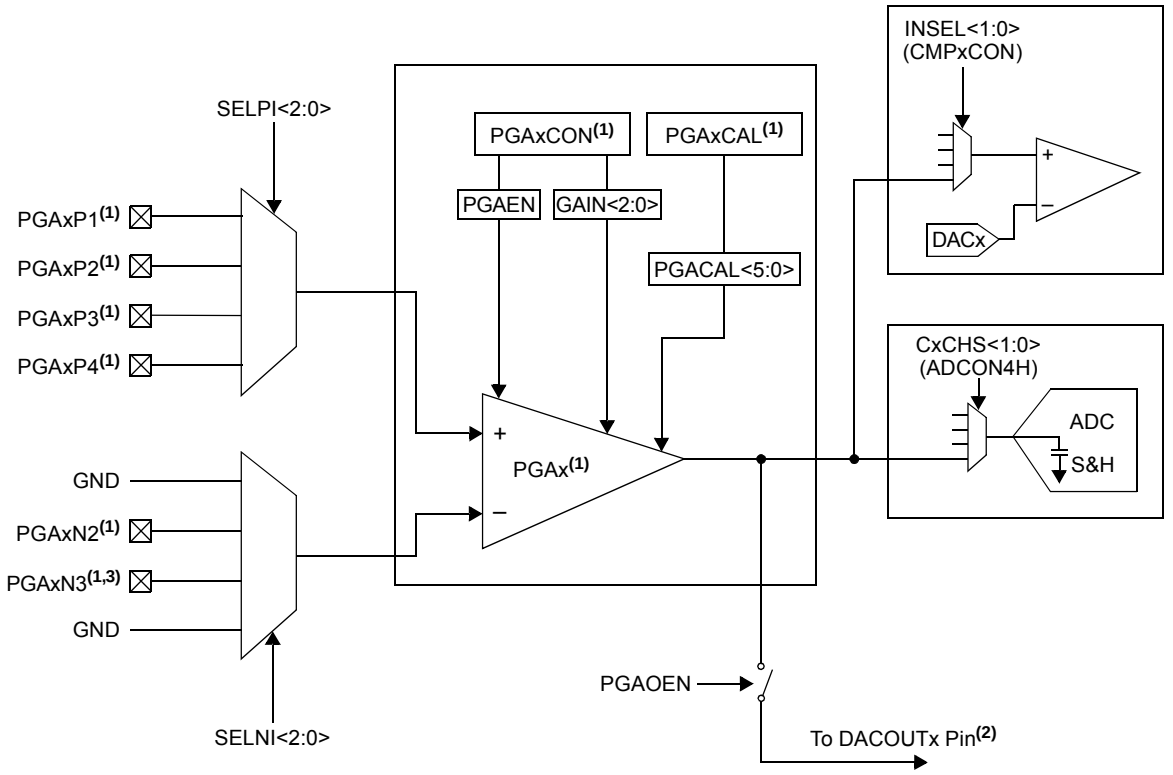
The gain of the PGAx module is selectable via the GAIN<2:0> bits in the PGAxCON register. There are five selectable gains, ranging from 4x to 64x. The SELPI<2:0> and SELNI<2:0> bits in the PGAxCON register select one of four positive/negative inputs to the PGAx module. For single-ended applications, the SELNI<2:0> bits will select the ground as the negative input source. To provide an independent ground reference, PGAxN2 and PGAxN3 pins are available as the negative input source to the PGAx module.

Note 1:	Not all PGA positive/negative inputs are available on all devices. Refer to the specific device pinout for available input source pins.

The output voltage of the PGAx module can be connected to the DACOUTx pin by setting the PGAOEN bit in the PGAxCON register. When the PGAOEN bit is enabled, the output voltage of PGA1 is connected to DACOUT1 and PGA2 is connected to DACOUT2. For devices with a single DACOUTx pin, the output voltage of PGA2 can be connected to DACOUT1 by configuring the DBCC Configuration bit in the FDEVOPT register (FDEVOPT<6>).

If both the DACx output voltage and PGAx output voltage are connected to the DACOUTx pin, the resulting output voltage would be a combination of signals. There is no assigned priority between the PGAx module and the DACx module.

FIGURE 21-2: PGAx FUNCTIONAL BLOCK DIAGRAM



Note 1: x = 1 and 2.
2: The DACOUT2 device pin is only available on 64-pin devices.
3: The PGAxN3 input is not available on 28-pin devices.

