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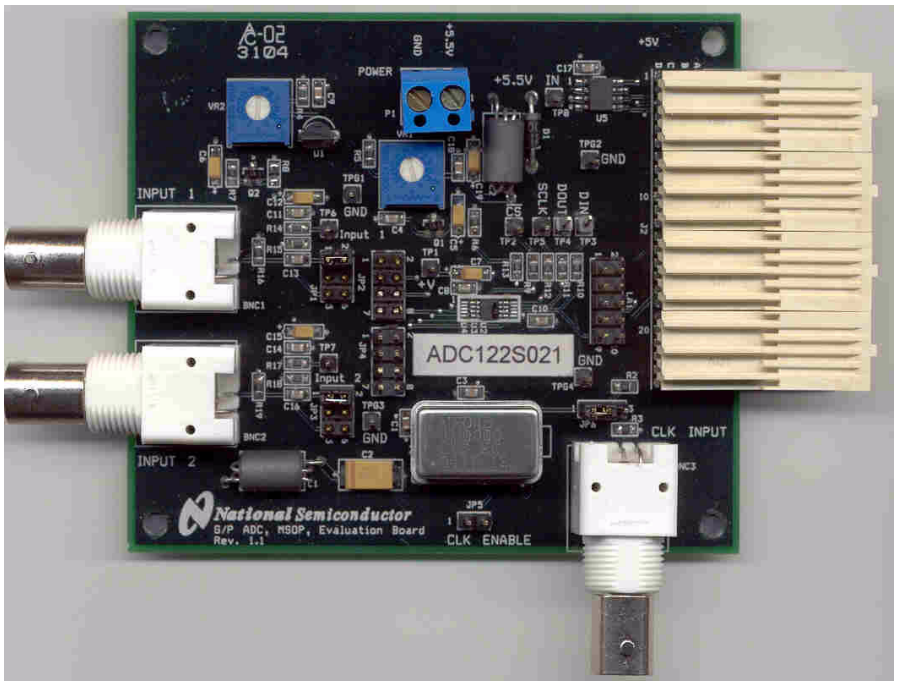
August 2005
Rev -

Evaluation Board User's Guide

12-, 10- and 8-Bit General Purpose Analog-to-Digital Converters with Input Multiplexer

ADC122S101 / ADC102S101 / ADC082S101
ADC122S051 / ADC102S051 / ADC082S051
ADC122S021 / ADC102S021 / ADC082S021

ADC124S101 / ADC104S101 / ADC084S101
ADC124S051 / ADC104S051 / ADC084S051
ADC124S021 / ADC104S021 / ADC084S021



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1.0 Introduction

These ADC Design Kits (consisting of one of these evaluation boards: ADC12xS101, ADC10xS101, ADC08xS101, ADC12xS051, ADC10xS051, ADC08xS051, ADC12xS021, ADC10xS021, ADC08xS021 and WaveVision4 hardware, where "x" in the device types here could be a 2 or a 4, indicating the number of multiplexer inputs) is designed to ease evaluation and design-in of these National Semiconductor Analog-to-Digital Converters. These evaluation boards allow the desivgner to evaluate product performance in a choice of two ways: in standalone mode with a logic analyzer and appropriate software (including National's WaveVision software), or with a personal computer and *WaveVision4* hardware and software.

Reference in this Guide to DUT is meant to refer to the particular device for which you have the evaluation board.

For operation with a computer system, this evaluation board should be coupled to a WaveVision4 data capture board (National part number WAVEVSN BRD 4.0) using the WaveVision software operating under Microsoft Windows. The analog signal presented to the DUT is captured by the WaveVision4 data capture board, and displayed on the computer screen as a dynamic waveform, FFT, and/or histogram. The software also computes and displays dynamic performance in the form of SNR, SINAD, THD, SFDR, and ENOB.

Important Note: The evaluation boards for all of these ADCs look identical. The actual device placed on your evaluation board can be identified by the label on the board and verified by looking at the DUT (Device Under Test) top mark. The devices have the following top marks:

Device	Top Mark
ADC082S101	X22C
ADC082S051	X04C
ADC082S021	X16C
ADC084S101	X25C
ADC084S051	X10C
ADC084S021	X19C
ADC102S101	X23C
ADC102S051	X05C
ADC102S021	X17C
ADC104S101	X26C
ADC104S051	X11C
ADC104S021	X20C
ADC122S101	X24C
ADC122S051	X06C
ADC122S021	X18C
ADC124S101	X27C
ADC124S051	X12C
ADC124S021	X21C

The signal at the Analog Input to the board is digitized and is available at FutureBus connector J2.

