National Semiconductor

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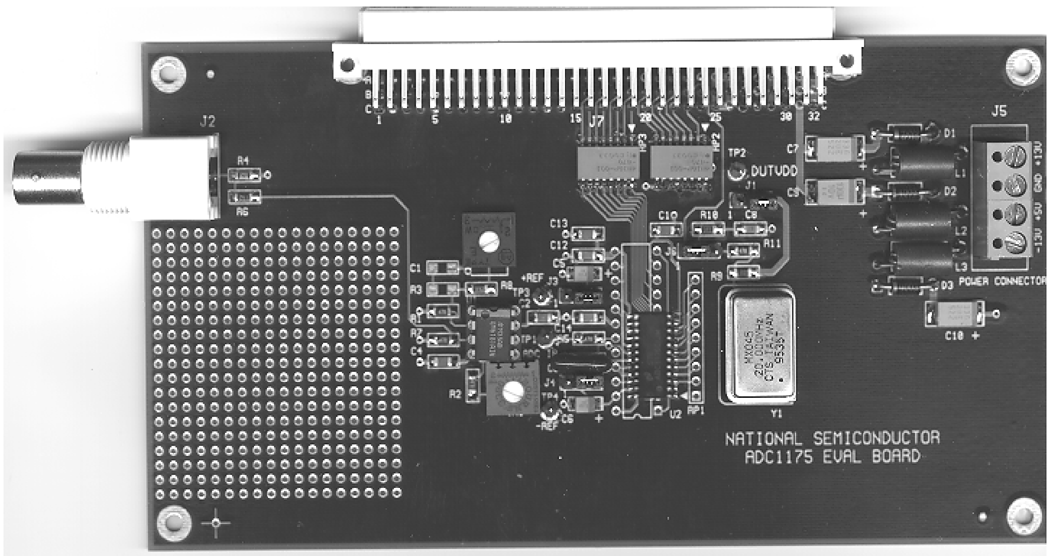
Rev -

Evaluation Board Instruction Manual

ADC1175-50: 8-Bit, 50MSPS, 150mW Analog-to-Digital Converter

Rev



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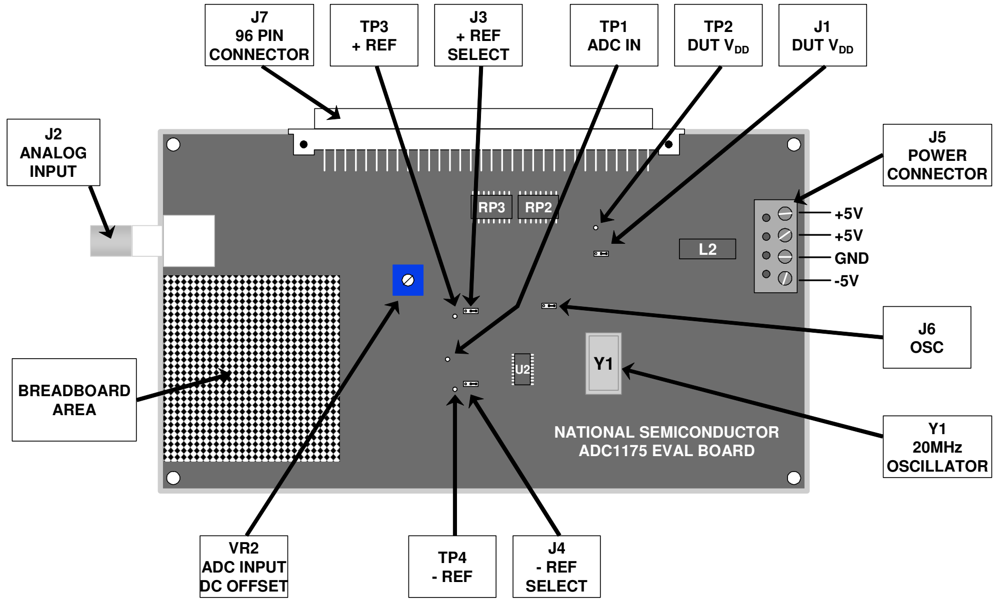

Figure 1 ADC1175-50 Eval Board

1.0 Introduction

The ADC1175-50EVAL Evaluation System (consisting of the Evaluation Board and manual, the WaveVision3 Data Capture Board and its manual and a personal computer with WaveVision2 software loaded) is designed to ease evaluation and design-in of National Semiconductor's ADC1175-50 50Msps Analog-to-Digital Converter.