23.3 User OTP Memory

dsPIC33EPXXGS50X family devices contain 64 words of User One-Time-Programmable (OTP) memory, located at addresses, 0x800F80 through 0x800FFE. The User OTP Words can be used for storing checksum, code revisions, product information, such as serial numbers, system manufacturing dates, manufacturing lot numbers and other application-specific information. These words can only be written once at program time and not at run time; they can be read at run time.

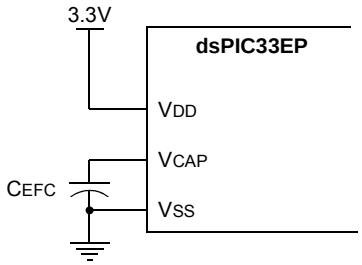
23.4 On-Chip Voltage Regulator

All the dsPIC33EPXXGS50X family devices power their core digital logic at a nominal 1.8V. This can create a conflict for designs that are required to operate at a higher typical voltage, such as 3.3V. To simplify system design, all devices in the dsPIC33EPXXGS50X family incorporate an on-chip regulator that allows the device to run its core logic from VDD.

The regulator provides power to the core from the other VDD pins. A low-ESR (less than 1 Ohm) capacitor (such as tantalum or ceramic) must be connected to the VCAP pin (Figure 23-1). This helps to maintain the stability of the regulator. The recommended value for the filter capacitor is provided in Table 26-5, located in **Section 26.0 "Electrical Characteristics"**.

Note:	It is important for the low-ESR capacitor to be placed as close as possible to the VCAP pin.

FIGURE 23-1: CONNECTIONS FOR THE ON-CHIP VOLTAGE REGULATOR(1,2,3)



Note 1: These are typical operating voltages. Refer to Table 26-5 located in **Section 26.0 "Electrical Characteristics"** for the full operating ranges of VDD and VCAP.

2: It is important for the low-ESR capacitor to be placed as close as possible to the VCAP pin.

3: Typical VCAP pin voltage = 1.8V when VDD ≥ VDDMIN.

23.5 Brown-out Reset (BOR)

The Brown-out Reset (BOR) module is based on an internal voltage reference circuit that monitors the regulated supply voltage, VCAP. The main purpose of the BOR module is to generate a device Reset when a brown-out condition occurs. Brown-out conditions are generally caused by glitches on the AC mains (for example, missing portions of the AC cycle waveform due to bad power transmission lines or voltage sags due to excessive current draw when a large inductive load is turned on).

A BOR generates a Reset pulse which resets the device. The BOR selects the clock source based on the device Configuration bit values (FNOSC<2:0> and POSCMD<1:0>).

If an Oscillator mode is selected, the BOR activates the Oscillator Start-up Timer (OST). The system clock is held until OST expires. If the PLL is used, the clock is held until the LOCK bit (OSCCON<5>) is '1'.

Concurrently, the PWRT Time-out (TPWRT) is applied before the internal Reset is released. If TPWRT = 0 and a crystal oscillator is being used, then a nominal delay of TFSCM is applied. The total delay in this case is TFSCM. Refer to Parameter SY35 in Table 26-23 of **Section 26.0 "Electrical Characteristics"** for specific TFSCM values.

The BOR status bit (RCON<1>) is set to indicate that a BOR has occurred. The BOR circuit continues to operate while in Sleep or Idle modes and resets the device should VDD fall below the BOR threshold voltage.

TABLE 26-11: DC CHARACTERISTICS: I/O PIN INPUT SPECIFICATIONS (CONTINUED)

DC CHARACTERISTICS			Standard Operating Conditions: 3.0V to 3.6V (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended				
Param No.	**Symbol**	**Characteristic**	**Min.**	**Typ.(1)**	**Max.**	**Units**	**Conditions**
DI60a	IICL	**Input Low Injection Current**	0	—	-5(5,8)	mA	All pins except VDD, VSS, AVDD, AVSS, MCLR, VCAP and RB7
DI60b	IICH	**Input High Injection Current**	0	—	+5(6,7,8)	mA	All pins except VDD, VSS, AVDD, AVSS, MCLR, VCAP, RB7 and all 5V tolerant pins(7)
DI60c	∑IICT	**Total Input Injection Current (sum of all I/O and control pins)**	-20(9)	—	+20(9)	mA	Absolute instantaneous sum of all ± input injection currents from all I/O pins (| IICL | + | IICH |) ≤ ∑IICT

Note 1: Data in "Typ." column is at 3.3V, +25°C unless otherwise stated.

2: The leakage current on the MCLR pin is strongly dependent on the applied voltage level. The specified levels represent normal operating conditions. Higher leakage current can be measured at different input voltages.

3: Negative current is defined as current sourced by the pin.

4: See the **"Pin Diagrams"** section for the 5V tolerant I/O pins.

