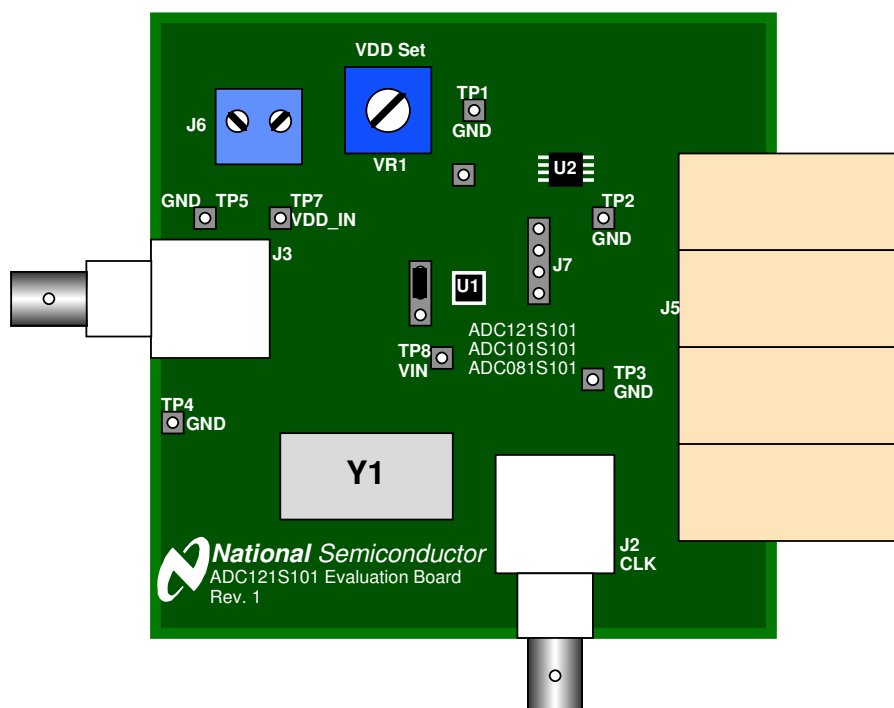


Evaluation Board User's Manual

**ADC121S101 / ADC101S101 / ADC081S101
ADC121S051 / ADC101S051 / ADC081S051
ADC121S021 / ADC101S021 / ADC081S021:
50 kps to 1 Msps, 12-, 10- and 8-Bit
Analog-to-Digital Converters**



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1.0 Introduction

The ADCxx1Sxx1 Design Kit (consisting of the ADCxx1S101 / ADCxx1S051 / ADCxx1S021 evaluation board, where "xx" can be "08", "10" or "12", and WaveVision4 hardware) is designed to ease evaluation and design-in of National Semiconductor's ADC121S101 / ADC101S101 and ADC081S101, one megasample-per-second 12-, 10- and 8-bit analog-to-digital converters, the ADC121S051, ADC101S051 and ADC081S051, 200 to 500 kilosample-per-second 12-, 10- and 8-bit analog-to-digital converters and the ADC121S021, ADC101S021 and ADC081S021, 50 to 200 kilosample-per-second 12-, 10- and 8-bit analog-to-digital converters.

This evaluation board allows you to evaluate product performance in one of two ways. This evaluation board can be operated either in standalone mode with a logic analyzer, or with a personal computer and WaveVision4 hardware and software.

Reference to the ADC121S101 in this document is meant to refer to all of the above devices, unless otherwise stated or implied.

For operation with a computer system, this evaluation board should be coupled to a WaveVision data capture board (National part number WAVEVSN BRD 4.0). The WaveVision4 software that controls that board operates on Microsoft Windows. The analog signal presented to the ADC121S101 is captured by the WaveVision4 data capture board, and displayed on the computer screen as a dynamic waveform, FFT, and histogram. The software also computes and displays SNR, SINAD, THD, SFDR, and ENOB.

Important Note: The evaluation board for all of these products look identical. The actual device placed on your evaluation board can be verified by looking at its top mark. The devices have the following top marks:

<u>Device</u>	<u>Top Mark</u>
ADC121S101	X01C
ADC101S101	X02C
ADC081S101	X03C
ADC121S051	X13C
ADC101S051	X14C
ADC081S051	X15C
ADC121S021	X07C
ADC101S021	X08C
ADC081S021	X09C

The signal at the Analog Input to the board is digitized and is available at FutureBus connector J5. (See *Figure 1* the board schematic of *Figure 2*).

