



Welcome to [E-XFL.COM](https://www.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	PIC
Core Size	8-Bit
Speed	40MHz
Connectivity	I <sup>2</sup> C, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, HLVD, POR, PWM, WDT
Number of I/O	36
Program Memory Size	32KB (16K x 16)
Program Memory Type	FLASH
EEPROM Size	256 x 8
RAM Size	1.5K x 8
Voltage - Supply (Vcc/Vdd)	2V ~ 5.5V
Data Converters	A/D 13x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	44-VQFN Exposed Pad
Supplier Device Package	44-QFN (8x8)
Purchase URL	<a href="https://www.e-xfl.com/product-detail/microchip-technology/pic18lf4523-i-ml">https://www.e-xfl.com/product-detail/microchip-technology/pic18lf4523-i-ml</a>

---

**Note the following details of the code protection feature on Microchip devices:**

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

---

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights.

#### **Trademarks**

The Microchip name and logo, the Microchip logo, dsPIC, KEELOQ, KEELOQ logo, MPLAB, PIC, PICmicro, PICSTART, rfPIC and UNI/O are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

FilterLab, Hampshire, HI-TECH C, Linear Active Thermistor, MXDEV, MXLAB, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Analog-for-the-Digital Age, Application Maestro, CodeGuard, dsPICDEM, dsPICDEM.net, dsPICworks, dsSPEAK, ECAN, ECONOMONITOR, FanSense, HI-TIDE, In-Circuit Serial Programming, ICSP, Mindi, MiWi, MPASM, MPLAB Certified logo, MPLIB, MPLINK, mTouch, Octopus, Omniclient Code Generation, PICC, PICC-18, PICDEM, PICDEM.net, PICKit, PICtail, PIC<sup>32</sup> logo, REAL ICE, rLAB, Select Mode, Total Endurance, TSHARC, UniWinDriver, WiperLock and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

All other trademarks mentioned herein are property of their respective companies.

© 2009, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

 Printed on recycled paper.

**QUALITY MANAGEMENT SYSTEM**  
**CERTIFIED BY DNV**  
**== ISO/TS 16949:2002 ==**

*Microchip received ISO/TS-16949:2002 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.*

**MICROCHIP****PIC18F2423/2523/4423/4523**

## 28/40/44-Pin, Enhanced Flash Microcontrollers with 12-Bit A/D and nanoWatt Technology

**Power Management Features:**

- Run: CPU on, Peripherals on
- Idle: CPU off, Peripherals on
- Sleep: CPU off, Peripherals off
- Ultra Low 50 nA Input Leakage
- Run mode Currents Down to 11  $\mu$ A Typical
- Idle mode Currents Down to 2.5  $\mu$ A Typical
- Sleep mode Current Down to 100  $\mu$ A Typical
- Timer1 Oscillator: 900 nA, 32 kHz, 2V
- Watchdog Timer: 1.4  $\mu$ A, 2V Typical
- Two-Speed Oscillator Start-up

**Flexible Oscillator Structure:**

- Four Crystal modes, up to 40 MHz
- 4x Phase Lock Loop (PLL) – Available for Crystal and Internal Oscillators
- Two External RC modes, up to 4 MHz
- Two External Clock modes, up to 40 MHz
- Internal Oscillator Block:
  - Fast wake from Sleep and Idle, 1  $\mu$ s typical
  - 8 user-selectable frequencies, from 31 kHz to 8 MHz
  - Provides a complete range of clock speeds, from 31 kHz to 32 MHz, when used with PLL
  - User-tunable to Compensate for Frequency Drift
- Secondary Oscillator using Timer1 @ 32 kHz
- Fail-Safe Clock Monitor:
  - Allows for safe shutdown if peripheral clock stops

**Peripheral Highlights:**

- 12-Bit, Up to 13-Channel Analog-to-Digital Converter module (A/D):
  - Auto-acquisition capability
  - Conversion available during Sleep mode
- Dual Analog Comparators with Input Multiplexing
- High-Current Sink/Source 25 mA/25 mA
- Three Programmable External Interrupts
- Four Input Change Interrupts
- Up to Two Capture/Compare/PWM (CCP) modules, One with Auto-Shutdown (28-pin devices)
- Enhanced Capture/Compare/PWM (ECCP) module (40/44-pin devices only):
  - One, two or four PWM outputs
  - Selectable polarity
  - Programmable dead time
  - Auto-shutdown and auto-restart

**Peripheral Highlights (Continued):**

- Master Synchronous Serial Port (MSSP) module Supporting 3-Wire SPI (all four modes) and I<sup>2</sup>C™ Master and Slave modes
- Enhanced USART module:
  - Support for RS-485, RS-232 and LIN/J2602
  - RS-232 operation using internal oscillator block (no external crystal required)
  - Auto-wake-up on Start bit
  - Auto-Baud Detect (ABD)

**Special Microcontroller Features:**

- C Compiler Optimized Architecture: Optional Extended Instruction Set Designed to Optimize Re-Entrant Code
- 100,000 Erase/Write Cycle, Enhanced Flash Program Memory Typical
- 1,000,000 Erase/Write Cycle, Data EEPROM Memory Typical
- Flash/Data EEPROM Retention: 100 Years Typical
- Self-Programmable under Software Control
- Priority Levels for Interrupts
- 8 x 8 Single-Cycle Hardware Multiplier
- Extended Watchdog Timer (WDT): Programmable Period, from 4 ms to 131s
- Single-Supply In-Circuit Serial Programming™ (ICSP™) via Two Pins
- In-Circuit Debug (ICD) via Two Pins
- Operating Voltage Range: 2.0V to 5.5V
- Programmable, 16-Level High/Low-Voltage Detection (HLVD) module: Supports Interrupt on High/Low-Voltage Detection
- Programmable Brown-out Reset (BOR): With Software-Enable Option

**Note:** This document is supplemented by the "PIC18F2420/2520/4420/4520 Data Sheet" (DS39631). See **Section 1.0 "Device Overview"**.