The evaluation board can be used in either of two modes. The first mode is the Manual or Stand Alone mode where the board can be used with suitable test equipment to evaluate the ADC1175-50's performance.

The second mode is the Computer or Automatic mode. In this mode, evaluation is simplified by connecting the board to the WaveVision Digital Interface Board (order number WAVEVISION BRD 3.0), which is connected to a personal computer through a serial communication port, and using National Semiconductor's WaveVision2 software, which operates under Microsoft Windows, but NOT Windows NT.

The signal at BNC connector J2 (the Analog Input to the board) is digitized and is available at 96-pin DIN connector J7. Provision is made for offset voltage adjustment.

2.0 Board Assembly

The ADC1175-50 Evaluation Board comes fully assembled, but there are components that are intentionally not mounted. The purpose of these components may be gleaned by comparing the schematic of this board with the schematic of the ADC1175 (20 Msps device) evaluation board schematic. Refer to *Figure 1* for the location of major components, to Bill of Materials (Section 8.0) for component description and part types and to *Figure 2* for the Evaluation Board schematic.

While the oscillator may be soldered to the board, using a socket will allow the user to easily change frequencies and to remove this oscillator when using the board with the Digital Interface Board.

The breadboard area is useful for building customized circuitry. For best performance, keep circuitry neat and arrange components to provide short, direct connections.

3.0 Quick Start

Once the board is assembled, the following will allow the user to get the board up an running quickly. The digitized signal is available at pins B16 through B19 and C16 through C19 of J7. See the Evaluation Board schematic of *Figure 2* for details.

1. Be sure that all jumpers are in their default positions, as shown in *Figure 1*.
2. Be sure there is a crystal of desired frequency in its socket at Y1.
3. Connect +5V and ground to Power Connector J7 positions 3 and 2, respectively. No other voltages should be connected.
4. Connect a 1 to 5MHz signal from a 75-Ohm source to Analog Input BNC J2. This signal must be connected through a bandpass filter and have an amplitude of $2V_{P-P}$ at test point TP1.

5. Adjust VR2, ADC Input DC Offset, as needed to ensure that the signal at TP1 remains with the limits of the top and bottom reference voltages at pin2 of J3 and J4.

4.0 Functional Description

Figure 2 shows the schematic of the ADC1175-50 evaluation board. U2 is the device under test.

4.1 Input (signal conditioning) circuitry.

The input signal to be digitized should be applied to BNC connector J2. This 50 Ohm input is intended to accept any signal input with a maximum amplitude of 2V peak-to-peak. The input signal range should be between the voltages at pin2 of J3 and pin 2 of J4, which are a nominal 2.6V and 0.6V, respectively.

4.2 ADC reference circuitry.

The ADC1175-50 being tested can use the self bias reference included on the IC, or the reference pins of the ADC1175-50 can be driven with external reference voltages applied to TP3 (+REF) and TP4 (-REF).

You can use the ADC1175-50's self-bias reference connection by shorting pins 2 and 3 of J3 and of J4. With a +5V supply for the ADC1175-50, this fixes the top reference voltage at about 2.6V and the bottom reference voltage at about 0.6V.

If you short pins 1 and 2 of J3 and of J4, the top and bottom reference pins of the ADC1175-50 are connected to TP3 and TP4, respectively. Quiet, stable external reference voltage sources should then be applied to test points TP3 and TP4. The top reference voltage at TP3 should be a minimum of 1V but not below the bottom reference voltage at TP4 or above the ADC1175-50 supply voltage, while the lower reference voltage applied to TP4 should be between 0V and 1V below the top reference voltage.

If the difference between the top and bottom reference voltages is small, or if the input signal does not use all or nearly all of the ADC1175-50 input dynamic range, you could see a degradation of SNR because the size of the LSB becomes small enough to be lost in the system noise. We recommend operating the ADC1175-50 with a difference of 2V to 2.8V between the top and bottom reference, and driving the ADC1175-50 analog input such that the peak-to-peak signal at TP1 is about 5mV less than the difference between the voltages at TP3 and TP4.

4.3 Board Outputs.

The digital data from the ADC1175-50 output, as well as a clock signal for this data, is available at the 96 pin DIN Connector J7 (See *Figure 2*). Pull-up resistors are used at the ADC1175-50 outputs to ensure adequate drive. Series resistors (RP3) are used to isolate the ADC1175-50 from the capacitance of any circuits or instruments that are driven and/or bus ccpacitance. These capacitances can degrade noise performance of the ADC1175-50 as it charges and discharges these capacitances.

