Application Report
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CONTROLLING THE ADS7805 WITH TMS320 SERIES DSPs

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ABSTRACT

The ADS7805 16-bit, bipolar input, parallel output analog-to-digital converter (ADC) has features that allow for an easy interface to many of the TMS320 series of digital signal processors from Texas Instruments. This application report focuses on configuring, sampling, and converting analog data presented to the ADS7805 ADC, with software examples using the TMS320C6713 and TMS320C5416 DSPs. The software code developed for this application report shows how the ADC's BUSY pin can be used as an interrupt source to the host processor. The code is available for download and contains two projects in two directories, one for each processor mentioned. Project collateral discussed in this application report can be downloaded from the following URL: www.ti.com/lit/zip/SLAA229.

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1 INTRODUCTION

The Texas Instruments ADS7805 is a single-channel, 16-bit, parallel analog-to-digital converter (ADC) with bipolar inputs. The device features a chip select ($\overline{CS}$), convert start strobe (R/$\overline{C}$), parallel data input (D [0:15]), and flexible control signals that can interface easily to the C2000, C3000, C5000, and C6000 family of digital signal processors (DSP).

The ADS7805 ADC operates from 5-V analog (AVdd) and digital (DVdd) supplies. In order to protect the digital inputs of the DSP, 5-V tolerant buffers should be used on all digital outputs connecting the ADS7805 to the processor. This includes the 16 data lines as well as the BUSY signal if it is to be used as an interrupt signal.

The SN74LVCH16245 transceiver is an excellent solution for the data lines. This device has a 16-bit wide data bus, operates on 3.3 V, and accepts input voltages to 5.5 V. If the BUSY signal is to be used as an interrupt source to the DSP, a single channel SNLVC1G125 can be used to level-shift the 5-V output before it reaches the DSP. This single gate buffer is available in SOT23-5, NanoStar™ and NanoFree™ packaging to minimize board space requirements

The sample code described in Section 5 of this report was developed using Code Composer Studio V2.20 on the TMS320C6713DSK and TMS320C5416DSK with the ADS7805/ADS8505EVM. These simple code examples demonstrate how to configure the DSP, initialize the data converter, and process an interrupt (via the BUSY pin) from the data converter. Two conversion methods are shown, one using the timer output as a source of the R/$\overline{C}$ input and the other using the DSP write strobe.

2 THE ADS7805 EVM DIGITAL INTERFACE

The ADS7805EVM is part of a series of modular evaluation modules (EVM) from the TI Data Acquisition Products Group. The EVM is designed to allow operation on C5000 and C6000 series DSP Starter Kits when used with the 5-6K Interface Board (SLAU104) and the HPA449 Development Board, featuring the MSP430F449 microcontroller. For additional information on using the HPA449 Development Board, visit the SoftBaugh, Inc. Web site, www.SoftBaugh.com. The EVM can also be operated with simple laboratory equipment, such as a pattern and/or signal generator.

2.1 PARALLEL CONTROL CONNECTOR J5

Five address lines (EVM_A0:EVM_A4) are available to the ADS7805/ADS8505 EVM through the parallel control connector, J5. The EVM uses an SN74AHC138 to decode the address of the ADS7805's chip select ($\overline{CS}$) signal. Jumper W8 determines to which EVM address the data converter responds. EVM_A0 through EVM_A2 provide the ability to select one of three possible address spaces. The actual address space is determined by the connected DSP; see the DSP interface section corresponding to a particular processor for details.

The ADS7805's R/$\overline{C}$ signal connects to the host processor's write enable (DC_/WE) through a single OR gate U4. The derived $\overline{CS}$ from the address decoder serves as the second input to the OR gate. This allows the host processor to write a conversion start command to a specific address, allowing the possibility to stack multiple ADC cards on the 5-6K Interface Board.