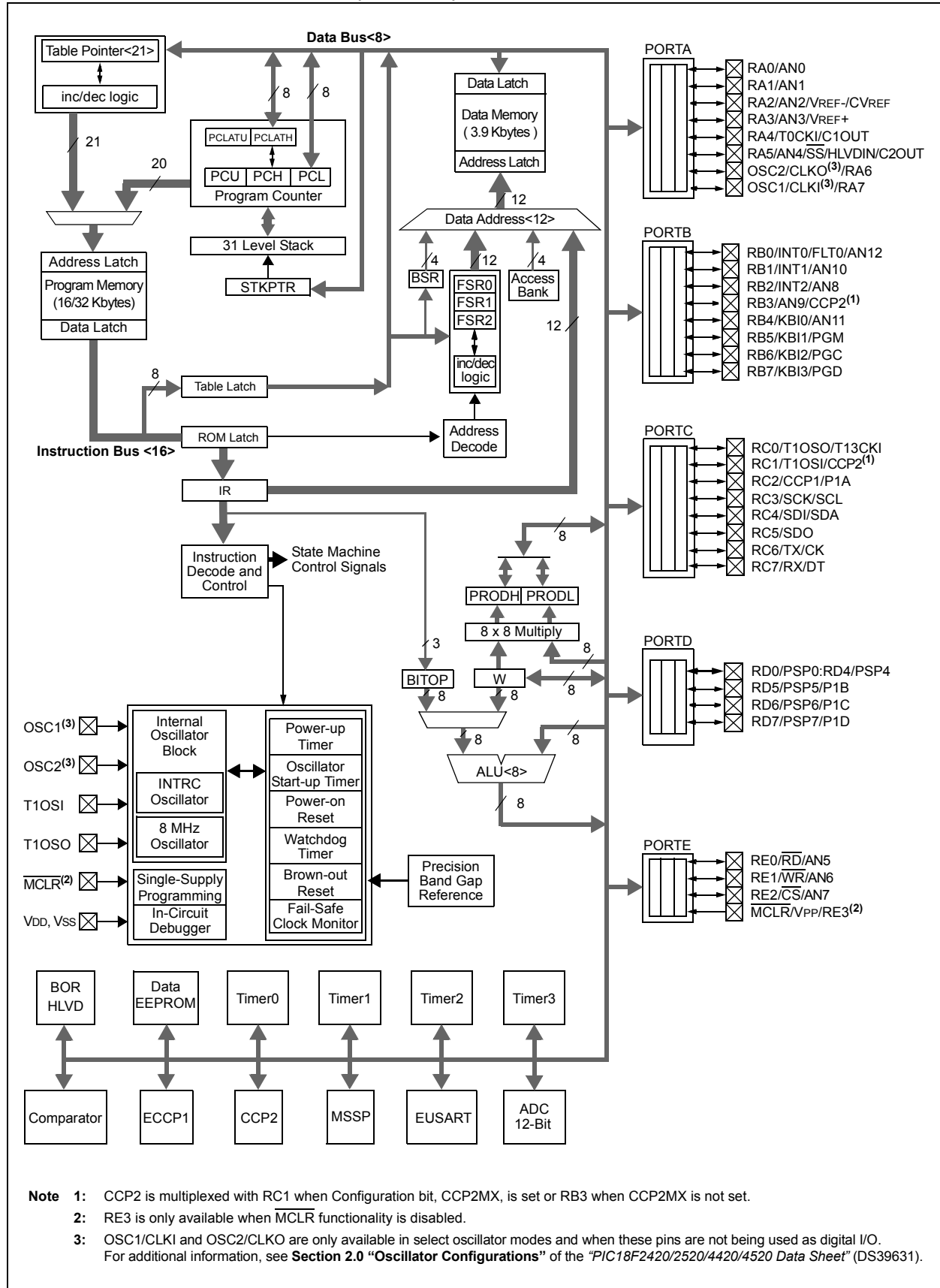
Device	Program Memory		Data Memory		I/O	12-Bit A/D (ch)	CCP/ ECCP (PWM)	MSSP		EUSART	Comp.	Timers 8/16-Bit
	Flash (bytes)	# Single-Word Instructions	SRAM (bytes)	EEPROM (bytes)				SPI	Master I <sup>2</sup> C™			
PIC18F2423	16K	8192	768	256	25	10	2/0	Y	Y	1	2	1/3
PIC18F2523	32K	16384	1536	256	25	10	2/0	Y	Y	1	2	1/3
PIC18F4423	16K	8192	768	256	36	13	1/1	Y	Y	1	2	1/3
PIC18F4523	32K	16384	1536	256	36	13	1/1	Y	Y	1	2	1/3

## Table of Contents

1.0	Device Overview .....	9
2.0	12-Bit Analog-to-Digital Converter (A/D) Module .....	25
3.0	Special Features of the CPU .....	35
4.0	Electrical Characteristics .....	37
5.0	Packaging Information.....	43
	Appendix A: Revision History.....	45
	Appendix B: Device Differences .....	45
	Appendix C: Conversion Considerations .....	46
	Appendix D: Migration from Baseline to Enhanced Devices.....	46
	Appendix E: Migration from Mid-Range to Enhanced Devices .....	47
	Appendix F: Migration from High-End to Enhanced Devices.....	47
	Index .....	49
	The Microchip Web Site .....	51
	Customer Change Notification Service .....	51
	Customer Support.....	51
	Reader Response .....	52
	Product Identification System .....	53

# PIC18F2423/2523/4423/4523

**FIGURE 1-2: PIC18F4423/4523 (40/44-PIN) BLOCK DIAGRAM**



# PIC18F2423/2523/4423/4523

**TABLE 1-3: PIC18F4423/4523 PINOUT I/O DESCRIPTIONS**

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
MCLR/VPP/RE3 MCLR  VPP RE3	1	18	18	I  P I	ST   ST	Master Clear (input) or programming voltage (input). Master Clear (Reset) input. This pin is an active-low Reset to the device. Programming voltage input. Digital input.
OSC1/CLKI/RA7 OSC1  CLKI  RA7	13	32	30	I  I I/O	ST  CMOS TTL	Oscillator crystal or external clock input. Oscillator crystal input or external clock source input. ST buffer when configured in RC mode; analog otherwise. External clock source input. Always associated with pin function, OSC1. (See related OSC1/CLKI, OSC2/CLKO pins.) General purpose I/O pin.
OSC2/CLKO/RA6 OSC2  CLKO  RA6	14	33	31	O  O I/O	—  — TTL	Oscillator crystal or clock output. Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode. In RC mode, OSC2 pin outputs CLKO, which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate. General purpose I/O pin.