The board inputs are provided at BNC1 and BNC2. Jumper headers JP1 and JP3 allow these inputs to be either a.c. or d.c. coupled to the DUT. Provision is made to adjust the DUT supply voltage (measured at TP1) with potentiometer VR1.

VR2 is used to set the input offset.

2.0 Board Assembly

These Evaluation Boards come fully assembled and ready to use. Refer to the Bill of Materials for a description of components, to *Figure 1* for major component placement and to *Figure 2* for the Evaluation Board schematic.

3.0 Quick Start

Refer to *Figure 1* for locations of test points and major components.

1. Connect the evaluation board to the Capture Board (order number WAVEVSN BRD 4.0). See the Capture Board Manual for operation of that board.
2. Connect a clean power supply to the terminals of connector P1. Adjust power supply to a voltage of ±5.5V to ±5.7V before connecting it to the board.
3. Connect a voltmeter to TP1 and use VR1 to set the DUT analog supply voltage for the desired value between +2.7V and +5.0V.
4. Set the jumper to short pins 1 and 2 of JP6 and be sure there is a clock oscillator of the appropriate frequency at Y1.
5. Put a jumper between pins 1 and 2 of JP1 and pins 1 and 2 of JP2.
6. Connect a signal, through an appropriate bandpass filter, to BNC1. The peak-to-peak amplitude of this signal at TP6 should be the same as or just under the power supply voltage setting.
7. Connect a USB cable between the WaveVision Capture Board and the PC.
8. Run the WaveVision 4 software and click on Settings, then click on Capture. Under "Board Type" select "WaveVision 4.0 (USB)".
9. Under "Communication" press the "Test" button. If you get a "Communication Failed" message, check all connections and be sure the power supply is on.
10. If the appropriate sample rate (not clock rate) is not reported, check to be sure the clock signal has adequate amplitude and repeat the previous step.
11. Click "Accept" then gather data by pressing F1 on the keyboard. Perform an FFT on the data by clicking on the FFT tab.

See the WaveVision Capture Board Manual for complete data gathering instructions.

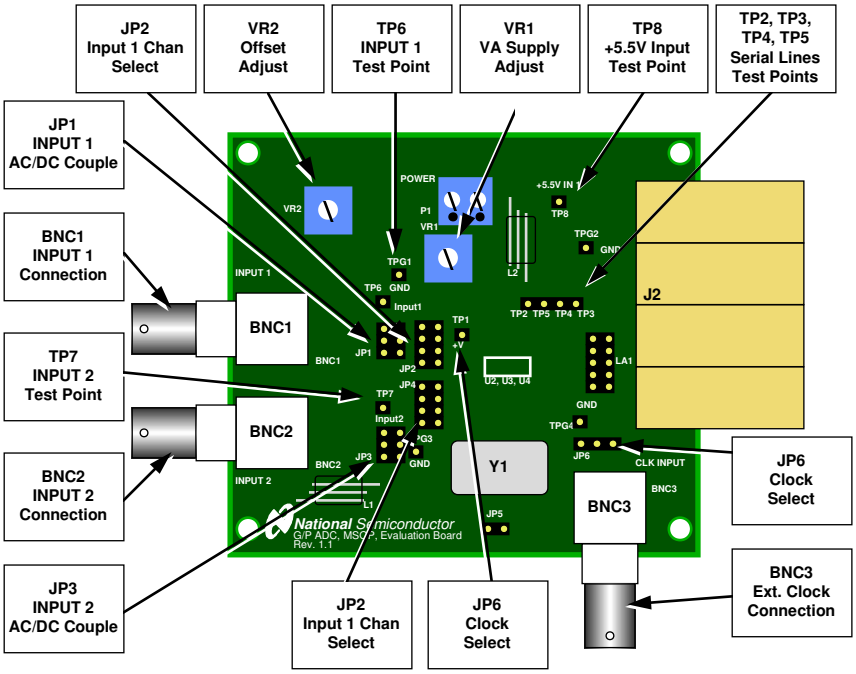


Figure 1. Major Components and Test Points of the Evaluation Board

4.0 Functional Description

The Evaluation Board component locations are shown in *Figure 1*. The board schematic is shown in *Figure 2*.