5: VIL Source < (VSS – 0.3). Characterized but not tested.

6: VIH Source > (VDD + 0.3) for pins that are not 5V tolerant only.

7: Digital 5V tolerant pins do not have internal high-side diodes to VDD and cannot tolerate any "positive" input injection current.

8: Injection Currents > | 0 | can affect the ADC results by approximately 4-6 counts.

9: Any number and/or combination of I/O pins not excluded under IICL or IICH conditions are permitted provided the mathematical "absolute instantaneous" sum of the input injection currents from all pins do not exceed the specified limit. Characterized but not tested.

TABLE 26-35: SPIx SLAVE MODE (FULL-DUPLEX, CKE = 1, CKP = 0, SMP = 0) TIMING REQUIREMENTS

AC CHARACTERISTICS			Standard Operating Conditions: 3.0V to 3.6V (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended				
Param No.	**Symbol**	**Characteristic(1)**	**Min.**	**Typ.(2)**	**Max.**	**Units**	**Conditions**
SP70	FscP	Maximum SCKx Input Frequency	—	—	Lesser of: FP or 15	MHz	**(Note 3)**
SP72	TscF	SCKx Input Fall Time	—	—	—	ns	See Parameter DO32 **(Note 4)**
SP73	TscR	SCKx Input Rise Time	—	—	—	ns	See Parameter DO31 **(Note 4)**
SP30	TdoF	SDOx Data Output Fall Time	—	—	—	ns	See Parameter DO32 **(Note 4)**
SP31	TdoR	SDOx Data Output Rise Time	—	—	—	ns	See Parameter DO31 **(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	**(Note 4)**
SP52	TscH2ssH, TscL2ssH	$\overline{SSx}$ ↑ after SCKx Edge	1.5 TCY + 40	—	—	ns	**(Note 4)**
SP60	TssL2doV	SDOx Data Output Valid After $\overline{SSx}$ Edge	—	—	50	ns	

Note 1: These parameters are characterized but 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 26-17: SPIx SLAVE MODE (FULL-DUPLEX, CKE = 0, CKP = 1, SMP = 0) TIMING CHARACTERISTICS

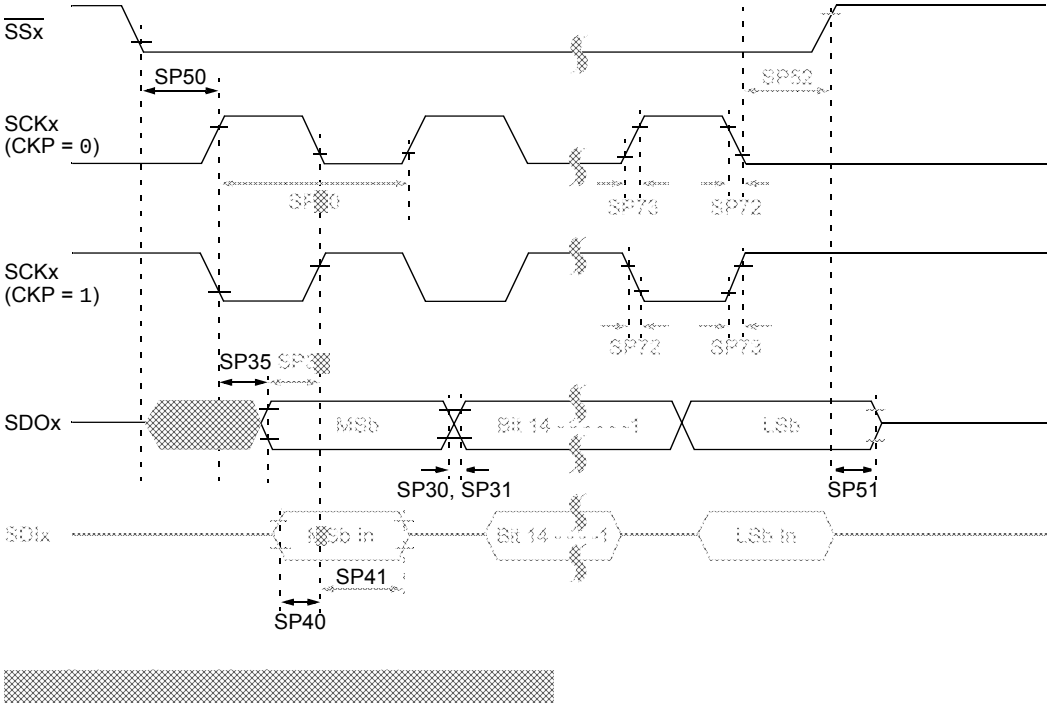


TABLE 26-43: ADC MODULE SPECIFICATIONS (CONTINUED)