**Legend:** TTL = TTL compatible input      CMOS = CMOS compatible input or output  
ST = Schmitt Trigger input with CMOS levels      I = Input  
O = Output      P = Power  
I<sup>2</sup>C = I<sup>2</sup>C™/SMBus

- Note 1:** Default assignment for CCP2 when Configuration bit, CCP2MX, is set.  
**2:** Alternate assignment for CCP2 when Configuration bit, CCP2MX, is cleared.

# PIC18F2423/2523/4423/4523

**TABLE 1-3: PIC18F4423/4523 PINOUT I/O DESCRIPTIONS (CONTINUED)**

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	QFN	TQFP			
RC0/T1OSO/T13CKI	15	34	32	I/O	ST	PORTC is a bidirectional I/O port.
RC0				O	—	Digital I/O.
T1OSO				I	—	Timer1 oscillator output.
T13CKI				I	ST	Timer1/Timer3 external clock input.
RC1/T1OSI/CCP2	16	35	35	I/O	ST	Digital I/O.
RC1				I	CMOS	Timer1 oscillator input.
T1OSI				I/O	ST	Capture 2 input/Compare 2 output/PWM2 output.
CCP2 <sup>(2)</sup>						
RC2/CCP1/P1A	17	36	36	I/O	ST	Digital I/O.
RC2				I/O	ST	Capture 1 input/Compare 1 output/PWM1 output.
CCP1				O	—	Enhanced CCP1 output.
P1A						
RC3/SCK/SCL	18	37	37	I/O	ST	Digital I/O.
RC3				I/O	ST	Synchronous serial clock input/output for SPI mode.
SCK				I/O	I <sup>2</sup> C	Synchronous serial clock input/output for I <sup>2</sup> C™ mode.
SCL						
RC4/SDI/SDA	23	42	42	I/O	ST	Digital I/O.
RC4				I	ST	SPI data in.
SDI				I/O	I <sup>2</sup> C	I <sup>2</sup> C data I/O.
SDA						
RC5/SDO	24	43	43	I/O	ST	Digital I/O.
RC5				O	—	SPI data out.
SDO						
RC6/TX/CK	25	44	44	I/O	ST	Digital I/O.
RC6				O	—	EUSART asynchronous transmit.
TX				I/O	ST	EUSART synchronous clock (see related RX/DT).
CK						
RC7/RX/DT	26	1	1	I/O	ST	Digital I/O.
RC7				I	ST	EUSART asynchronous receive.
RX				I/O	ST	EUSART synchronous data (see related TX/CK).
DT						

**Legend:** TTL = TTL compatible input

ST = Schmitt Trigger input with CMOS levels

O = Output

I<sup>2</sup>C = I<sup>2</sup>C™/SMBus

CMOS = CMOS compatible input or output

I = Input

P = Power

**Note 1:** Default assignment for CCP2 when Configuration bit, CCP2MX, is set.

**2:** Alternate assignment for CCP2 when Configuration bit, CCP2MX, is cleared.

# PIC18F2423/2523/4423/4523

## REGISTER 2-2: ADCON1: A/D CONTROL REGISTER 1

U-0	U-0	R/W-0	R/W-0	R/W-0 <sup>(1)</sup>	R/W <sup>(1)</sup>	R/W <sup>(1)</sup>	R/W <sup>(1)</sup>
—	—	VCFG1	VCFG0	PCFG3	PCFG2	PCFG1	PCFG0
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 7-6 **Unimplemented:** Read as '0'

bit 5 **VCFG1:** Voltage Reference Configuration bit (VREF- source)

1 = VREF- (AN2)

0 = VSS

bit 4 **VCFG0:** Voltage Reference Configuration bit (VREF+ source)

1 = VREF+ (AN3)

0 = VDD

bit 3-0 **PCFG<3:0>:** A/D Port Configuration Control bits:

PCFG<3:0>	AN12	AN11	AN10	AN9	AN8	AN7 <sup>(2)</sup>	AN6 <sup>(2)</sup>	AN5 <sup>(2)</sup>	AN4	AN3	AN2	AN1	AN0
0000 <sup>(1)</sup>	A	A	A	A	A	A	A	A	A	A	A	A	A
0001	A	A	A	A	A	A	A	A	A	A	A	A	A
0010	A	A	A	A	A	A	A	A	A	A	A	A	A
0011	D	A	A	A	A	A	A	A	A	A	A	A	A
0100	D	D	A	A	A	A	A	A	A	A	A	A	A
0101	D	D	D	A	A	A	A	A	A	A	A	A	A
0110	D	D	D	D	A	A	A	A	A	A	A	A	A
0111 <sup>(1)</sup>	D	D	D	D	D	A	A	A	A	A	A	A	A
1000	D	D	D	D	D	D	A	A	A	A	A	A	A
1001	D	D	D	D	D	D	D	A	A	A	A	A	A
1010	D	D	D	D	D	D	D	D	A	A	A	A	A
1011	D	D	D	D	D	D	D	D	D	A	A	A	A
1100	D	D	D	D	D	D	D	D	D	D	A	A	A
1101	D	D	D	D	D	D	D	D	D	D	D	A	A
1110	D	D	D	D	D	D	D	D	D	D	D	D	A
1111	D	D	D	D	D	D	D	D	D	D	D	D	D

A = Analog input

D = Digital I/O

**Note 1:** The POR value of the PCFG bits depends on the value of the PBADEN Configuration bit. When PBADEN = 1, PCFG<3:0> = 0000; when PBADEN = 0, PCFG<3:0> = 0111.

**2:** AN5 through AN7 are only available on PIC18F4423/4523 devices.



# PIC18F2423/2523/4423/4523

The analog reference voltage is software selectable to either the device's positive and negative supply voltage (VDD and VSS), or the voltage level on the RA3/AN3/VREF+ and RA2/AN2/VREF-/CVREF pins.

The A/D Converter has a unique feature of being able to operate while the device is in Sleep mode. To operate in Sleep, the A/D conversion clock must be derived from the A/D's internal RC oscillator.

