CE002

Configuring 10-bit dsPIC30F A/D Converters for 1 Msps Conversion Rate

Author: Hrushikesh (Rishi) Vasuki
Microchip Technology Inc.

INTRODUCTION

Several dsPIC30F devices feature 10-bit A/D converters that are capable of converting up to 1 Mega samples per second (Msps). This capability allows applications to sample high-frequency analog signals. This code example demonstrates how the application can configure the A/D converter on the dsPIC® DSC to convert signals at such high speeds.

This document and the accompanying code example are intended to supplement **Section 17 "10-Bit A/D Converter"** of the *"dsPIC30F Family Reference Manual"* (DS70046).

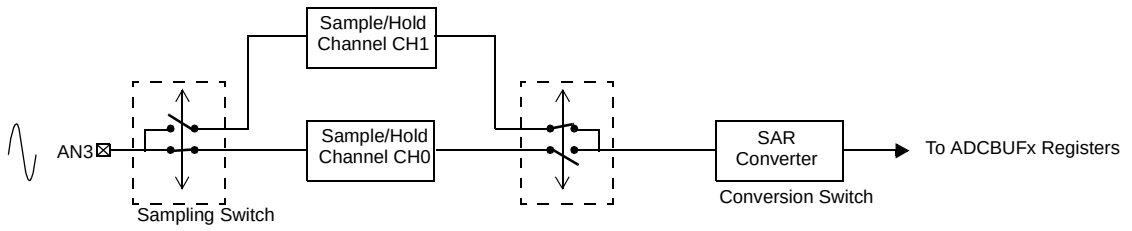
THEORY OF OPERATION

The 10-bit A/D converters on the dsPIC DSC devices contain four sample-and-hold (S/H) channels, namely, CH0, CH1, CH2 and CH3. Analog input pins on the dsPIC DSC are connected to these S/H channels via a system of multiplexers. Typically, any of the analog input pins on the dsPIC DSC can be configured as an input to S/H channel, CH0. S/H channels, CH1, CH2 and CH3, derive their input from one of two choices of analog input pins. The exact pin choices depends on the dsPIC DSC device being used. Special Function Register (SFR) ADCHS is used to set up the analog input pin to be used by each S/H channel. The CHPS (ADCON2<9:8>) bits are used to enable one, two or all four S/H channels. For example, a value of '01' loaded into the CHPS bits enables two S/H channels, CH0 and CH1.

The 10-bit A/D converter can be set up so that two or four S/H channels acquire the analog signals on their respective input pins simultaneously (at the same instant in time) or sequentially (one after the other). The sequential sampling mode allows the 10-bit A/D converter to operate at the maximum conversion rate. The sequential sampling option is set up by clearing the SIMSAM (ADCON1<3>) bit.

To achieve a 1 Msps conversion rate, the application should set up the A/D converter module (via software initialization) to use the same analog input pin for both the S/H channels, CH0 and CH1, as shown in Figure 1. In this scenario, the use of two S/H channels to convert in sequential mode ensures maximum conversion rate. Following is a detailed procedure to configure the module for a 1 Msps conversion rate.

FIGURE 1: MAXIMIZING CONVERSION RATE ON THE dsPIC® DSC 10-BIT A/D CONVERTER



Note: This is a conceptual diagram that depicts how two S/H channels on the 10-bit A/D converter may be used in tandem to sample and convert an analog input signal on a single input pin.

© 2005 Microchip Technology Inc.

PROCEDURE:

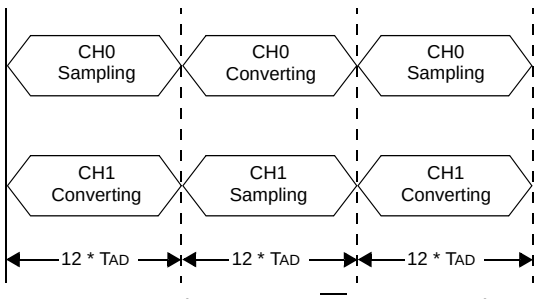
To set up the A/D Converter module to operate at 1 Msps conversion rate, follow these steps in your code:

1. Enable Auto Sampling Mode:
   `ASAM(ADCON1<2>) = '1'`
2. Enable Auto Convert Mode:
   `SSRC(ADCON1<7:5>) = '111'`
3. Enable Sequential Sampling:
   `SIMSAM(ADCON1<3>) = '0'`
4. Enable 2 S/H channels:
   `CHPS<1:0>(ADCON2<x:y) = '01'`
5. Ensure Samples per Interrupt is greater than 1:
   `SMPI<3:0>(ADCON2<5:2>) > '0000'`
   This ensures that at least one conversion result from each S/H channel is written to the A/D result buffer registers.
6. Select Minimum Sampling Time:
   `SAMC<4:0>(ADCON3<12:8>) = '00010'`
7. Select Minimum TAD time: Set up
   `ADCS<5:0>(ADCON3<5:0>)`
   so that TAD > 83.3 ns
8. Set up ADCHS register so that the analog input pin to CH0 and CH1 S/H channel is the same. For example, AN3 may be supplied to both CH0 and CH1.