4.4 Power requirements.

Power to this board is supplied through power connector J7. Voltage and current requirements for the board are:

- +5V at 50mA (1.0A with Digital Interface Board)

The 5V supply is protected with a shunt diode.

5.0 Installing the ADC1175-50 Evaluation Board

The evaluation board requires a power supply voltage of 5V, as described in paragraph 4.4, above. No input signals for evaluation are generated on the board. An appropriate signal generator (such as the HP3325B, HP8662A or the Tektronix TSG130A) with 50-Ohm source impedance should be connected to the Analog Input BNC, J2, through an appropriate band pass filter.

If this board is used in conjunction with the Digital Interface Board and WaveVision software, a cable with a DB-9 connector should be connected between the Digital Interface Board and the host computer. See the Digital Interface Board manual for details.

6.0 Evaluation Board Specifications

Board Size:	3.5" x 6.3" (8.9 x 16 cm)
Power Requirements:	+5V @ 50 mA *
Clock Frequency Range:	1 MHz to 20 MHz
Analog Input	
Nominal Voltage:	$1V_{P-P}$
Impedance:	50 Ohms
Frequency Range:	d.c. to 100 MHz
Normal board Input Range:	1.0V to 2.0V

* +5V supply must supply 1.0 Amps when this evaluation board is used with the Digital Interface board.