4.1 Input (signal conditioning) circuitry

The input signal to be digitized should be applied to BNC connector BNC1 or to BNC2, or to both through (an) appropriate filter(s). These 50 Ohm inputs are intended to accept a low-noise sine wave signal of peak-to-peak amplitude up to the power supply level. To accurately evaluate the ADC dynamic performance, the input test signal should be a single frequency passed through a high-quality band pass filter as described in Section 5.0.

The input signal may be either a.c. or d.c. coupled to the DUT with the setting of jumpers on J1 and JP3. See schematic *Figure 2*.

4.2 The ADC reference

The reference voltage for the DUT is the device supply voltage. Therefore, adjusting this voltage will change the full scale range of the DUT. Since the operational supply voltage range of the these ADCs is 2.7V to 5.25V, this is also the range of the reference voltage.

4.3 ADC Input Bias

To maximize ADC performance it is necessary that the input signal swing cover nearly the entire ADC input range. If the input biasing is not at the center of the signal swing, it will not be possible to get maximum signal swing without clipping of the signal, at which point there will be excessive distortion.

VR2 is provided to allow adjustment of the input bias point when a.c. input coupling is used. VR2 should be adjusted to provide a d.c. voltage at TP6 and TP7 that are one half the DUT supply voltage at TP1.

4.4 ADC clock circuit

The clock signal applied to the ADC can come from BNC3 or from an on-board oscillator at position Y1 or Y2. Y1 is for a through-hole TTL oscillator, while Y2 is for a surface mounted TTL oscillator. Only one oscillator should be mounted at a time and either an oscillator or an external generator should be connected. JP6 is used to select the oscillator source. Shorting pins 1 and 2 of JP6 selects the on-board oscillator, while shorting pins 2 and 3 selects the oscillator signal at BNC3.

4.5 Digital Data Output.

The digital output data from the DUT is available at Header LA1 for connection to a logic analyzer. Data is transferred over FutureBus J5 for use with the WaveVision4 data capture board.

4.6 Power Supply Connections

Power to this board is supplied through power connector J6. The only Voltage needed for the evaluation board is a single +5.5V to +5.7V supply.

When using this evaluation Board with the WaveVision4 Capture Board, the +5V logic power supply for that Capture board and the +5V of the DUT evaluation board are connected together through pins A1, B1, A2 and B2 of J2. Diode D1 between P1 and the WaveVision4 board is meant to prevent the higher voltage at DUT board P1 from getting to the WaveVision4 board. Providing the +5.5V to +5.7V to the DUT board will provide +5V to the WaveVision4 board through D1 and the WaveVision4 board pins A1, B1, A2 and B2 of J2.

4.7 Power Requirements

Voltage and current requirements for the DUT Evaluation Board are

- Pin 1 of P1: +5.5V to 5.7V at 50 mA
- Pin 2 of P1: Ground

4.8 Analog Inputs

The evaluation board input channel is composed of termination components and a user choice of a.c. or d.c. signal coupling to the DUT, as well as a choice of DUT multiplexer inputs that are connected to inputs BNC1 and BNC2. Short together pins 1 and 2 of JP1 and JP3 to a.c. couple the input signals. Short pins 5 and 6 of JP1 and JP3 to d.c. couple the input signal to the DUT. Shorting together pins 3 and 4 of JP1 or JP3 will ground the corresponding ADC input.

JP2 and JP4 determine which BNC connector is connected to which ADC input. See *Figure 2* for the device schematic.

Caution: Be sure that the input signals to the DUT do not go more negative than -0.3V or more than 0.3V above the DUT power supply.