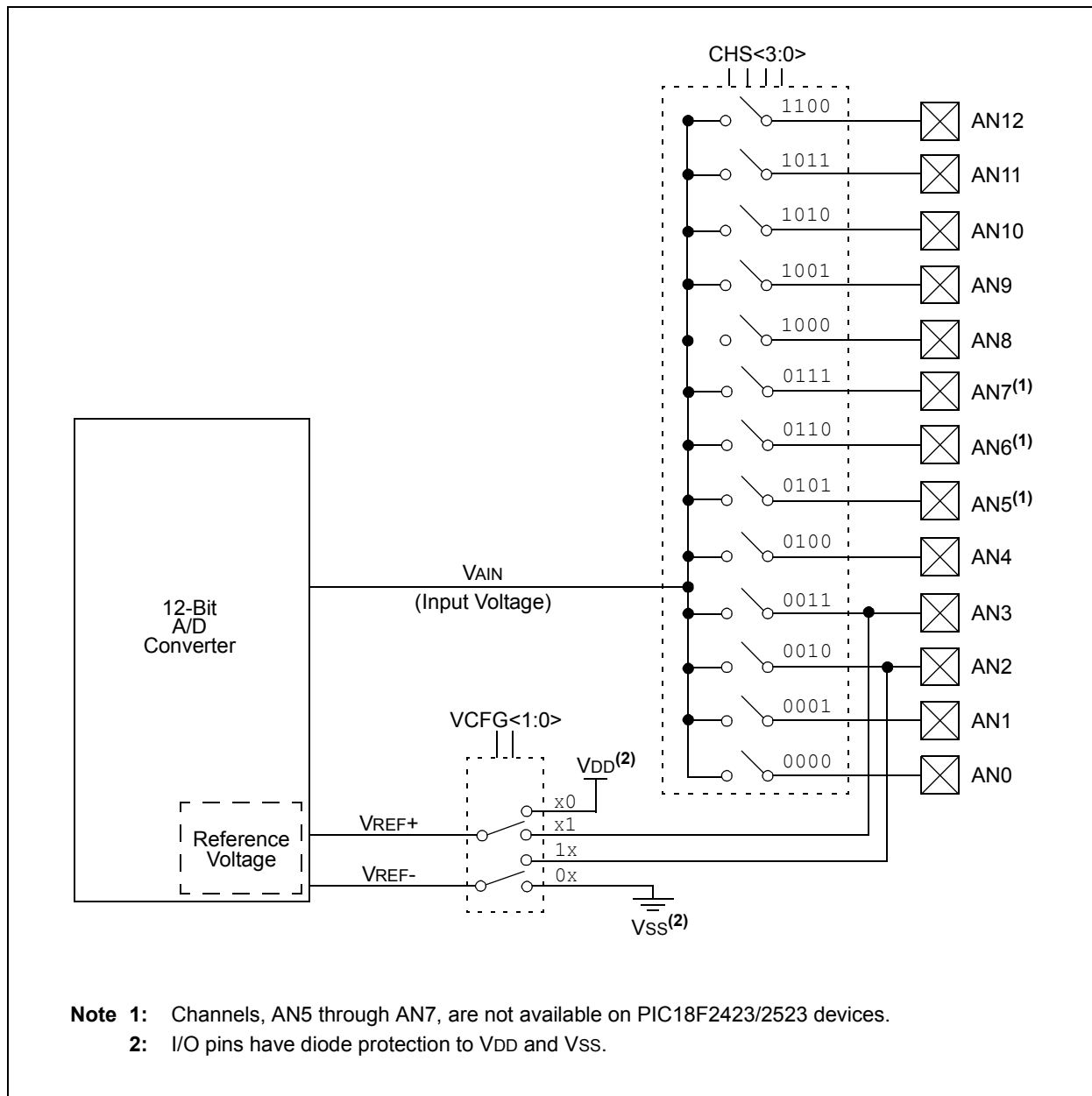
The output of the sample and hold is the input into the converter, which generates the result via successive approximation.

A device Reset forces all registers to their Reset state. This forces the A/D module to be turned off and any conversion in progress is aborted.

Each port pin associated with the A/D Converter can be configured as an analog input or as a digital I/O. The ADRESH and ADRESL registers contain the result of the A/D conversion. When the A/D conversion is complete, the result is loaded into the ADRESH:ADRESL register pair, the GO/DONE bit (ADCON0<1>) is cleared and A/D Interrupt Flag bit, ADIF, is set.

The block diagram of the A/D module is shown in Figure 2-1.

**FIGURE 2-1: A/D BLOCK DIAGRAM**



# PIC18F2423/2523/4423/4523

The value in the ADRESH:ADRESL registers is unknown following POR and BOR Resets and is not affected by any other Reset.

After the A/D module has been configured as desired, the selected channel must be acquired before the conversion is started. The analog input channels must have their corresponding TRIS bits selected as inputs. To determine acquisition time, see **Section 2.1 “A/D Acquisition Requirements”**.

After this acquisition time has elapsed, the A/D conversion can be started. An acquisition time can be programmed to occur between setting the GO/DONE bit and the actual start of the conversion.

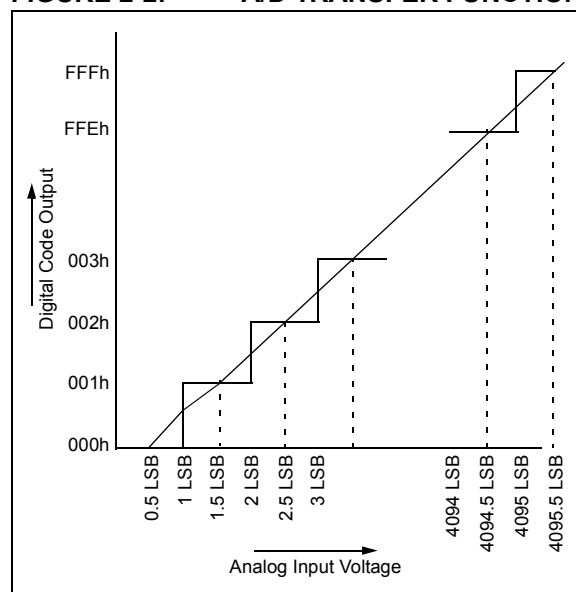
The following steps should be followed to perform an A/D conversion:

1. Configure the A/D module:
  - Configure analog pins, voltage reference and digital I/O (ADCON1)
  - Select A/D input channel (ADCON0)
  - Select A/D acquisition time (ADCON2)
  - Select A/D conversion clock (ADCON2)
  - Turn on the A/D module (ADCON0)
2. Configure the A/D interrupt (if desired):
  - Clear ADIF bit
  - Set ADIE bit
  - Set GIE bit
3. Wait the required acquisition time (if required).
4. Start conversion by setting the GO/DONE bit (ADCON0<1>).