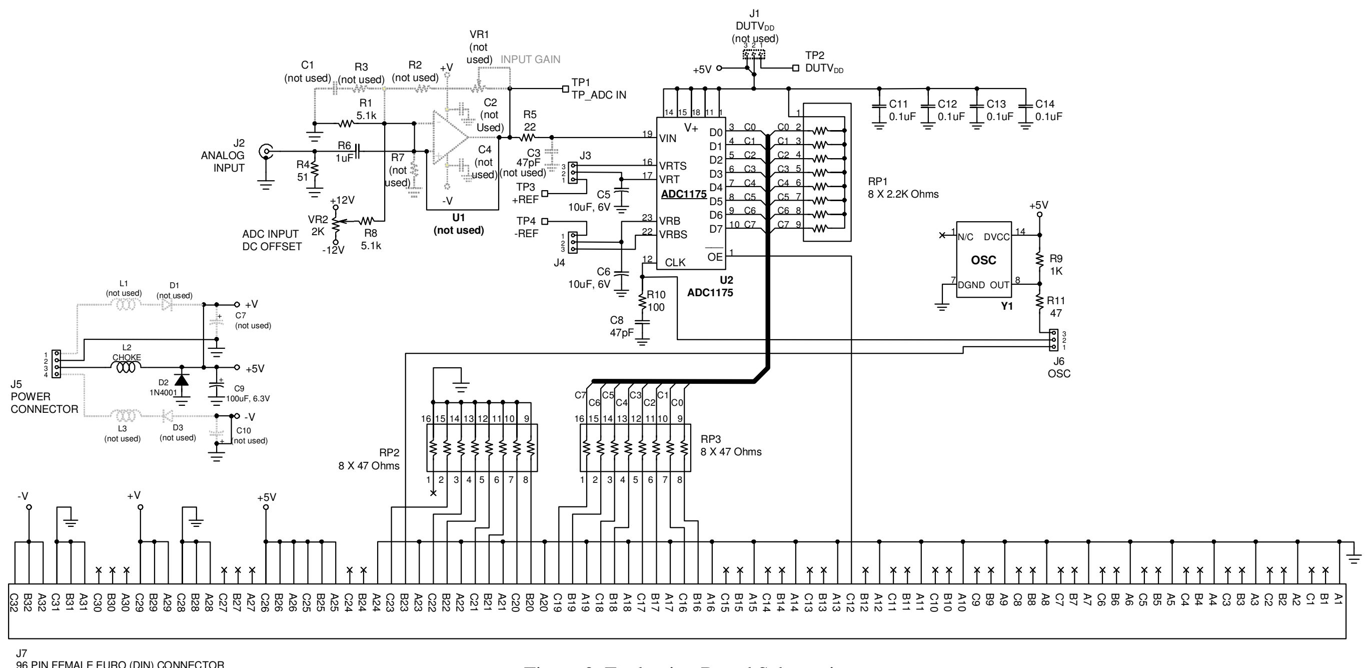

Figure 2. Evaluation Board Schematic

8.0 ADC1175-50 Evaluation Board Bill of Materials

Item	Qty	Reference	Part	Source
1	-	C1, C3, C2, C4, C7,	not used	- -
2	1	C8	47pF	Size 1206
3	1	C10	0Ω resistor	Size 1206
4	4	C11, C12, C13, C14	0.1uF	Size 1206, X7R
5	2	C5, C6	10uF, 6.3V	Type 3216 [A size]
6	1	C9	100uF, 6.3V	Type 7343 [D size]
7	-	D1, D3	not used	- -
8	1	D2	1N4001	Various
9	4	J1, J3, J4, J6	3-PIN Post Header	DigiKey # A19351-ND
10	1	J2	BNC	DigiKey # ARF1177-ND
11	1	J5	2-Post Terminal Block	DigiKey # ED1605-ND
12	1	J7	96 Pin Female DIN Connector	DigiKey # H7096-ND
13	-	L1, L3	not used	- -
14	1	L2	Choke	DigiKey # M2304-ND
15	2	R1, R8	5.1kΩ, 5%, 1/10W	Size 1206
16	-	R2, R3, R7	not used	- -
17	1	R4	51.1Ω, 1%, 1/10W	Size 1206
18	1	R5	22Ω, 5%, 1/10W	Size 1206
19	1	R10	100Ω, 1%, 1/10W	Size 1206
20	1	R11	47Ω, 5%, 1/10W	Size 1206
21	1	R6	1.0uF capacitor	Size 1206
22	1	R9	1kΩ	Type 0805
23	1	RP1	8 X 2.2kΩ	DigiKey # 4310R-1-222-ND
24	2	RP2, RP3	8 X 47Ω	DigiKey # 767-163-R47-ND CTS # 767163470G
25	1	TP1, TP2, TP3, TP4	Breakable Header	DigiKey # S1012-36-ND
26	-	U1	not used	- -
27	1	U2	ADC1175-50CIMJ	National
28	-	VR1	not used	- -
29	1	VR2	2kΩ [Offset Adjust]	DigiKey # 3386F-202-ND
30	1	Y1	50MHz Oscillator	Pletronics # DigiKey # CTX-216-ND
31	1	Socket	for Y1	DigiKey # A462-ND
	3	--	Shorting Jumper	DigiKey # S96001-ND

APPENDIX

WaveVision and Computer Mode Operation with the Data Capture Board

A1.0 Operating in the Computer (Automatic) Mode

When using the ADC1175-50 evaluation board with the WaveVision3 Data Capture Board for Computer mode operation, There is a choice of using the oscillator on the ADC1175-50 board or the divided clock from the WaveVision3 Data Capture Board to clock the ADC1175-50.

J6 is used to select the ADC clock source. With the jumper on pins 1 and 2 of J6, the divided clock from the WaveVision3 Data Capture Board is selected. Wtih the jumper on pins 2 and 3 of J6, the oscillator on the ADC1175-50 board is selected. It is a good idea to remove the oscillator from socket Y1 when using the divided clock from the WaveVision3 Data Capture Board.

It is recommended that the oscillator on the ADC1175-50 board be used because the divided clock from the WaveVision3 Data Capture Board may have enough phase noise to degrade the SNR performance of the ADC1175-50.

When using the oscillator on the ADC1175-50 board, data capture can sometimes be very bad because there is no way to synchronize that oscillator with the oscillator on the Data Capture Board and data can be captured during data transition. For this reason it may be necessary to take samples a number of times before reasonable data is observed. Also, the oscillator at Y1 must be the same frequency as the divided clock from the Data Capture Board.

Follow these steps to operate the board in the Computer mode. Refer to *Figure 1*.

1. Set up the Digital Interface Board per the instructions in the Digital Interface Board manual.
2. Adjust VR2 so that the d.c. voltage at TP1 is half way between the voltages at pins 2 of J3 and J4.
3. Set up the WaveVision software in accordance with the Data Capture Board Manual. The clock frequency on the board is set by Program Switch of the Data Capture Board. See the Data Capture Board manual for more information.
4. Select the desired number of samples to acquire (ALT, P, B or CTRL-P. See the Data Capture Board manual).
5. Acquire data by clicking on the capture icon, or by pressing CTRL-X on the computer keyboard.
6. Once data transfer is complete, portions of the waveform may be selected for viewing by clicking the mouse pointer at one corner of the area to be viewed and dragging to the opposite corner of the area to be viewed. Restore the full display by clicking the right mouse button when the cursor is over the display area.