Table 1. Parallel Control Connections via J5

EVM CONNECTOR PIN NO.	CONNECTS TO ADC SIGNAL PIN	SIGNAL DESCRIPTION / HOST PROCESSOR FUNCTION
J5.1	none	DC_CSa – Connect to G2A of the SN74AHC138. Can be tied low by installing a shunt jumper on J5 pins 1-2.
J5.3	R/$\overline{C}$	DC_/WE – Host writes to ADS7805 to signal a start of conversion. Used with J5.1 and J5.7 – J5.13
J5.5	none	DC_/RD – ORed with derived $\overline{CS}$ to enable output buffer U3.
J5.7	$\overline{CS}$ by U5	EVM_A0 – Used with U5 to develop the chip select to the ADS7805
J5.9	$\overline{CS}$ by U5	EVM_A1 – Used with U5 to develop the chip select to the ADS7805
J5.11	$\overline{CS}$ by U5	EVM_A2 – Used with U5 to develop the chip select to the ADS7805
J5.13	$\overline{CS}$ by U5	EVM_A3 – Used with U5 to develop the chip select to the ADS7805
J5.15	BYTE	EVM_A4 – Can be tied to BYTE input. BYTE can also be controlled by W2 on the EVM.
J5.17	TOUT	TOUT – Used with W5 to provide the ADS7805 with a processor-controlled conversion start signal
J5.19	BUSY	DC_INT – Used as an interrupt source to the host processor to indicate valid data is ready for transfer from the ADC's data buffer

Additional signals on the parallel control connector include TOUT and DC_INT. The TOUT signal allows a conversion start strobe derived by the host processor to be fed to the ADS7805 via jumper W5. The BUSY signal from the ADS7805 is fed via DC_INT to the host processor to act as an interrupt source, indicating that valid data is ready to be transferred. If the timer output is used to provide the R/$\overline{C}$ signal, the ADS7805 can be permanently chip-selected by removing the jumper from W8. This places a 10-KΩ pulldown resistor on the ADS7805 $\overline{CS}$ pin.

2.2 PARALLEL DATA CONNECTOR J4

The lower 16 data lines from the host processor are connected directly to the ADS7805/ADS8505 EVM aligned LSB to LSB. Table 1 shows the connections incorporated on the evaluation module for the ADS7805 and the parallel data connector, J4.

Table 2. Parallel Data Connections via J4

EVM CONNECTOR / PIN NO.	ADC PIN NO.	SIGNAL DESCRIPTION
J4.1	22	DB_D0 – LSB from the ADS7805
J4.3	21	DB_D1
J4.5	20	DB_D2
J4.7	19	DB_D3
J4.9	18	DB_D4
J4.11	17	DB_D5
J4.13	16	DB_D6
J4.15	15	DB_D7
J4.17	13	DB_D8
J4.19	12	DB_D9
J4.21	11	DB_D10
J4.23	10	DB_D11
J4.25	9	DB_D12
J4.27	8	DB_D13
J4.29	7	DB_D14
J4.31	6	DB_D15 – MSB from the ADS7805
J4.2 – J4.32 even	n/a	Digital Ground Connections

3 SETTING UP THE DSP

The following sections provide an overview of the hardware configurations used for each of the DSPs mentioned in this application report.

3.1 TMS320C6713DSK

The following section provides details on the setup of the TMS320C6713DSK™ and the 5-6K Interface Board for use with the ADS7805/ADS8505 EVM.

3.1.1 SETUP OF THE EXTERNAL INTERRUPT

The $\overline{BUSY}$ signal from the ADS7805 is sent to the EXT_INT5 pin on the TMS320C6713DSK™. The interrupt is defined in the Scheduling/HWI section of the ADS78_8505_6713.CDB file. The interrupt is configured to operate on a low-to-high transition, which actives the EXT5_ISR subroutine in the C6713 code example provided.