The board input is provided at BNC J3. Jumper header J4 allow this input to be either a.c. or d.c. coupled to the ADC121S101. Provision is made to adjust the ADC121S101 supply voltage with potentiometers VR1.

2.0 Board Assembly

The ADC121S101 Evaluation Board comes 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 J6. Adjust power supply to a voltage of $\pm 5.5V$ to $\pm 5.7V$ before connecting it to the board. This voltage will be the maximum supply voltage for the ADC121S101. Connect the power to the board.
3. Connect a voltmeter to TP6 and use VR1 to set the ADC121S101 analog supply voltage for the desired value between +2.7V and +5.0V.
4. Apply a 10 MHz clock source to J2. Be sure the signal excursion goes to ground and to at least 70% of the ADC121S101 supply voltage.
5. Put a jumper between pins 2 and 3 of J4. Connect a signal whose peak-to-peak amplitude is the same as the power supply voltage setting.
6. Connect a USB cable between the WaveVision Capture Board and the PC.
7. Run the WaveVision 4 software and click on Settings, then click on Capture. Under "Board Type" select "WaveVision 4.0 (USB)".
8. 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.
9. Be sure that the appropriate clock speed is reported. If not, check to be sure the clock signal has adequate amplitude and repeat step 8.
10. Click "Accept" then gather data by pressing F1 on the keyboard. Perform an FFT on the data by clicking on the FFT tab. Note that an appropriate filter should be used at the signal input to the board.
11. See the WaveVision Capture Board Manual for complete data gathering instructions.

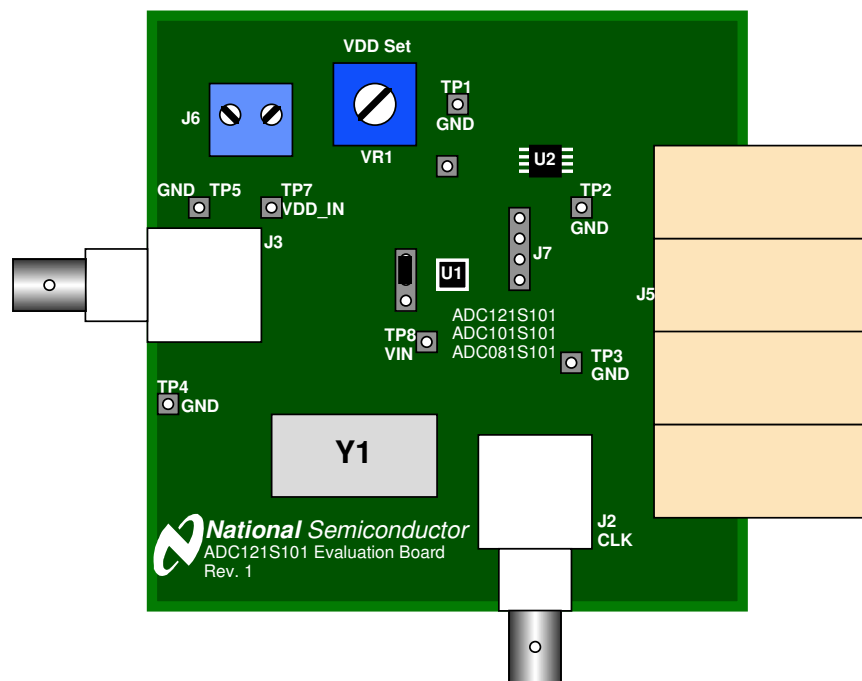


Figure 1. The Evaluation Board

4.0 Functional Description

The ADC121S101 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 J3 through an appropriate filter. This 50 Ohm input is intended to accept a low-noise sine wave signal of peak-to-peak amplitude up to the power supply level. To accurately evaluate the ADC121S101 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 ADC121S101 with the setting of the jumper on J4. See schematic *Figure 2*.

4.2 The ADC reference

The reference voltage for the ADC121S101 is the device supply voltage. Therefore, adjusting this voltage will change the full scale range of the ADC121S101. Since the operational supply voltage range of the ADC121S101

is 2.7V to 5.25V, this is also the range of the reference voltage.