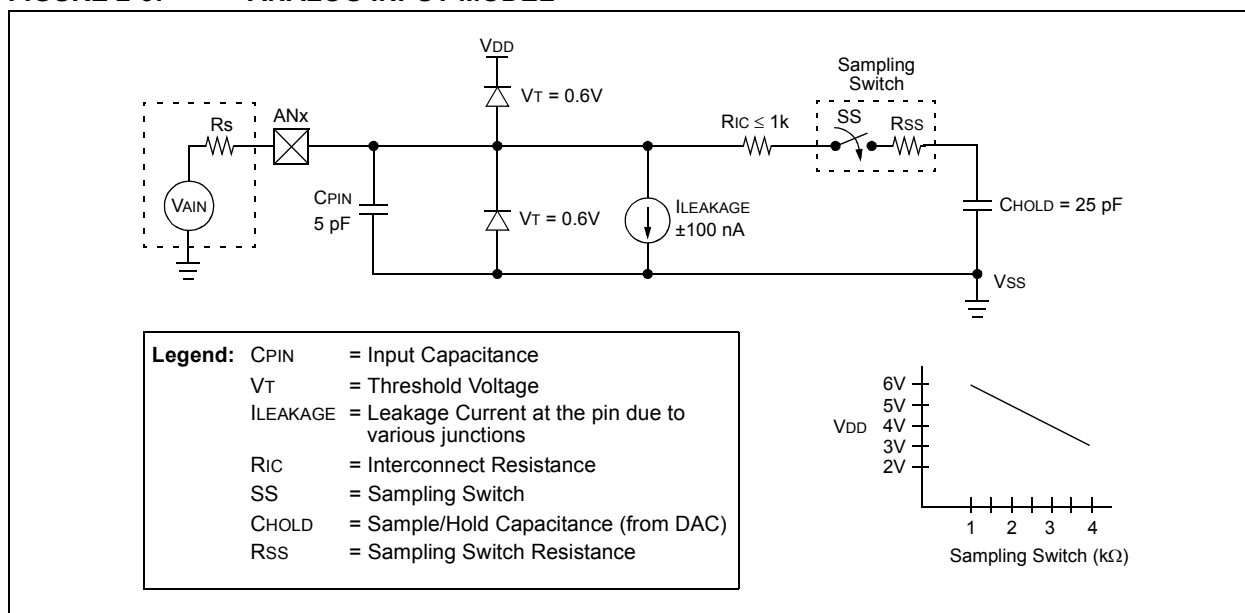
5. Wait for the A/D conversion to complete by either:
  - Polling for the GO/DONE bit to be cleared
 OR
  - Waiting for the A/D interrupt
6. Read the A/D Result registers (ADRESH:ADRESL) and clear the ADIF bit, if required.
7. For the next conversion, go to step 1 or step 2, as required.

The A/D conversion time per bit is defined as TAD. A minimum wait of 2 TAD is required before the next acquisition starts.

**FIGURE 2-2: A/D TRANSFER FUNCTION**



**FIGURE 2-3: ANALOG INPUT MODEL**



# PIC18F2423/2523/4423/4523

## 2.1 A/D Acquisition Requirements

For the A/D Converter to meet its specified accuracy, the charge holding capacitor (CHOLD) must be allowed to fully charge to the input channel voltage level. The analog input model is shown in Figure 2-3.

The source impedance (Rs) and the internal sampling switch (Rss) impedance directly affect the time required to charge the capacitor, CHOLD. The sampling switch (Rss) impedance varies over the device voltage (VDD). The source impedance affects the offset voltage at the analog input (due to pin leakage current). **The maximum recommended impedance for analog sources is 2.5 kΩ.**

After the analog input channel is selected (changed), the channel must be sampled for at least the minimum acquisition time before starting a conversion.

**Note:** When the conversion is started, the holding capacitor is disconnected from the input pin.

To calculate the minimum acquisition time, Equation 2-1 may be used. This equation assumes that 1/2 LSB error is used (4,096 steps for the A/D). The 1/2 LSB error is the maximum error allowed for the A/D to meet its specified resolution.

Example 2-3 shows the calculation of the minimum required acquisition time, TACQ. This calculation is based on the application system assumptions shown in Table 2-1:

**TABLE 2-1: TACQ ASSUMPTIONS**

CHOLD	=	25 pF
Rs	=	2.5 kΩ
Conversion Error	≤	1/2 LSB
VDD	=	3V → Rss = 4 kΩ
Temperature	=	85°C (system maximum)

### EQUATION 2-1: ACQUISITION TIME

$$\begin{aligned} \text{TACQ} &= \text{Amplifier Settling Time} + \text{Holding Capacitor Charging Time} + \text{Temperature Coefficient} \\ &= \text{TAMP} + \text{TC} + \text{TCOFF} \end{aligned}$$

### EQUATION 2-2: A/D MINIMUM CHARGING TIME

$$\begin{aligned} \text{VHOLD} &= (\text{VREF} - (\text{VREF}/4096)) \cdot (1 - e^{-(\text{TC}/\text{CHOLD}(\text{RIC} + \text{RSS} + \text{RS})))} \\ \text{or} \\ \text{TC} &= -(\text{CHOLD})(\text{RIC} + \text{RSS} + \text{RS}) \ln(1/4096) \end{aligned}$$

### EQUATION 2-3: CALCULATING THE MINIMUM REQUIRED ACQUISITION TIME

$$\begin{aligned} \text{TACQ} &= \text{TAMP} + \text{TC} + \text{TCOFF} \\ \text{TAMP} &= 0.2 \mu\text{s} \\ \text{TCOFF} &= (\text{Temp} - 25^\circ\text{C})(0.02 \mu\text{s}/^\circ\text{C}) \\ &\quad (85^\circ\text{C} - 25^\circ\text{C})(0.02 \mu\text{s}/^\circ\text{C}) \\ &\quad 1.2 \mu\text{s} \end{aligned}$$

Temperature coefficient is only required for temperatures > 25°C. Below 25°C, TCOFF = 0 ms.

$$\begin{aligned} \text{TC} &= -(\text{CHOLD})(\text{RIC} + \text{RSS} + \text{RS}) \ln(1/4096) \mu\text{s} \\ &\quad -(25 \text{ pF})(1 \text{ k}\Omega + 4 \text{ k}\Omega + 2.5 \text{ k}\Omega) \ln(0.0004883) \mu\text{s} \\ &\quad 1.56 \mu\text{s} \\ \text{TACQ} &= 0.2 \mu\text{s} + 1.56 \mu\text{s} + 1.2 \mu\text{s} \\ &\quad 2.96 \mu\text{s} \end{aligned}$$

## 2.2 Selecting and Configuring Acquisition Time

The ADCON2 register allows the user to select an acquisition time that occurs each time the GO/DONE bit is set. It also gives users the option of having an automatically determined acquisition time.

