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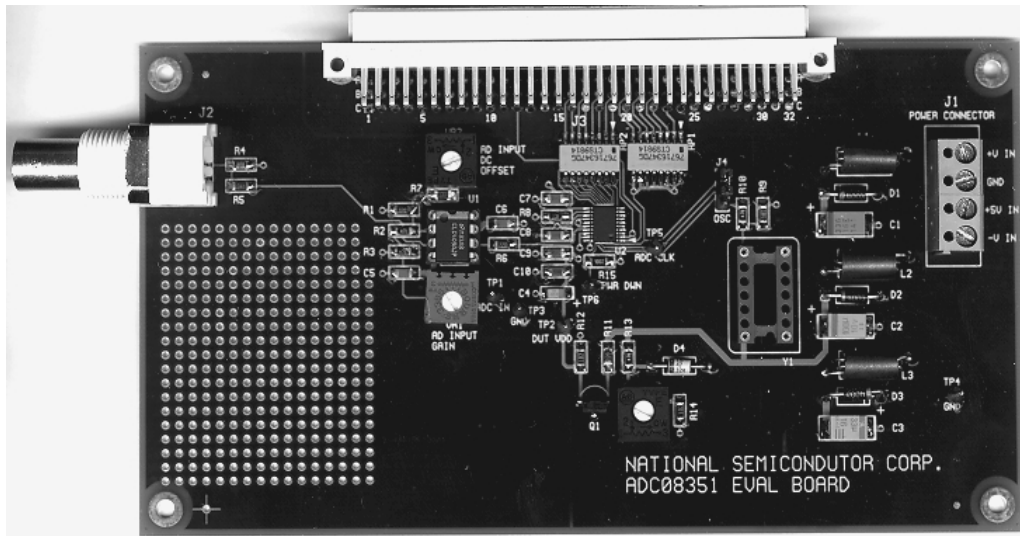
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August 2000  
Rev. 1.0

# Evaluation Board Instruction Manual

**ADC08351: 8-Bit, 42MSPS, 36mW Analog-to-Digital Converter**



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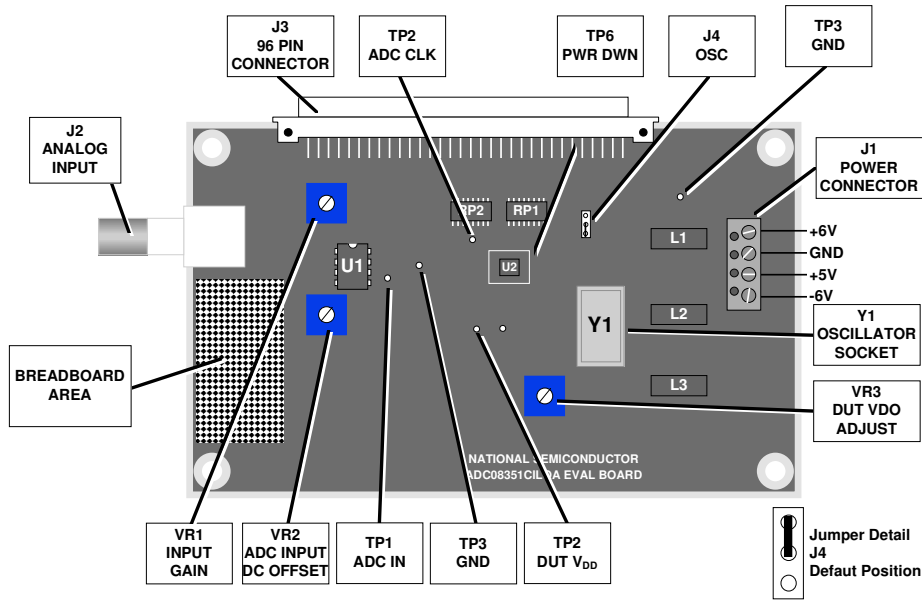
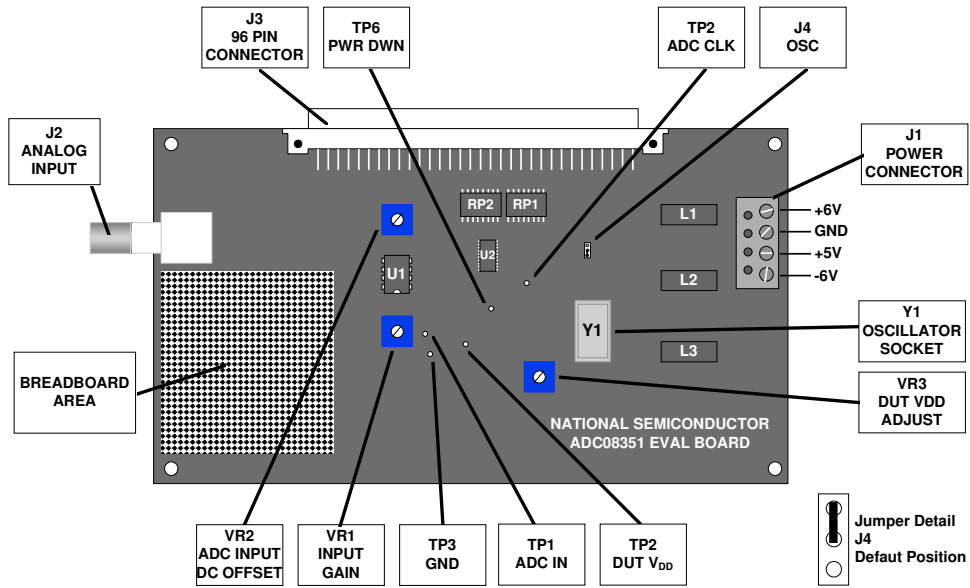