4.3 ADC clock circuit

The clock signal applied to the ADC can come from BNC J2 or from an on-board TTL 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. When using an external clock source, be sure that there is a 51 Ohm resistor at position R2 near BNC J2. Resistor R2 should be removed if the on-board oscillator is used. These boards are shipped without R2 populated.

4.5 Digital Data Output.

The digital output data from the ADC121S101 is available at Header J7 for connection to a logic analyzer. Data is transferred over FutureBus J5 for use with the WaveVision data capture board.

4.6 Power Supply Connections

Power to this board is supplied through power connector J6. The only Voltage needed for the ADC121S101 evaluation board is a single +2.7V to +5.6V supply.

When using the ADC121S101 Evaluation Board with the WaveVision Capture Board, the 5V logic power supply for that Capture board is passed to the ADC121S101 evaluation board through pins A1, B1, A2 and B2 of J10. However, that voltage is not connected to the power header J6. If it is desired to use the +5V from the WaveVision Capture board for the ADC121S101 evaluation board, it is necessary to add a wire from A1, B1, A2 or B2 of J5 to pin 1 of J6.

4.7 Power Requirements

Voltage and current requirements for the ADC121S101 Evaluation Board is

- Pin 1 of J6: +2.7V to 5.7V at 5 mA
- Pin 2 of J6: Ground

4.8 Analog Inputs

The ADC121S101 evaluation board input channel is composed of termination components and a user choice of a.c. or d.c. signal coupling to the ADC121S101. Short together pins 2 and 3 of J4 to a.c. couple the input signal. Short pins 1 and 2 on J4 to present your input signal directly to the ADC121S101.

Caution: Be sure that the input signals to the ADC121S101 do not go more negative than -0.3V or more than 0.3V above the ADC121S101 power supply.

5.0 Installing and Using the ADC121S101 Evaluation Board

The evaluation board requires a power supply as described in Section 4.7. An appropriate signal generator (such as the HP3325B, HP8662A or the Tektronix AWG2000 series) with 50 Ohm source impedance should be connected to the Analog Input BNC J3. A bandpass filter should be inserted between the generator output and the input to the ADC121S101 evaluation board when evaluating sinusoidal signals to be sure there are no unwanted frequencies (harmonics and noise) presented to the ADC. A USB cable must be connected between the WaveVision Capture Board and the host computer. See the WaveVision Capture Board User's Guide for details.

5.1 Software Installation

The WaveVision software provided requires about 6 Megabytes of hard drive space, include the Java files, and will run under Windows. See the WaveVision Capture Board Manual for WaveVision software installation instructions.

5.2 Setting up the ADC121S101 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 ADC121S101. 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 ADC121S101 evaluation board to WaveVision Capture Board, WAVEVSN BRD 4.0.
2. Connect the desired jumper to J4. See Section 4.8.
3. Connect power to the board per requirements of paragraph 4.7.
4. Connect an USB cable between the Capture Board and a USB port on your computer.
5. Apply power to both the WaveVision Capture Board and the ADC121S101 evaluation board.
6. Connect an appropriate test signal source to BNC connector J3 of the ADC121S101 evaluation board through an appropriate filter.

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 ADC121S101 supply voltage (and reference voltage) at TP6.
3. Scope TP8 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 steps 1 through 3 of Paragraph 5.2.2, above.
2. Adjust the signal source at Analog Input J3 for a peak-to-peak signal amplitude at TP8 very slightly below the value of the d.c. voltage at TP6.
3. Be sure there is an interconnecting cable between the Capture Board and your computer USB port.
4. RUN the WaveVision4 program.
5. Acquire data by pressing the F1 key. Data transfer can take a few seconds.
6. 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.
7. With the mouse, you may click on the magnifying glass, then and drag (top left to bottom right) to select a small portion of the displayed waveform for better examination.
8. 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, easing the performance verification of the ADC121S101.

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

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, and SS, the number of samples taken, can not have a common divisor that would yield a whole number for both. The easiest way to ensure this is to be sure that CY is a prime integer and SS, the number of samples in the record, is a even number. For evaluation with an FFT (as opposed to a DFT), SS must be a power of 2 integer.