5.0 Installing and Using the ADCxx1S101 Evaluation Board

The evaluation board requires a power supply as described in Section 4.7. An appropriate signal generator with 50 Ohm source impedance should be connected to the Analog Input BNC1 and/or BNC2. A bandpass filter should be inserted between the generator output and the input to the evaluation board when evaluating sinusoidal signals to be sure there are no unwanted frequencies (harmonics and noise) presented to the ADC. It is important to realize that no frequency generator or synthesizer produces a pure enough sine wave to evaluate an A/D Converter without the use of a good filter. If the WaveVison4 capture board is used, a USB cable must be connected between the WaveVision4 Capture Board and the host computer. See the WaveVision4 Capture Board User's Guide for details.

5.1 Software Installation

The WaveVision4 software provided requires about 6 Megabytes of hard drive space, including the Java files, and runs under Windows. See the WaveVision4 Capture Board Users' Guide for WaveVision4 software installation instructions.

5.2 Setting up the Evaluation Board

This evaluation package was designed to be easy and simple to use, and to provide a quick and simple way to evaluate the DUT. The procedures given here will help you to properly set up the board.

5.2.1 Board Set-up

Refer to *Figure 1* for locations of the major components on the board.

1. Connect The evaluation board to a WaveVision4 Capture Board, WAVEVSN BRD 4.0.
2. Connect the desired jumper to JP1, JP2, JP3 and JP4. (See Section 4.8).
3. Connect power to the board per requirements of paragraph 4.7.
4. Connect a USB cable between the WaveVision4 Capture Board and a USB port on your computer.
5. Connect a clean power supply to the terminals of connector P1. Adjust power supply to a voltage of ±5.5V to ±5.7V before connecting it to the board. Apply power to the WaveVision4 Capture Board.
6. Connect an appropriate test signal source to connector BNC1 and/or BNC2 of the evaluation board through (an) appropriate filter(s).

5.2.2 Quick Check of Analog Functions

Refer to *Figure 1* for locations of major components on the board. If at any time the expected response is not obtained, see section 5.2.5 on Troubleshooting.

1. Perform steps 1 through 6 of Section 5.2.1.
2. Adjust VR1 for the desired DUT supply voltage at TP1.
3. Adjust VR2 for a voltage at TP6 and TP7 that are 1/2 that at TP1.
4. Apply a signal to BNC1 and scope TP6 to be sure the input signal is present.
5. Apply a signal to BNC2 and scope TP7 to be sure the input signal is present.

This completes the testing of the analog portion of the evaluation board.

5.2.3 Quick Check of Software and Computer Interface Operation

1. Perform the steps of Paragraph 5.2.2, above.
2. Put a jumper between pins 1 and 2 of JP1 and between pins 1 and 2 of JP2.
3. Apply a signal to BNC1. Adjust the signal source at Analog Input BNC1 for a peak-to-peak signal amplitude at TP6 that is very slightly below the value of the d.c. voltage at TP1.
4. Be sure there is an interconnecting cable between the Capture Board and your computer USB port.
5. Run the WaveVision4 program and click on Settings, then click on Capture. Under "Board Type" select "WaveVision 4.0 (USB)".
6. Under "Communication" press the "Test" button. If you get a "Communication Failed" message, test all connections and be sure the power supply to the boards is turned on. Click on "Accept".
7. Acquire data by pressing the computer F1 key. Data transfer can take a few seconds.
8. When transfer is complete, the data window should show many sine waves. The display may show a nearly solid area of red, which is O.K.
9. With the mouse, you may click on the magnifying glass, then and drag (top left to bottom right) to select a portion of the displayed waveform for better examination.
10. Click on the FFT tab to compute the FFT and display a frequency domain plot.

The FFT data will provide a measurement of SINAD, SNR, THD SFDR and ENOB, simplifying the performance verification of the DUT.

Note: Be sure to use a band pass filter between the signal source and this board for accurate dynamic performance measurement.

To change the selected input channel, click on the "Settings" pull-down, then on "Product Board Settings" and choose the selected channel. Choosing "GND" will internally ground the ADC input. It is necessary to select the mainWaveVision4 window before capturing data.

5.2.4 Getting Consistent Readings

Artifacts can result when we perform an FFT on a digitized waveform, producing inconsistent results when testing repeatedly. The presence of these artifacts means that the ADC under test may perform better than our measurements would indicate. Windowing is a common method of improving FFT results of finite data.