Acquisition time may be set with the ACQT<2:0> bits (ADCON2<5:3>), which provide a range of 2 to 20 TAD. When the GO/DONE bit is set, the A/D module continues to sample the input for the selected acquisition time, then automatically begins a conversion. Since the acquisition time is programmed, there may be no need to wait for an acquisition time between selecting a channel and setting the GO/DONE bit.

Manual acquisition time is selected when ACQT<2:0> = 000. When the GO/DONE bit is set, sampling is stopped and a conversion begins. The user is responsible for ensuring the required acquisition time has passed between selecting the desired input channel and setting the GO/DONE bit. This option is also the default Reset state of the ACQT<2:0> bits and is compatible with devices that do not offer programmable acquisition times.

In either case, when the conversion is completed, the GO/DONE bit is cleared, the ADIF flag is set and the A/D begins sampling the currently selected channel again. If an acquisition time is programmed, there is nothing to indicate if the acquisition time has ended or if the conversion has begun.

## 2.3 Selecting the A/D Conversion Clock

The A/D conversion time per bit is defined as TAD. The A/D conversion requires 13 TAD per 12-bit conversion. The source of the A/D conversion clock is software selectable.

There are seven possible options for TAD:

- 2 TOSC
- 4 TOSC
- 8 TOSC
- 16 TOSC
- 32 TOSC
- 64 TOSC
- Internal RC Oscillator

For correct A/D conversions, the A/D conversion clock (TAD) must be as short as possible, but greater than the minimum TAD. (For more information, see parameter 130 on page 41.)

Table 2-2 shows the resultant TAD times derived from the device operating frequencies and the A/D clock source selected.

**TABLE 2-2: TAD vs. DEVICE OPERATING FREQUENCIES**

A/D Clock Source (TAD)		Assumes TAD Min. = 0.8 $\mu$ s
Operation	ADCS<2:0>	Maximum Fosc
2 TOSC	000	2.50 MHz
4 TOSC	100	5.00 MHz
8 TOSC	001	10.00 MHz
16 TOSC	101	20.00 MHz
32 TOSC	010	40.00 MHz
64 TOSC	110	40.00 MHz
RC <sup>(2)</sup>	x11	1.00 MHz <sup>(1)</sup>

**Note 1:** The RC source has a typical TAD time of 2.5  $\mu$ s.

**2:** For device frequencies above 1 MHz, the device must be in Sleep for the entire conversion or a Fosc divider should be used instead; otherwise, the A/D accuracy specification may not be met.

# PIC18F2423/2523/4423/4523

## 3.0 SPECIAL FEATURES OF THE CPU

**Note:** For additional details on the Configuration bits, refer to **Section 23.1 “Configuration Bits”** in the “PIC18F2420/2520/4420/4520 Data Sheet” (DS39631). Device ID information presented in this section is for the PIC18F2423/2523/4423/4523 devices only.

## 3.1 Device ID Registers

The Device ID registers are read-only registers. They identify the device type and revision for device programmers and can be read by firmware using table reads.

**TABLE 3-1: DEVICE IDs**

File Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Default/ Unprogrammed Value
3FFFFEh	DEV3	DEV2	DEV1	DEV0	REV3	REV2	REV1	REV0	xxxx xxxx <sup>(2)</sup>
3FFFFh	DEV11	DEV10	DEV9	DEV8	DEV7	DEV6	DEV5	DEV4	xxxx xxxx <sup>(2)</sup>

**Legend:** x = unknown, u = unchanged, — = unimplemented. Shaded cells are unimplemented, read as '0'.

**Note 1:** DEVID registers are read-only and cannot be programmed by the user.

**2:** See Register 3-1 and Register 3-2 for DEVID1 and DEVID2 values.

**REGISTER 3-1: DEVID1: DEVICE ID REGISTER 1 FOR PIC18F2423/2523/4423/4523**

R	R	R	R	R	R	R	R
DEV3	DEV2	DEV1	DEV0	REV3	REV2	REV1	REV0
bit 7				bit 0			

**Legend:**

R = Read-only bit

P = Programmable bit

U = Unimplemented bit, read as '0'

-n = Value when device is unprogrammed

u = Unchanged from programmed state

bit 7-4 **DEV<3:0>:** Device ID bits

1101 = PIC18F4423

1001 = PIC18F4523

0101 = PIC18F2423

0001 = PIC18F2523

bit 3-0 **REV<3:0>:** Revision ID bits

These bits are used to indicate the device revision.

# PIC18F2423/2523/4423/4523

## REGISTER 3-2: DEVID2: DEVICE ID REGISTER 2 FOR PIC18F2423/2523/4423/4523

R	R	R	R	R	R	R	R
DEV11 <sup>(1)</sup>	DEV10 <sup>(1)</sup>	DEV9 <sup>(1)</sup>	DEV8 <sup>(1)</sup>	DEV7 <sup>(1)</sup>	DEV6 <sup>(1)</sup>	DEV5 <sup>(1)</sup>	DEV4 <sup>(1)</sup>
bit 7							bit 0

### Legend:

R = Read-only bit

P = Programmable bit

U = Unimplemented bit, read as '0'

-n = Value when device is unprogrammed

u = Unchanged from programmed state

bit 7-0      **DEV<11:4>**: Device ID bits<sup>(1)</sup>

These bits are used with the DEV<3:0> bits in Device ID Register 1 to identify the part number.

0001 0001 = PIC18F2423/2523 devices

0001 0000 = PIC18F4423/4523 devices

**Note 1:** These values for DEV<11:4> may be shared with other devices. The specific device is always identified by using the entire DEV<11:0> bit sequence.