Further, f_{in} (signal input frequency) and f_s (sampling rate) should be locked to each other to ensure the proper ratio.

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

5.2.5 Troubleshooting

If nothing happens when F1 is pressed, Select Settings, then Capture Board Settings and look at 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 ADC121S101 evaluation board has power, and that the ADC121S101 evaluation board is properly connected to and properly seated with the WaveVision Capture Board.

If there is no output from the ADC121S101, perform the following:

- Be sure that a shorting jumper is appropriately placed on J4.
- Be sure that the proper voltage and polarity is present at Power Connector J6.
- Check to see that the ADC121S101 input signal does not go below ground or above the ADC121S101 supply voltage.
- Be sure there is a clock signal is present at ADC121S101 pin 5.

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

- Be sure a shorting jumper is appropriately on J4.
- Check to see that the ADC121S101 input signal does not go below ground or above the ADC121S101 analog supply voltage.
- Be sure that a minimum of +2.7V is at J6 connector pin 1.

6.0 Evaluation Board Specifications

Board Size:	2.8" x 2.8" (7.2 cm x 7.2 cm)
Power Requirements:	+ 2.9V to 5.7 @ 5 mA
Clock Frequency Range:	1 MHz to 20 MHz
Analog Input	
Nominal Voltage:	2.7 V _{P-P} to 5.25 V _{P-P}
Impedance:	50 Ohms