We can eliminate the need for windowing and get more consistent results if we observe the proper ratios between the input and sampling frequencies, forcing the data to cleanly "wrap around" itself, providing coherent sampling. This eliminates the distortion that would otherwise be present in an FFT and greatly increases its spectral resolution. This, in turn, allows us to more accurately evaluate the spectral response of the A/D converter.

When we do this, however, we must be sure that the input signal has high spectral purity and stability and that the sampling clock signal is extremely stable with minimal jitter.

Coherent sampling of a periodic waveform occurs when an integer number of cycles exists in the sample window. The relationship between the number of cycles sampled (CY), the number of samples taken (SS), the signal input frequency (f_{in}) and the sample rate (f_S), for coherent sampling, is

$$\frac{CY}{SS} = \frac{f_{in}}{f_s}$$

CY, the number of cycles in the data record, must be a prime integer number and SS, the number of samples in the record, must be a power of 2 integer.

Further, f_{in} (signal input frequency) and f_S (sampling rate) should be locked to each other. Then, if they come from the same generator, whatever frequency instability (jitter) is present in the two signals will cancel each other.

Windowing (an FFT Option under WaveVision) should not be used for coherent sampling.

5.2.5 Troubleshooting

Nothing happens when F1 is pressed: Select Settings, then Capture Board Settings and look at the top for "Board Properties" If you see "No WaveVision hardware is present", be sure that the WaveVision Capture Board is connected to an USB port and has power, that the evaluation board has power and is properly connected to and seated with the WaveVision4 Capture Board.

There is no output from the DUT: perform the following:

- Be sure the appropriate input channel is selected through the WaveVision4 software.
- Be sure that a shorting jumper is appropriately placed on JP1 through JP4.
- Be sure that the proper voltage and polarity is present at Power Connector J6.
- Check to see that the DUT input signal does not go below ground or above the DUT supply voltage.
- Be sure there is a clock signal is present at TP5.

The PC displayed waveform appears to be noisy, or the FFT plot shows nothing but noise with no apparent signal:

- Be sure the appropriate input channel is selected through the WaveVision4 software.
- Be sure shorting jumpers are appropriately on JP1 through JP4.

- Check to see that the DUT input signal does not go below ground or above the DUT analog supply voltage.
- Be sure that a minimum of +2.7V is at pin 1 of TP1.
- Be sure that only one clock source (oscillator at Y1 or signal at BNC3) is active on the board.

6.0 Evaluation Board Specifications

Board Size:	3.1" x 3.8" (8.0 cm x 9.6 cm)
Power Requirements:	+ 5.5V to 5.7 @ 15 mA
Clock Frequency Range:	1 MHz to 20 MHz
Analog Input	
Nominal Voltage:	Supply peak-to-peak Voltage
Impedance:	50 Ohms