If desired, an FFT may be performed on the captured data (ALT, P, F or CTRL-F or click on FFT icon. See Appendix of the Data Capture Board manual).

A2.0 The Data Capture Board and WaveVision Software

To fully evaluate the ADC1175-50 with minimal external equipment, you need the WaveVision Evaluation Kit (order number WAVEVISION BRD 3.0). This kit consists of a Data Capture Board that connects to the ADC1175-50 Evaluation board through the 96-pin connector, a serial cable for connecting the Data Capture Board to a computer and the WaveVision2 program. This program is available for download on National Semiconductor's web site and is generally supplied on 3.5" diskette with the evaluation board and with the Data Capture Board. This program is all that is needed to control the combined Data Capture Board and ADC1175-50 Evaluation board.

A3.0 Exploring the Video Waveform

WaveVision software, Data Capture Board and the ADC1175-50 Evaluation Board add a great tool to the designer's toolbox. The evaluation board, together with the Data Capture Board, can be used to capture any signal desired. The captured data can then be displayed and the frequency content of that wave form can viewed by performing an FFT of the data. When capturing a pure sine wave, ADC1175-50 performance parameters can be measured.

See the Appendix of the Data Capture Board manual for software operation.

A3.1 Basic Waveform

After the ADC1175-50 Evaluation Board has uploaded a captured wave form to the PC, The WaveVision software displays this wave form on the computer monitor. The WaveVision software can then be used to evaluate the ADC1175-50's performance.

A3.1.1 Estimating Differential Gain

To estimate differential gain of the circuit, capture a modulated video ramp and measure the peak-to-peak amplitude of the subcarrier (3.58 MHz for NTSC, 4.43 MHz for PAL) at the white (highest) level and at the black (lowest) level. The percentage difference between these two levels is an estimate of differential gain.

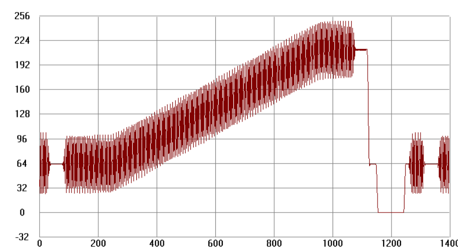

Figure 5. Modulated ramp of a video signal. The chroma level near black, subtracted from the chroma level near white will give an estimate of overall differential gain of the circuit.

Figures 6 and *7* show enlargements of the black level and the white level, respectively, of the signal in *Figure 5*.

Another method of estimating differential gain (without a modulated video ramp), is to capture a pure, stable continuous wave at two different d.c. levels. The peak-to-peak amplitude of the sine wave should be about 25% of the input full scale swing, or about 500mV$_{P-P}$ with a 2V reference span.

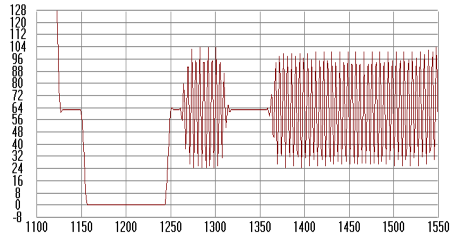

Figure 6. Enlargement of the black level area of the modulated ramp of Figure 5 showing the digital values of the chroma information.

First, capture the waveform with the offset adjust potentiometer, VR2, set to give an average code of about 64 at the ADC output. This would correspond to a DC potential of about 1.1V at the ADC input (TP1) with a nominal 2.6V and 0.6V at the top and bottom reference inputs, respectively. Measure the peak-to-peak level of this signal on the screen.

Then capture another waveform with the offset adjust potentiometer, VR2, set to give an average code of about 192 at the ADC output. This would correspond to an input DC potential of about 2.1V at the ADC input (TP1, *Figure 7* and *Figure 8*). Measure the peak-to-peak level of this signal. You might want to open a new window for this second waveform capture, so that both levels may be displayed at once.

The estimated differential gain is the percentage difference in the peak-to-peak readings of these two signals.

A way to more accurately measure the peak-to-peak amplitudes of these signals is to perform a histogram on these two sets of data. To do so, press CRTL-H with the raw data panel selected, or click on the histogram icon.