Note:	Step 5 is important because the A/D converter writes conversion results starting at location ADCBUF0 on each interrupt. If you use multiple S/H channels in sequential sampling mode, you must configure the SMPI bits so that more than one sample is written to the ADCBUFx registers. This ensures that results from both S/H channels are written to the buffer.

Figure 2 shows a conceptual timing diagram for the 10-bit A/D converters when it is configured for 1 Msps conversion rate using the procedure outlined above.

FIGURE 2: SEQUENTIAL SAMPLING USING 2 S/H CHANNELS



Note: TAD is set to 83.$\overline{33}$ nanoseconds to achieve a conversion rate of 1 Msps.

DEVELOPMENT TOOLS

The example workspace was created using MPLAB® IDE v7.11. All source code in the project is written in C. Source-level comments have been provided to aid understanding. The example MPLAB IDE workspace is configured for a dsPIC30F2010 device, but it is easily re-configured for any dsPIC30F device with a 10-bit converter. The analog input pin, AN7, used in this project is available for use on all dsPIC DSC development boards and many dsPIC DSC devices.

The project/workspace assumes that a 7.37 MHz crystal provides device clocking. Such crystals are provided on several dsPIC30F development boards, for example dsPICDEM™ 64-Pin Starter Development Board, dsPICDEM 1.1, dsPICDEM 2, dsPICDEM.net™ and dsPICDEM MC1 Development Boards. Additional oscillator and PLL options have been configured in source code to operate the device at a throughput of 29.4 MIPS. All Microchip software tools and dsPIC30F documentation described in this document can be downloaded from:

http://www.microchip.com

SUMMARY

This example project lets you set up the dsPIC30F 10-bit A/D converter for sampling an analog input signal at 1 MHz in an interrupt-driven fashion using C language. Refer to the Readme.txt file for a summary description of the various files and folders provided in the project. Operational aspects are described in source-level comments in each file.

For connection considerations in your circuit, refer to **Section 17 "10-Bit A/D Converter"** in the *"dsPIC30F Family Reference Manual"* (DS70064D, or later).

© 2005 Microchip Technology Inc.

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's products as critical components in life support systems is not authorized except with express written approval by Microchip. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights.

Trademarks

The Microchip name and logo, the Microchip logo, Accuron, dsPIC, KEELOQ, microID, MPLAB, PIC, PICmicro, PICSTART, PRO MATE, PowerSmart, rfPIC, and SmartShunt are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

AmpLab, FilterLab, Migratable Memory, MXDEV, MXLAB, PICMASTER, SEEVAL, SmartSensor 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, dsPICDEM, dsPICDEM.net, dsPICworks, ECAN, ECONOMONITOR, FanSense, FlexROM, fuzzyLAB, In-Circuit Serial Programming, ICSP, ICEPIC, Linear Active Thermistor, MPASM, MPLIB, MPLINK, MPSIM, PICkit, PICDEM, PICDEM.net, PICLAB, PICtail, PowerCal, PowerInfo, PowerMate, PowerTool, rfLAB, rfPICDEM, Select Mode, Smart Serial, SmartTel, Total Endurance and WiperLock 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.

© 2005, 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 quality system certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona and Mountain View, California in October 2003. The Company's quality system processes and procedures are for its PICmicro® 8-bit MCUs, 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.

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

Atlanta
Alpharetta, GA
Tel: 770-640-0034
Fax: 770-640-0307

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

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

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

San Jose
Mountain View, CA
Tel: 650-215-1444
Fax: 650-961-0286

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

ASIA/PACIFIC

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: 86-28-8676-6200
Fax: 86-28-8676-6599

China - Fuzhou
Tel: 86-591-8750-3506
Fax: 86-591-8750-3521

China - Hong Kong SAR
Tel: 852-2401-1200
Fax: 852-2401-3431

China - Qingdao
Tel: 86-532-502-7355
Fax: 86-532-502-7205

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 - Shunde
Tel: 86-757-2839-5507
Fax: 86-757-2839-5571

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

China - Xian
Tel: 86-29-8833-7250
Fax: 86-29-8833-7256

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-2229-0061
Fax: 91-80-2229-0062

India - New Delhi
Tel: 91-11-5160-8631
Fax: 91-11-5160-8632

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

Malaysia - Penang
Tel: 604-646-8870
Fax: 604-646-5086

Philippines - Manila
Tel: 011-632-634-9065
Fax: 011-632-634-9069

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

Taiwan - Hsinchu
Tel: 886-3-572-9526
Fax: 886-3-572-6459

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 - Weis
Tel: 43-7242-2244-399
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: 34-91-352-30-52
Fax: 34-91-352-11-47

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

07/01/05

© 2005 Microchip Technology Inc.