AC CHARACTERISTICS			Standard Operating Conditions: 3.0V to 3.6V (unless otherwise stated)[5] Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended				
Param No.	**Symbol**	**Characteristics**	**Min.**	**Typical**	**Max.**	**Units**	**Conditions**
ADC Accuracy: Single-Ended Input							
AD20b	Nr	Resolution	12			bits	
AD21b	INL	Integral Nonlinearity	> -3	—	< 3	LSb	AVSS = 0V, AVDD = 3.3V
AD22b	DNL	Differential Nonlinearity	> -1	—	< 1.5	LSb	AVSS = 0V, AVDD = 3.3V **(Note 2)**
AD23b	GERR	Gain Error (Dedicated Core)	> 5	13	< 20	LSb	AVSS = 0V, AVDD = 3.3V
		Gain Error (Shared Core)	> -1	5	< 10	LSb	
AD24b	EOFF	Offset Error (Dedicated Core)	> 2	10	< 18	LSb	AVSS = 0V, AVDD = 3.3V
		Offset Error (Shared Core)	> 2	8	< 15	LSb	
AD25b	—	Monotonicity	—	—	—	—	Guaranteed
Dynamic Performance							
AD31b	SINAD	Signal-to-Noise and Distortion	63	—	> 65	dB	**(Notes 3, 4)**
AD34b	ENOB	Effective Number of Bits	10.3	—	—	bits	**(Notes 3, 4)**

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

2: No missing codes, limits based on characterization results.

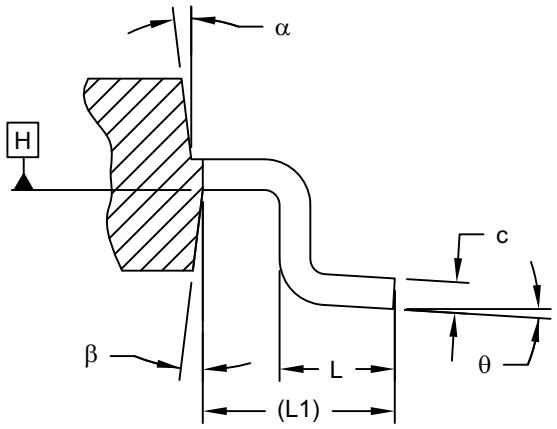
3: These parameters are characterized but not tested in manufacturing.

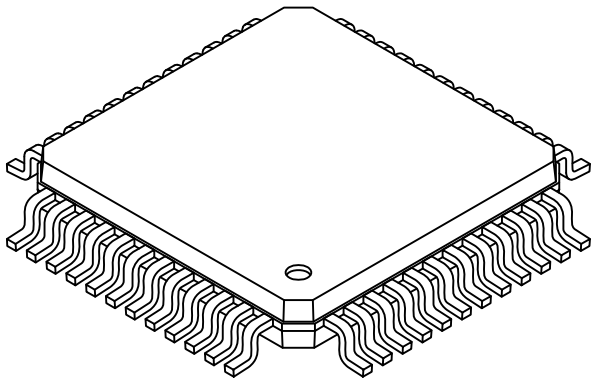
4: Characterized with a 1 kHz sine wave.

5: The ADC module is functional at VBORMIN < VDD < VDDMIN, but with degraded performance. Unless otherwise stated, module functionality is ensured, but not characterized.

48-Lead Thin Quad Flatpack (Y8) - 7x7x1.0 mm Body [TQFP]

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





SECTION A-A

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Leads	N		48	
Lead Pitch	e		0.50 BSC	
Overall Height	A	-	-	1.20
Standoff	A1	0.05	-	0.15
Molded Package Thickness	A2	0.95	1.00	1.05
Foot Length	L	0.45	0.60	0.75
Footprint	L1		1.00 REF	
Foot Angle	ϕ	0°	3.5°	7°
Overall Width	E		9.00 BSC	
Overall Length	D		9.00 BSC	
Molded Package Width	E1		7.00 BSC	
Molded Package Length	D1		7.00 BSC	
Lead Thickness	c	0.09	-	0.16
Lead Width	b	0.17	0.22	0.27
Mold Draft Angle Top	α	11°	12°	13°
Mold Draft Angle Bottom	β	11°	12°	13°

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Chamfers at corners are optional; size may vary.
3. Dimensions D1 and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.25mm per side.
4. Dimensioning and tolerancing per ASME Y14.5M