# PIC18F2423/2523/4423/4523

## 4.0 ELECTRICAL CHARACTERISTICS

**Note:** Other than some basic data, this section documents only the PIC18F2423/2523/4423/4523 devices' specifications that differ from those of the PIC18F2420/2520/4420/4520 devices. For detailed information on the electrical specifications shared by the PIC18F2423/2523/4423/4523 and PIC18F2420/2520/4420/4520 devices, see the "PIC18F2420/2520/4420/4520 Data Sheet" (DS39631).

### Absolute Maximum Ratings<sup>(†)</sup>

Ambient temperature under bias .....	-40°C to +125°C
Storage temperature .....	-65°C to +150°C
Voltage on any pin with respect to V <sub>SS</sub> (except V <sub>DD</sub> and $\overline{\text{MCLR}}$ ) .....	-0.3V to (V <sub>DD</sub> + 0.3V)
Voltage on V <sub>DD</sub> with respect to V <sub>SS</sub> .....	-0.3V to +7.5V
Voltage on $\overline{\text{MCLR}}$ with respect to V <sub>SS</sub> ( <b>Note 2</b> ) .....	0V to +13.25V
Total power dissipation ( <b>Note 1</b> ) .....	1.0W
Maximum current out of V <sub>SS</sub> pin .....	300 mA
Maximum current into V <sub>DD</sub> pin .....	250 mA
Input clamp current, I <sub>IK</sub> (V <sub>I</sub> < 0 or V <sub>I</sub> > V <sub>DD</sub> ) .....	±20 mA
Output clamp current, I <sub>OK</sub> (V <sub>O</sub> < 0 or V <sub>O</sub> > V <sub>DD</sub> ) .....	±20 mA
Maximum output current sunk by any I/O pin .....	25 mA
Maximum output current sourced by any I/O pin .....	25 mA
Maximum current sunk by all ports .....	200 mA
Maximum current sourced by all ports .....	200 mA

**Note 1:** Power dissipation is calculated as follows:

$$P_{dis} = V_{DD} \times \{I_{DD} - \sum I_{OH}\} + \sum \{(V_{DD} - V_{OH}) \times I_{OH}\} + \sum (V_{OL} \times I_{OL})$$

- 2:** Voltage spikes below V<sub>SS</sub> at the  $\overline{\text{MCLR}}$ /V<sub>PP</sub>/RE3 pin, inducing currents greater than 80 mA, may cause latch-up. Thus, a series resistor of 50-100Ω should be used when applying a "low" level to the  $\overline{\text{MCLR}}$ /V<sub>PP</sub>/RE3 pin, rather than pulling this pin directly to V<sub>SS</sub>.

**† NOTICE:** Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

## 5.0 PACKAGING INFORMATION

For packaging information, see **Section 28.0 “Packaging Information”** in the “*PIC18F2420/2520/4420/4520 Data Sheet*” (DS39631).



# PIC18F2423/2523/4423/4523

## APPENDIX A: REVISION HISTORY

### Revision A (June 2006)

Original data sheet for PIC18F2423/2523/4423/4523 devices.

### Revision B (January 2007)

This revision includes updates to the packaging diagrams.

### Revision C (September 2009)

Electrical specifications updated. Preliminary condition status removed. Converted document to the "mini data sheet" format.

## APPENDIX B: DEVICE DIFFERENCES

The differences between the devices listed in this data sheet are shown in Table B-1.

**TABLE B-1: DEVICE DIFFERENCES**

Features	PIC18F2423	PIC18F2523	PIC18F4423	PIC18F4523
Program Memory (Bytes)	16384	32768	16384	32768
Program Memory (Instructions)	8192	16384	8192	16384
Interrupt Sources	19	19	20	20
I/O Ports	Ports A, B, C, (E)	Ports A, B, C, (E)	Ports A, B, C, D, E	Ports A, B, C, D, E
Capture/Compare/PWM Modules	2	2	1	1
Enhanced Capture/Compare/PWM Modules	0	0	1	1
Parallel Communications (PSP)	No	No	Yes	Yes
12-Bit Analog-to-Digital Module	10 Input Channels	10 Input Channels	13 Input Channels	13 Input Channels
Packages	28-Pin PDIP 28-Pin SOIC 28-Pin QFN	28-Pin PDIP 28-Pin SOIC 28-Pin QFN	40-Pin PDIP 44-Pin TQFP 44-Pin QFN	40-Pin PDIP 44-Pin TQFP 44-Pin QFN

# PIC18F2423/2523/4423/4523

---

## R

Reader Response .....	52
Registers	
ADCON0 (A/D Control 0) .....	25
ADCON1 (A/D Control 1) .....	26
ADCON2 (A/D Control 2) .....	27
DEVID1 (Device ID 1) .....	35
DEVID2	
(Device ID 2) .....	36
Revision History .....	45

## S

Special Features of the CPU .....	35
-----------------------------------	----

## T

Timing Diagrams	
A/D Conversion .....	41
Timing Diagrams and Specifications	
A/D Conversion Requirements .....	41

## V

Voltage-Frequency Graphics	
PIC18F2423/2523/4423/4523 (Extended) .....	38
PIC18F2423/2523/4423/4523 (Industrial) .....	38
PIC18LF2423/2523/4423/4523 (Industrial) .....	39

## W

WWW Address .....	51
WWW, On-Line Support .....	8

## THE MICROCHIP WEB SITE

Microchip provides online support via our WWW site at [www.microchip.com](http://www.microchip.com). This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQ), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

## CUSTOMER CHANGE NOTIFICATION SERVICE

Microchip's customer notification service helps keep customers current on Microchip products. Subscribers will receive e-mail notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, access the Microchip web site at [www.microchip.com](http://www.microchip.com), click on Customer Change Notification and follow the registration instructions.

## CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support
- Development Systems Information Line

Customers should contact their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

**Technical support is available through the web site at: <http://support.microchip.com>**

# PIC18F2423/2523/4423/4523

---

## READER RESPONSE

It is our intention to provide you with the best documentation possible to ensure successful use of your Microchip product. If you wish to provide your comments on organization, clarity, subject matter, and ways in which our documentation can better serve you, please FAX your comments to the Technical Publications Manager at (480) 792-4150.

Please list the following information, and use this outline to provide us with your comments about this document.