Figure 1. Indicators and Adjustments Locations. Jumpers are shown in default positions

### 1.0 Introduction

The ADC08351EVAL and the ADC08351EVALLP Evaluation Boards (consisting of an ADC08351 Evaluation Board and this manual) are designed to ease evaluation and design-in of National Semiconductor's ADC08351 42 MSPS Analog-to-Digital Converter in the TSSOP and LLP.

These evaluation board can be used in either of two modes. In the Manual or Stand Alone mode the board can be used with suitable test equipment to evaluate the ADC08351's performance.

In the Computer or Automatic mode evaluation is simplified by connecting the board to the WaveVision Digital Interface Board (order number WAVEVISION BRD, WAVEVSN BRD 2.0 or WAVEVSN BRD 3.0), which is connected to a personal computer through a serial communication port, and using National Semiconductor's WaveVision software operating under Microsoft Windows.

The signal at BNC connector J2 (the Analog Input to the board) is digitized and is available at 96-pin DIN connector J3.

Provision is made for adjustment of gain and offset voltage.

### 2.0 Board Assembly

The ADC08351 Evaluation Board is delivered as a fully assembled board with a surface mounted ADC08351. The board with order number ADC08351EVAL has an ADC08351 in the TSSOP, while the board with order number ADC08351EVALLP has an ADC08351 in the LLP. 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 allows you to change frequencies and to remove this oscillator when using the board with the Digital Interface Board. Removing the oscillator when not need reduces the chance of adding noise to the conversion result.

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

The following will allow you to get the board up and running quickly. The digitized signal is available at pins B16 through B19 and C16 through C19 of J3. See the Evaluation Board schematic in Figure 2 for details.

1. Be sure that jumper J4 is in its default position.
2. Be sure there is a 40MHz or 42MHz crystal in its socket.
3. Connect  $\pm 5V$  and +5V to Power Connector J1.
4. Adjust VR3, so that  $V_{DD}$  measures 3.0V at TP2.
5. Center VR1. Set VR2 for 1.1V d.c. at TP1.
6. Connect a 1 to 5MHz signal of  $1V_{p-p}$  to BNC J2.
7. Adjust VR1 and VR2 so that the signal at TP1 falls within the limits of 0.2V and 2.24V.