7.0 Hardware Schematic

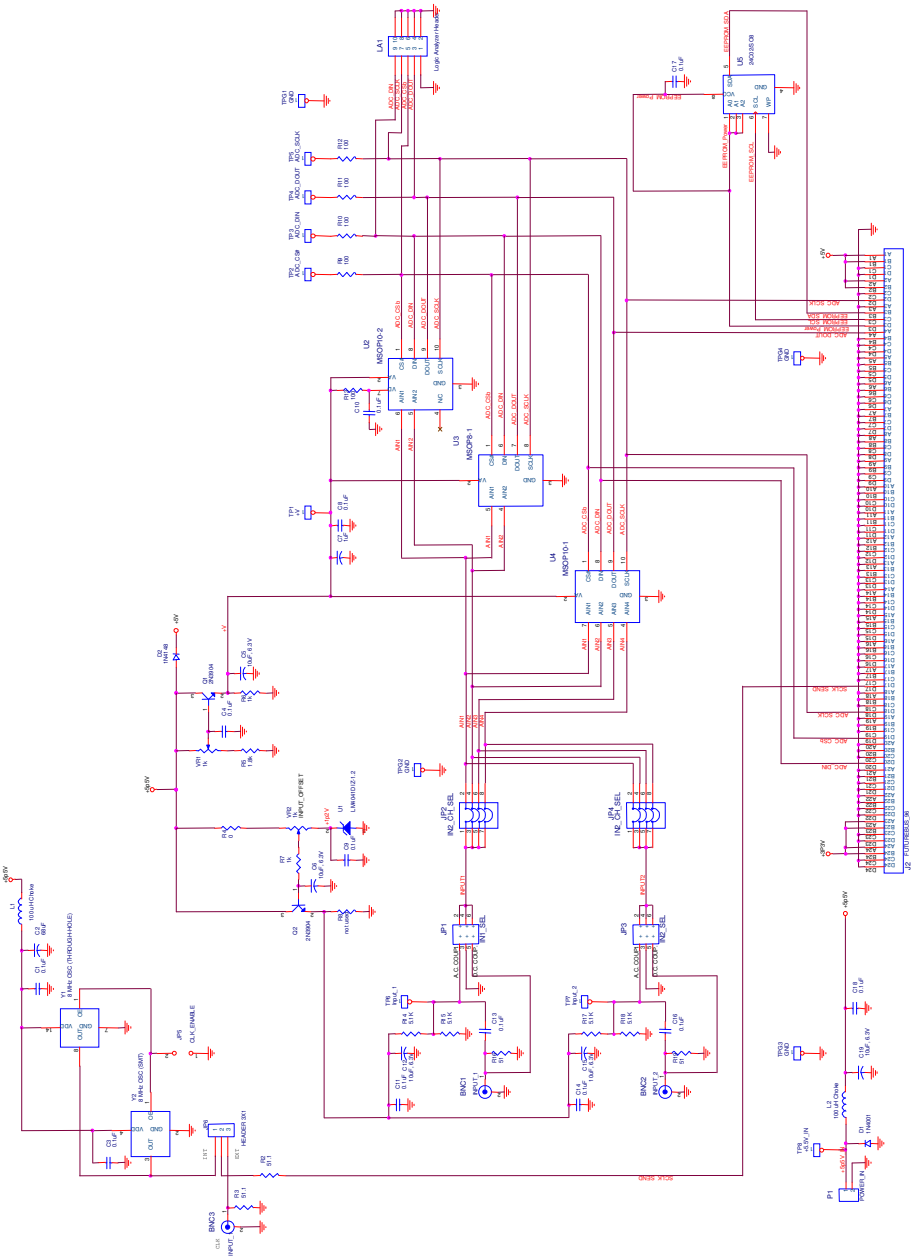


Figure 2. ADC12xSxx1 / ADC10xSxx1 / ADC08xSxx1 Evaluation Board Schematic

8.0 ADC12/10/08xSxx1 Evaluation Board Bill of Materials

Item	Qty	Reference	Part	Source
1	12	C1, C3, C4, C8, C9, C10, C11, C13, C14, C16, C17, C18	0.1uF	Type 0805
2	1	C2	68uF	Type 7343
3	5	C5, C6, C12, C15, C19	10uF, 6.3V	Type 3216
4	1	C7	1uF, 6.3V or 10V	Type 3216
5	3	BNC1, BNC2, BNC3	BNC Connector	DigiKey # ARF1177-ND
6	1	D1	1N4001 - DO-41 Pkg	Various
7	1	JP1, JP3	3x2 Pin Post Header	DigiKey # 22-28-4065-ND
8	2	JP2, JP4	2x2 Pin Post Header [2 input] 2x4 Pin Post Header [4 input]	DigiKey # 10-89-9047-ND DigiKey # 22-28-4085-ND
9	0	JP5	not used	n/a
10	1	JP6	3-pin Post Header	DigiKey # A19351-ND
11	1	J2	FUTUREBUS Connector	AMP/Tyco 536501-1
12	1	LA1	2 x 10 pin Post Header	DigiKey # 10-89-2101-ND
13	2	L1, L2	100uH Inductor	DigiKey # 445-1152-1-ND
14	1	P1	2-Pin Terminal Block	DigiKey # ED1609-ND
15	2	Q1, Q2	MMBTN3904 (SOT-23)	Various
16	2	R2, R3	51.1, 1%, 1/8 Watt	Size 0603
17	1	R4	0	Size 0603
18	1	R5	1.8k, 5%, 1/10 W	Size 0603
19	2	R6, R7	1k, 5%, 1/10 W	Size 0603
20	2	VR1, VR2	1k	DigiKey # 3386F-102-ND
21	0	R8	not used	n/a
22	5	R9, R10, R11, R12, R13	100, 5%, 1/10 W	Size 0603
23	4	R14, R15, R17, R18	5.11K, 1%, 1/10 W	Size 0603
24	2	R16, R19	51, 5%, 1/8 W	Size 0603
25	1	TP1, TP2, TP3, TP4, TP5 ,TP6, TP7, TP8, TPG1, TPG2, TPG3, TPG4	Breakable Header	DigiKey # S1012-36-ND
26	1	U1	LM4041DIZ-1.2	National Semiconductor
27	0	U2	not used	n/a
28	1	U3	ADCxx2Sxx1	National Semiconductor
29	0	U4	ADCxx4Sxx1	National Semiconductor
30	1	U5	24C02/SO8	Various
31	1	Y1	4 MHz OSC fo 50 ksps 20 MHz OSC for 200 ksps 20 MHz OSC for 1 Msps	DigiKey # CTX107-ND DigiKey # CTX114-ND DigiKey # CTX119-ND
32	0	Y2 - optional, not provided	not used	n/a
33	1	OSC Socket	For Y1	DigiKey # A400-ND
34	5	Shorting Jumpers	For JP1, JP2, JP3, JP4, JP6	DigiKey #S9601-ND