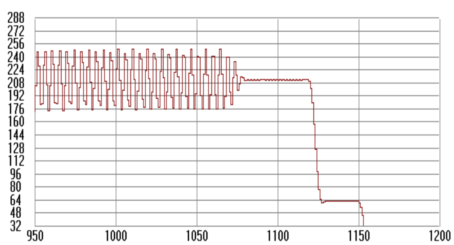

Figure 7. Enlargement of the white level area of the modulated ramp to be compared with the black level. The percentage difference between the two chroma levels is differential gain.

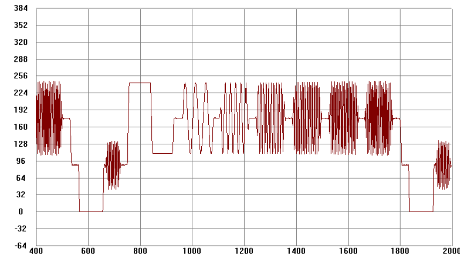

Figure 8. This multiburst signal shows the gain flatness of the overall circuit. Notice that all frequencies have about equal amplitude.

A3.1.2 Looking at Frequency Response

A video multiburst signal can be used to evaluate system frequency response. This approach will show the overall system response, including that of any input signal conditioning.

A multiburst signal has bursts of fixed frequencies, one after the other, that usually start at 0.5 MHz and increase to 4.5 MHz or 5.5 MHz, depending upon the video standard.

Figure 8 shows a captured PAL multiburst signal. Note the flat response, with all frequency components at the same amplitude.

The individual preset frequencies of the multiburst signal can be determined by performing an FFT on the data, (*Figure 9*). The individual frequencies are, in this case, 0.5 1, 2, 4, 4.75 and 5.75 MHz. The dynamic data at the upper right of the spectrum plot is useless for such data, or for anything other than a captured pure sine wave.

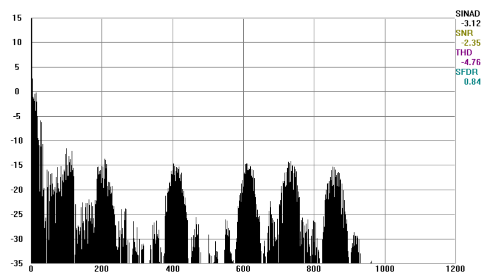

Figure 9. This FFT of the multiburst signal shows frequency on the horizontal axis, allowing a measurement of the bandwidth required for the burst of each frequency. This spectrum of the whole video signal indicates the bandwidth required to pass this signal without distortion.

A3.1.3 Low Frequency Triangle Wave Input

A low frequency (about 15KHz) triangle wave will provide general information on ADC performance.

<u>A3.1.3.1 Monotonicity and Uncertainty</u>

When a voltage ramp is digitized, the code sequence shows increasing codes up to the peak level, or decreasing codes to the minimum level, depending upon the slope of the ramp. A waveform with always increasing or decreasing codes is said to be monotonic, as in *Figure 10a*.

A converter that has one or more instances of codes consistently going in the wrong direction is said to be non-monotonic. See *Figure 10b*.

When digitizing signals with rise and fall times slow enough to result in more than one conversion result of the same code in sequence, it is normal to have some code uncertainty when the input is at a code transition point, as shown in *Figure 11*. Code uncertainty near transition points is not the same as being non-monotonic.

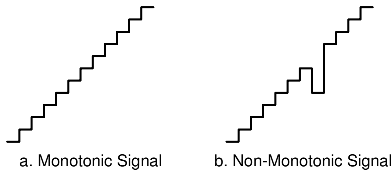

Figure 10. Monotonicity means codes are continually increasing or decreasing.

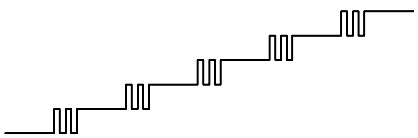

Figure 11. Code uncertainty when the ADC input voltage is near a code transition point.

A3.1.3.2 Rising / Falling Symmetry
The ideal A/D converter will give the same code when digitizing a given input voltage whether that voltage is approached from a lower voltage or from a higher voltage. If a *symmetrical* triangle wave is presented to the ADC, the falling side of the reconstructed waveform should be a mirror image of the rising side at the input and at the output. In practice, however, this may not be the case. Looking at the WaveVision data display of a digitized triangle wave will show how symmetrical the two slopes are with respect to each other. Choose your generator with care as *many triangle wave signal generators have non-symmetrical slopes*.