3.1.2 SETUP THE R/$\overline{C}$ SIGNAL THROUGH TOUTX

The DSP's internal timer, TOUTb, can be used as the conversion clock source for the ADS7805EVM. For the purpose of this application report, TOUTb was configured as a 2-clock-cycle-wide pulse with a period value of 150. This provides approximately a 167-KSPS conversion rate to the ADS7805. The timer is configured in the chip support library (CSL) portion of the DSP/BIOS configuration file (ADS78_8505_6713.CDB). When using the timer function to control R/$\overline{C}$, the $\overline{CS}$ pin can be held low by removing the shunt from W8.

3.1.3 SETUP OF THE R/$\overline{C}$ SIGNAL THROUGH CHIP SELECT ($\overline{CS}$) AND WRITE STROBE (DC_WE)

When using the write strobe to control the R/$\overline{C}$ signal, EVM_A0 through EVM_A2 determine which address activates the $\overline{CS}$ signal to the ADS7805. The ADS7805 EVM address lines EVM_A0:EVM_A4 are defined by jumper settings on the 5-6K Interface Board via W1. When W1 is open, EVM_A0:EVM_A4 correspond to upper address lines DC_A14 to DC_A17. Closing W1 connects the EVM address lines with the lower 'C6713 address lines DC_A2:DC_A5.

Table 3. ADS7805EVM Address Definitions for TMS320C6713DSK™

LOWER ADDRESS	FUNCTION - OPERATION	UPPER ADDRESS
0xA0000000	Not used	0xA0000000
0xA0000024	$\overline{RD}$ or $\overline{WR}$ - ADC $\overline{CS}$ Address "01"	0xA0024000
0xA0000028	$\overline{RD}$ or $\overline{WR}$ - ADC $\overline{CS}$ Address "10"	0xA0028000
0xA000002C	$\overline{RD}$ or $\overline{WR}$ - ADC $\overline{CS}$ Address "11"	0xA002C000

The ADS7805EVM uses the DSK's DC_CSa signal as a master chip select for the board. This signal is applied to G2A of the SN74AHC138 address decoder.

The derived $\overline{CS}$ signal via jumper settings on W8 and the address selected through U5 is ORed with the DSP write strobe. When a valid address is written to, the output of the OR gate goes low and starts a conversion cycle. This method of writing to the ADS7805 allows the DSP user to stack multiple ADS7805 EVMs onto the 5-6K Interface Board. Because of the eight possible analog input connections to the ADC, the user can realize a multiconverter configuration.

3.2 TMS320C5416DSK

The following section provides details on the setup of the TMS320C5416DSK™ and the 5-6K Interface Board for use with the ADS7805 EVM.

3.2.1 SETUP OF THE EXTERNAL INTERRUPT

The BUSY signal from the ADS7805 is sent to the EXT_INT1 pin on the TMS320C5416DSK™. The interrupt is defined in the Scheduling/HWI section of the ADS78_8505_5416.CDB file. The interrupt is configured to operate on a high-to-low transition, which actives the ReadFunc subroutine in the 5416 code example. To achieve this, the BUSY signal is inverted on the 5-6K Interface Board by moving the shunt jumper at W7 to cover pins 2-3.

3.2.2 SETUP OF THE R/$\overline{C}$ SIGNAL THROUGH TOUTX

The DSP's internal timer, TOUTa, can be used as the conversion start source for the ADS7805EVM. For the purpose of this application report, TOUTa was configured to produce an R/C pulse based on a periodic software interupt posted to the processor. Setting the TDDR and PRD registers to 2 and 1000 respectivly provides approximately a 53-KSPS conversion rate to the ADS7805. The timer is configured in the scheduling portion of the DSP/BIOS configuration file (ADS78_8505_5416.CDB). When using the timer function to control R/$\overline{C}$, the $\overline{CS}$ pin can be held low by removing the shunt from W8.