APPENDIX

A1 Summary Tables of Test Points and Connectors

P1 Connector - Power Supply Connections

Pin	Iput Voltage	Function
P1-1	+5.5V to +5.7V	Positive Power Supply
P1-2	GND	Power Supply Ground

LA1 - Logic Analyzer Header

Pin	Function
1	Ground
3	ADC Serial Data Output
5	ADC Chip Select (active low)
7	ADC serial Clock
9	ADC Serial Data Input
2	Ground
4	Ground
6	Ground
8	Ground
10	Ground

JP1 - Input 1 Select

Jumper	Function
none	Input 1 not connected to DUT
1 - 2	Input 1 a.c. coupled
3 - 4	Input 1 path grounded
5 - 6	Input 1 d.c. coupled

JP2 - Input 1 Channel Select

Jumper	Function
none	Input 1 NOT connected to DUT
1 - 2	Input 1 connected to IN1
3 - 4	Input 1 connected to IN2
5 - 6	Input 1 connected to IN3 (ADCxx4Sxx1 only)
7 - 8	Input 1 connected to IN4 (ADCxx4Sxx1 only)

JP3 - Input 2 Select

Jumper	Function
none	Input 2 not connected to DUT
1 - 2	Input 2 a.c. coupled
3 - 4	Input 2 path grounded
5 - 6	Input 2 d.c. coupled

JP4 - Input 2 Channel Select

Jumper	Function
none	Input 2 NOT connected to DUT
1 - 2	Input 2 connected to IN1
3 - 4	Input 2 connected to IN2
5 - 6	Input 2 connected to IN3 (ADCxx4Sxx1 only)
7 - 8	Input 2 connected to IN4 (ADCxx4Sxx1 only)

JP5 - Clock Enable

Jumper	Function
none	Clock at Y1 or Y2 is disabled if oscillator has enable input
1 - 2	Clock at Y1 or Y2 is enabled

Test Points on the Evaluation Board

Test Point	Function
TP 1	DUT supply voltage
TP 2	ADC CSb
TP 3	ADC D_{IN}
TP 4	ADC D_{OUT}
TP 5	SCLK
TP 6	INPUT1 Signal input to DUT
TP 7	INPUT2 Signal input to DUT
TP 8	Board +5.5V Supply Input voltage
TPG1 thru TPG4	Ground

J10 - FutureBus Connector

Pin(s)	Function
A1, B1, A2, B2	+5V from WaveVision4 Capture Board
D2	ADC Serial Clock
B3	EEPROM SDA (Data)
C3	EEPROM SCL (Clock)
D3	EEPROM Power
A4	ADC Data Output
D17	SCLK SEND
D18	ADC SCLK
D19	ADC CS#
D20	ADC Data Input
A23, B23, A24, B24	+3.3V from WaveVision4 Capture Board
All Others	Ground

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Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
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	TI E2E Community Home Page		e2e.ti.com

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