### 4.0 Functional Description

Figure 2 shows the schematic of the ADC08351 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 75 Ohm input is intended to accept any signal input with amplitudes from 0.1V to 0.25V peak-to-peak.

The input circuit, using U1 (a CLC409), provides a gain of approximately +4 to +7.5, adjustable with VR1. An adjustable offset of  $\pm 1V$  is controlled by VR2. This can be used to ensure that the signal remains between the reference voltage of the ADC08351 and ground.

#### 4.2 ADC reference circuitry.

The ADC08351 under evaluation includes a  $V_{REF}$  pin which is connected to the supply voltage on the product evaluation board. The supply voltage may be adjusted using VR3 and may be monitored at TP2.

If the difference between the reference voltage and ground is small, or if the input signal does not use nearly all of the ADC08351 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 ADC08351 with a supply voltage and reference voltage between 2.7V to 3.6V, and driving the ADC08351 analog input with  $0.5V_{p-p}$  to  $1.0V_{p-p}$ , as measured at TP1.

#### 4.3 Board Outputs.

The digital data from the ADC08351 output and a clock signal for this data are available at 96 pin DIN Connector J7 (See Figure 2). Resistors (RP1 & RP2) are used to isolate the ADC08351 from circuits or instruments that the ADC drives.

#### 4.4 Power requirements.

Power to this board is supplied through power connector J1 at the right side of the board. Voltage and current requirements are:

- +5V at 50mA (1.0A)
- +5V and -5V at 20mA, each

Values in parentheses are current requirements with the Digital Interface Board connected.

The  $\pm 5V$  and 5V supplies use shunt diodes to protect the board from accidental polarity reversal, along with series ferrite bead RF chokes for minimizing power supply noise. Power for the ADC08351 is derived from the 5V applied to Power Input Connector J1.

### 5.0 Installing the ADC08351 Evaluation Board

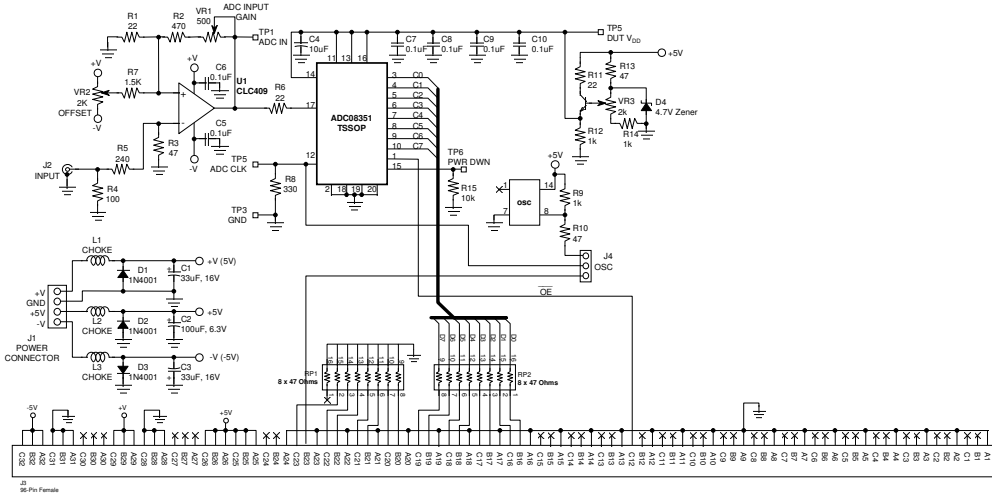
The evaluation board requires power supplies as described in paragraph 4.4. No input signals are generated on the board. An appropriate signal generator (such as the HP3325B, HP8662A or the Tektronix TSG130A) with 75-Ohm source impedance should be connected to the Analog Input BNC, J2.