3.2.3 SETUP OF THE R/$\overline{C}$ SIGNAL THROUGH CHIP SELECT ($\overline{CS}$), AND WRITE STROBE (DC_WE)

As with the 'C6713, the ADS7805 EVM address lines EVM_A0:EVM_A4 are defined by jumper settings on the 5-6K Interface Board via W1. When W1 is open, EVM_A0:EVM_A4 correspond to upper address lines DC_A12:DC_A15. Closing W1 connects the EVM address lines with the lower 'C5416 address lines DC_A0:DC_A3.

Table 4. ADS7805EVM Address Definitions for TMS320C5416DSK™

LOWER ADDRESS	FUNCTION - OPERATION	UPPER ADDRESS
0x8000	Not used	0x8000
0x8009	$\overline{RD}$ or $\overline{WR}$ - ADC $\overline{CS}$ Address “01”	0x9000
0x800A	$\overline{RD}$ or $\overline{WR}$ - ADC $\overline{CS}$ Address “10”	0xA000
0x800B	$\overline{RD}$ or $\overline{WR}$ - ADC $\overline{CS}$ Address “11”	0xB000

As with the C6713 DSK, the ADS7805EVM uses the DC_CSa signal as a master chip select for the board. Since this signal is not available on the 'C5416DSK, the G2A line of U5 can be held low by simply placing a jumper on J5 pins 1-2. This requires W6 on the 5-6K Interface Board to be completely removed.

The derived $\overline{CS}$ signal via jumper settings on W8 and the address selected through U5 is ORed with the DSP read/write strobe. When a valid address is written to, the output of the OR gate goes low and starts a conversion cycle. As with the 'C6713, this method of writing a conversion start command to the ADS7805 allows the DSP user to stack multiple ADS7805 EVMs onto the 5-6K Interface Board.

4 ADC INITIALIZATION AND OPERATION

The ADS7805 has no internal registers and requires no specific initialization setups. The conversion process begins when the device is chip-selected with an appropriate conversion start command. With the TMS320 series of DSPs, either the timer method or the write strobe method described in previous sections can be used to accomplish this task.

4.1 $\overline{BUSY}$

The $\overline{BUSY}$ signal is an active low output which indicates the conversion process has begun. $\overline{BUSY}$ is held low through the entire conversion/acquisition process. $\overline{BUSY}$ can be used to interrupt the host processor in order to initiate a read cycle. By using the timer method to control the conversion process, the user can avoid implementing an ISR provided that the software does not allow a data read access prior to the conversion cycle completion. The ADS7805 requires a 4-µs convert/acquisition time to maintain data-sheet specifications.

5 CODE EXAMPLES

An archive of projects, complete with source and header files associated with this application report, are available for download from the Texas Instruments Web site. Enter this application report’s document number (SLAA229) into the search window found at www.ti.com. Click on the link for the abstract to this document, and download the associated code files.

The archive is organized into two directories: C6713 and C5416. The complete Code Composer Studio Project files are located in these directories. Extract the directory (s) of your choice and open the project file from the Project Manager of Code Composer Studio™. The main.c files provided include comments that allow the user to choose two different methods of interacting with the ADS7805 – one associated with the timer mode of operation and one for the write strobe method. Simply associate the desired method with the project by adding or removing the appropriate comments; the CDB file is configured to work with either method.

These files were created with CCS V2.2x. Some manipulation of the .CDB file may be required when used with earlier versions of Code Composer Studio.

6 REFERENCES

1. *ADS7805, 16-Bit, 10-µs Sampling CMOS Analog-to-Digital Converter* data sheet (SBAS020)
2. *ADS7805/ADS8505EVM User's Guide* (SLAU145)
3. *ADS7804, 12-Bit, 10-µs Sampling CMOS Analog-to-Digital Converter* data sheet (SBAS019)
4. *SN74LVCH16245A, 16-Bit Bus Transceiver with 3-State Outputs* data sheet (SCES063)
5. *5-6K Interface Board EVM User's Guide* (SLAU104)
6. *Designing Modular EVMs for Data Acquisition Products* application report (SLAA185)
7. *TMS320 Cross-Platform Daughtercard Specification* application report (SPRA711)

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