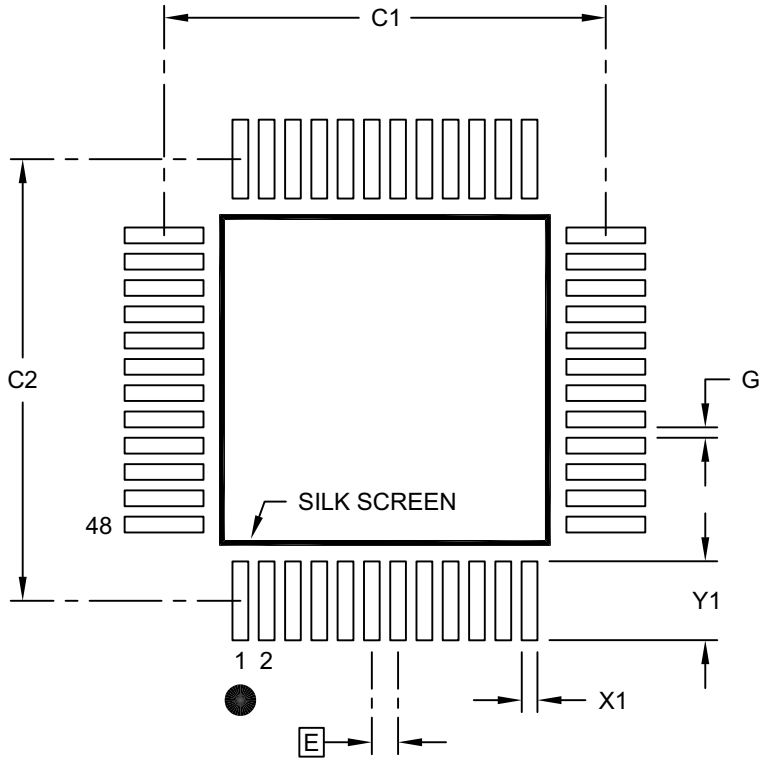
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

   REF: Reference Dimension, usually without tolerance, for information purposes only.
5. Datums A-B and D to be determined at center line between leads where leads exit plastic body at datum plane H

Microchip Technology Drawing C04-300-Y8 Rev A Sheet 2 of 2

48-Lead Thin Quad Flatpack (Y8) - 7x7x1.0 mm Body [TQFP]

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



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E		0.50 BSC	
Contact Pad Spacing	C1		8.40	
Contact Pad Spacing	C2		8.40	
Contact Pad Width (X48)	X1			0.30
Contact Pad Length (X48)	Y1			1.50
Distance Between Pads	G	0.20		

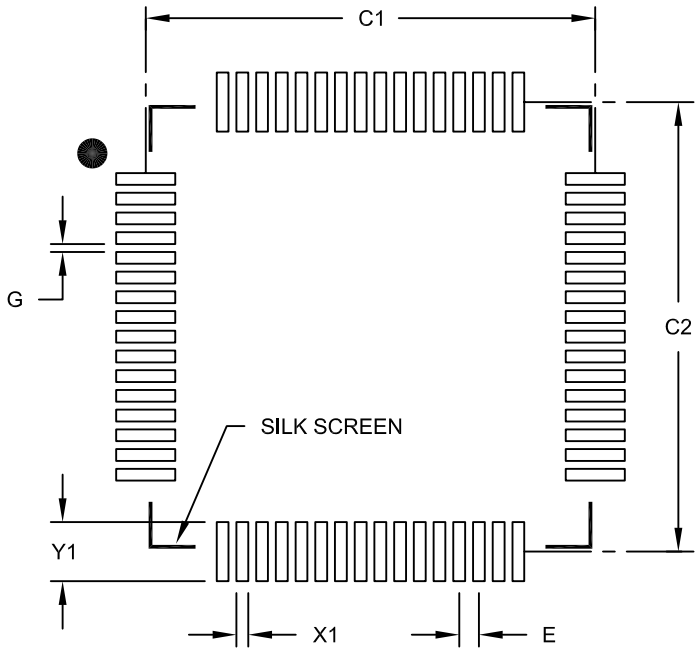
Notes:

1. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
2. For best soldering results, thermal vias, if used, should be filled or tented to avoid solder loss during reflow process

Microchip Technology Drawing C04-2300-Y8 Rev A

64-Lead Plastic Thin Quad Flatpack (PT) 10x10x1 mm Body, 2.00 mm Footprint [TQFP]

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



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E		0.50 BSC	
Contact Pad Spacing	C1		11.40	
Contact Pad Spacing	C2		11.40	
Contact Pad Width (X64)	X1			0.30
Contact Pad Length (X64)	Y1			1.50
Distance Between Pads	G	0.20		

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing No. C04-2085B