7.0 Hardware Schematic

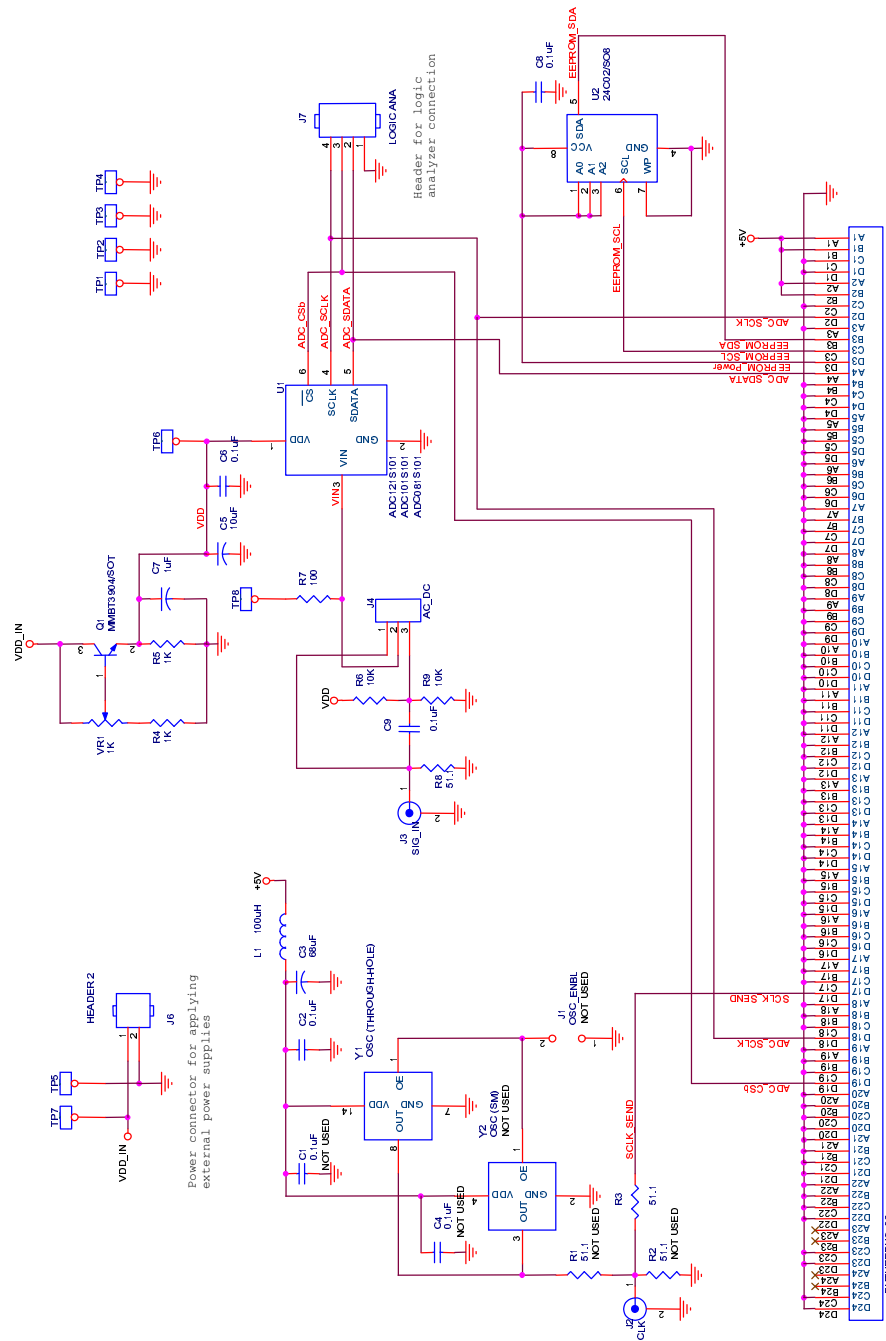


Figure 2. ADC121S101 / ADC081S101 Evaluation Board Schematic

8.0 ADC121S101 Evaluation Board Bill of Materials

Item	QTY	Reference	Part	Source
1	-	C1	Not Populated	n/a
2	5	C2, C4, C6, C8, C9	0.1 uF	Type 0805
3	1	C3	68 uF, 6.3V or 10V	Type 7343
4	1	C5	10 uF, 6.3V or 10V	Type 3216
5	1	C7	1 uF, 6.3V or 10V	Type 3216
6	-	J1	Not Populated	n/a
7	2	J2, J3	BNC Connector	DigiKey # ARF1177-ND
8	1	J4	2-Pin Post Header	DigiKey # A19350-ND
9	1	J5	FUTUREBUS Connector	AMP/Tyco 536501-1
10	1	J6	2-Pin Terminal Block	DigiKey # ED1609-ND
11	1	J7	5-Pin Post Header	DigiKey # WM6505-ND
12	1	L1	100 uH	DigiKey # 445-1155-1-ND or TDK # NLC322522T-331K
13	1	Q1	MMBT3904	Various
14	-	R2	Not Populated	n/a
15	3	R1, R3, R8	51.1, 1%	Type 0805
16	3	R4, R5	1K, 5%	Type 0805
17	2	R6, R9	10K, 1%	Type 0805
18	1	R7	100	Type 0805
19	1	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8	TEST POINTS	DigiKey # S1012-36-ND
20	1	U1	ADC121S101CIMF or ADC101S101CIMF or ADC081S101CIMF or ADC121S051CIMF or ADC101S051CIMF or ADC081S051CIMF ADC121S021CIMF or ADC101S021CIMF or ADC081S021CIMF	National Semiconductor
21	1	U2	24C02N	Various
22	1	VR1	1K Potentiometer	DigiKey # 3386F-103-ND
23	1	Y1 - Through-Hole Oscillator	4MHz Oscillator (021 suffix) 10MHz Oscillator (051 suffix) 20MHz Oscillator (101 suffix)	Pletronics # SM7745HY-4.0M Pletronics # SM7745HY-10.0M Pletronics # SM7745HY-20.0M
24	1	Y2 - SMD Oscillator- Optional - not populated	Not Populated (Surface Mount)	n/a
25	1	Oscillator Socket	For Y1	DigiKey # A400-ND
26	1	Shorting Jumper	for J4	DigiKey #S9601-ND

APPENDIX

A1 Summary Tables of Test Points and Connectors

Test Points on the ADC121S101 Evaluation Board

TP 1	Ground
TP 2	Ground
TP 3	Ground
TP 4	Ground
TP 5	Ground
TP 6	ADC supply voltage
TP 7	Board input voltage
TP 8	Signal input to ADC

J6 Connector - Power Supply Connections

J6-1	+2.9V to +5.7V	Positive Power Supply
J6-2	GND	Power Supply Ground

J7 - Logic Analyzer Header

1	Ground
2	ADC Serial Data Output
3	ADC Serial Data Input
4	ADC Chip Select (active low)
5	ADC serial Clock

J1 - Clock Enable

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

J10 - FutureBus Connector

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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