To: Technical Publications Manager  
RE: Reader Response  
From: Name \_\_\_\_\_  
Company \_\_\_\_\_  
Address \_\_\_\_\_  
City / State / ZIP / Country \_\_\_\_\_  
Telephone: (\_\_\_\_) \_\_\_\_\_ - \_\_\_\_\_ FAX: (\_\_\_\_) \_\_\_\_\_ - \_\_\_\_\_

Application (optional):

Would you like a reply? \_\_Y\_\_ \_\_N\_\_

Device: PIC18F2423/2523/4423/4523 Literature Number: DS39755C

Questions:

1. What are the best features of this document?

---

---

2. How does this document meet your hardware and software development needs?

---

---

3. Do you find the organization of this document easy to follow? If not, why?

---

---

4. What additions to the document do you think would enhance the structure and subject?

---

---

5. What deletions from the document could be made without affecting the overall usefulness?

---

---

6. Is there any incorrect or misleading information (what and where)?

---

---

7. How would you improve this document?

---

---



---

## WORLDWIDE SALES AND SERVICE

---

### AMERICAS

#### Corporate Office

2355 West Chandler Blvd.  
Chandler, AZ 85224-6199  
Tel: 480-792-7200  
Fax: 480-792-7277  
Technical Support:  
<http://support.microchip.com>  
Web Address:  
[www.microchip.com](http://www.microchip.com)

#### Atlanta

Duluth, GA  
Tel: 678-957-9614  
Fax: 678-957-1455

#### Boston

Westborough, MA  
Tel: 774-760-0087  
Fax: 774-760-0088

#### Chicago

Itasca, IL  
Tel: 630-285-0071  
Fax: 630-285-0075

#### Cleveland

Independence, OH  
Tel: 216-447-0464  
Fax: 216-447-0643

#### Dallas

Addison, TX  
Tel: 972-818-7423  
Fax: 972-818-2924

#### Detroit

Farmington Hills, MI  
Tel: 248-538-2250  
Fax: 248-538-2260

#### Kokomo

Kokomo, IN  
Tel: 765-864-8360  
Fax: 765-864-8387

#### Los Angeles

Mission Viejo, CA  
Tel: 949-462-9523  
Fax: 949-462-9608

#### Santa Clara

Santa Clara, CA  
Tel: 408-961-6444  
Fax: 408-961-6445

#### Toronto

Mississauga, Ontario,  
Canada  
Tel: 905-673-0699  
Fax: 905-673-6509

### ASIA/PACIFIC

#### Asia Pacific Office

Suites 3707-14, 37th Floor  
Tower 6, The Gateway  
Harbour City, Kowloon  
Hong Kong  
Tel: 852-2401-1200  
Fax: 852-2401-3431

#### Australia - Sydney

Tel: 61-2-9868-6733  
Fax: 61-2-9868-6755

#### China - Beijing

Tel: 86-10-8528-2100  
Fax: 86-10-8528-2104

#### China - Chengdu

Tel: 86-28-8665-5511  
Fax: 86-28-8665-7889

#### China - Hong Kong SAR

Tel: 852-2401-1200  
Fax: 852-2401-3431

#### China - Nanjing

Tel: 86-25-8473-2460  
Fax: 86-25-8473-2470

#### China - Qingdao

Tel: 86-532-8502-7355  
Fax: 86-532-8502-7205

#### China - Shanghai

Tel: 86-21-5407-5533  
Fax: 86-21-5407-5066

#### China - Shenyang

Tel: 86-24-2334-2829  
Fax: 86-24-2334-2393

#### China - Shenzhen

Tel: 86-755-8203-2660  
Fax: 86-755-8203-1760

#### China - Wuhan

Tel: 86-27-5980-5300  
Fax: 86-27-5980-5118

#### China - Xiamen

Tel: 86-592-2388138  
Fax: 86-592-2388130

#### China - Xian

Tel: 86-29-8833-7252  
Fax: 86-29-8833-7256

#### China - Zhuhai

Tel: 86-756-3210040  
Fax: 86-756-3210049

### ASIA/PACIFIC

#### India - Bangalore

Tel: 91-80-3090-4444  
Fax: 91-80-3090-4080

#### India - New Delhi

Tel: 91-11-4160-8631  
Fax: 91-11-4160-8632

#### India - Pune

Tel: 91-20-2566-1512  
Fax: 91-20-2566-1513

#### Japan - Yokohama

Tel: 81-45-471- 6166  
Fax: 81-45-471-6122

#### Korea - Daegu

Tel: 82-53-744-4301  
Fax: 82-53-744-4302

#### Korea - Seoul

Tel: 82-2-554-7200  
Fax: 82-2-558-5932 or  
82-2-558-5934

#### Malaysia - Kuala Lumpur

Tel: 60-3-6201-9857  
Fax: 60-3-6201-9859

#### Malaysia - Penang

Tel: 60-4-227-8870  
Fax: 60-4-227-4068

#### Philippines - Manila

Tel: 63-2-634-9065  
Fax: 63-2-634-9069

#### Singapore

Tel: 65-6334-8870  
Fax: 65-6334-8850

#### Taiwan - Hsin Chu

Tel: 886-3-6578-300  
Fax: 886-3-6578-370

#### Taiwan - Kaohsiung

Tel: 886-7-536-4818  
Fax: 886-7-536-4803

#### Taiwan - Taipei

Tel: 886-2-2500-6610  
Fax: 886-2-2508-0102

#### Thailand - Bangkok

Tel: 66-2-694-1351  
Fax: 66-2-694-1350

### EUROPE

#### Austria - Wels

Tel: 43-7242-2244-39  
Fax: 43-7242-2244-393

#### Denmark - Copenhagen

Tel: 45-4450-2828  
Fax: 45-4485-2829

#### France - Paris

Tel: 33-1-69-53-63-20  
Fax: 33-1-69-30-90-79

#### Germany - Munich

Tel: 49-89-627-144-0  
Fax: 49-89-627-144-44

#### Italy - Milan

Tel: 39-0331-742611  
Fax: 39-0331-466781

#### Netherlands - Drunen

Tel: 31-416-690399  
Fax: 31-416-690340

#### Spain - Madrid

Tel: 34-91-708-08-90  
Fax: 34-91-708-08-91

#### UK - Wokingham

Tel: 44-118-921-5869  
Fax: 44-118-921-5820