A3.2 The FFT Plot
At the right side of the frequency domain (FFT) plot are dynamic performance estimates of SINAD, SNR, THD and SFDR (Spurious-Free Dynamic Range). These readings are meaningful only for sine wave inputs to the ADC and are accurate only to the extent that the input waveform is stable and contains a single frequency, and to the extent that the clock is free of phase noist, or jitter.

Harmonics and other interfering signals at the input can be attenuated by inserting an appropriate filter at the Analog Input. The elliptic filters of *Figures 12* and *13* are examples of suitable filters for input frequencies of 1MHz to 5MHz and for 5MHz to 10MHz. respectively. These filters can filter a square wave, reducing 3rd and higher harmonics to negligible levels.

The FFT plot, however, can provide information from captured signals other than single frequency sinusoids. One example is shown in *Figure 9*.

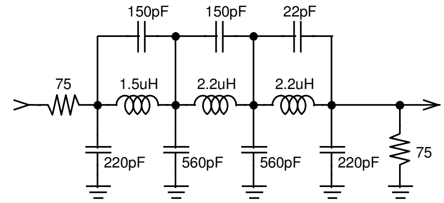

Figure 12. This 4MHz cutoff elliptic filter can be used for input frequencies of 1MHz to 4MHz. It should be driven by a generator of 75 Ohms source impedance and terminated with 75 Ohms. The input resistor shown here is normally the generator output impedance.

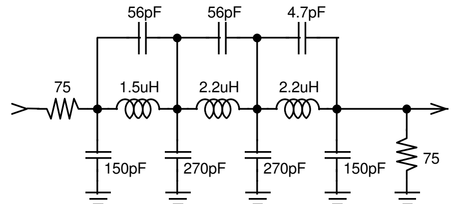

Figure 13. This elliptic filter has a cutoff frequency of about 11MHz and is suitable for input frequencies of 5MHz to 10MHz. Other comments of Figure 12 apply here.

A3.2.1 Dynamic Performance Estimates
The dynamic performance as indicated by SINAD, SNR, THD and SFDR are estimates rather than hard and fast figures because their accuracy depends upon how much of the ADC1175-50's dynamic input range is used, how many samples are taken and upon the exact starting point of data capture.

For example, if the input is reduced below a full scale swing such that the maximum and minimum codes obtained at the output are 235 and 20, rather than the full scale values of 255 and 0, only about 84% of the code range is used. The result is an apparent degradation of SNR and SINAD by about 1.5 dB. On the other hand, if the input exceeds the input dynamic range such that the top and bottom of the input signal is clipped at the ADC1175-50's output, THD, SFDR and SINAD will be degraded.

Furthermore, apparent performance may be limited by the purity of the input signal used. Because signal sources are nearly always not pure, it is important to use a narrow bandpass filter after a sine wave source for ADC evaluation.

A3.2.2 Bandwidth Estimation
If a constant amplitude frequency sweep is applied at the Analog Input (J2) and the signal at the ADC input is digitized and displayed, the data display will show any frequency dependent amplitude variation.

A4.0 Saving and Retrieving Files

WaveVision allows you to save data in two formats. One is a binary file, the other is an ASCII file. See the Data Capture Board manual for details.

A4.1 Binary Files

To save data as a binary file for use later by WaveVision, you can click on the save icon, enter ALT, F, S or enter CTRL-S. You will be prompted for a file name the first time you save a given set of data. The binary file created contains information as to program settings as well as the raw data.

To retrieve a binary file in WaveVision, click on the Open File icon, enter ALT, F, O or enter CTRL-O. You will be prompted for the name of the file you wish to retrieve.

A4.2 ASCII Files

To export an ASCII file for use later by another program, such as Excel, you must enter ALT, F, D. You will be prompted for a file name.

The ASCII file will contain only raw data with one data point per line.

To import an ASCII file, whether created with WaveVision or with any other program or utility, enter ALT, F, I. You will be prompted for the name of the file you wish to retrieve. Remember that imported files must have one data point per line and should have a binarily weighted number of samples.

If an imported file has more than one data point per line or has any non-numeric characters, the program will become hung up and it will be necessary to shut the program down and rerun it.

If a non-radix 2 number of data points are loaded and an attempt is made to perform an FFT, a DFT will be performed on the data, which can take a noticeably longer time to perform.

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