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.

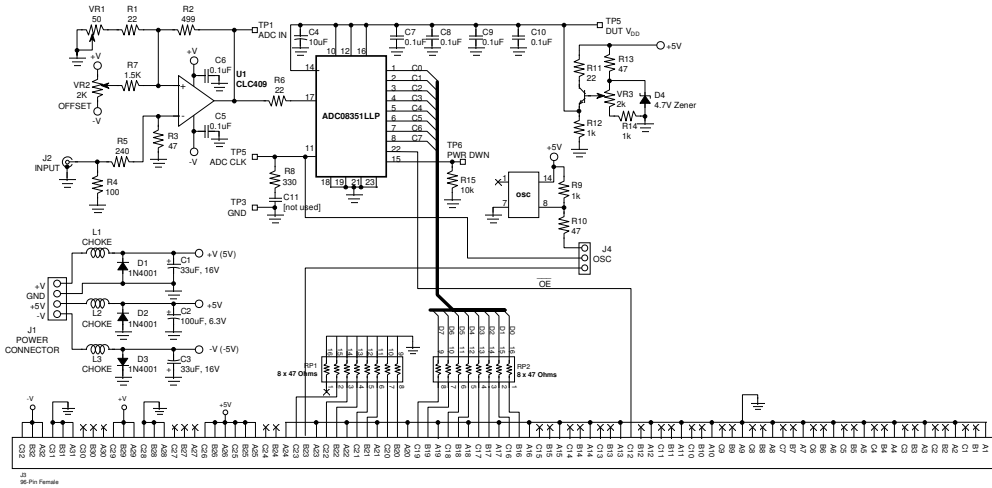
### 6.0 Evaluation Board Specifications

Board Size:	3.5" x 6.3" (8.9 x 16 cm)
Clock Frequency Range:	1 MHz to 40 MHz
Analog Input	
Nominal Voltage:	0.1V <sub>p-p</sub>
Impedance:	75 Ohms
Normal DUT Input Range:	0.5V to 1.0V

**7.0 Hardware Schematic**



**A. ADC08351 TSSOP Evaluation Board**



**B. ADC08351 LLP Evaluation Board**

**ADC08351 Evaluation Board Schematics**

**8.0 Evaluation Board Bill of Materials**

C1,C3	33uF	Type 7343 [D Size]
C2	100uF	Type 7343 [D Size]
C4	10uF, 6V	Type 3216 [A size]
C11	not used	--
D1, D2, D3	1N4001	Various
D4	1N4732 (4.7V Zener)	DigiKey # 1N4732AMSCT-ND
J4	3-PIN Post Header	DigiKey # A19351-ND
J2	BNC	DigiKey # ARF1177-ND
J1	2-Post Terminal Block [2 needed]	DigiKey # ED1605-ND
J3	96 Pin Female DIN Connector	DigiKey # H7096-ND
L1, L2, L3	RF Choke	DigiKey # M2204-ND
Q1	2N3904	TO-92
R1, R6, R11	22 $\Omega$	Type 1206
R2	470 $\Omega$	Type 1206
R3, R10, R13	47 $\Omega$	Type 1206
R4	82 $\Omega$	Type 1206
R5	240 $\Omega$	Type 1206
R7	1.5 k $\Omega$	Type 1206
R8	320 $\Omega$	Type 1206
R9, R12, R14	1 k $\Omega$	Type 1206
R15	10 k $\Omega$	Type 1206
RP1, RP2	8 X 47 $\Omega$	DigiKey # 4816P-1-470-ND
TP1, TP2, TP3, TP4, TP5, TP6	Breakable Header	DigiKey # S1012-36-ND
--	Shorting Jumper [1 needed]	DigiKey # S96001-ND
U1	CLC409AJP	National
U2	ADC08351CIMTC	National
VR1 (TSSOP)	500 $\Omega$ [Gain Adjust]	DigiKey # 3386F-501-ND
VR1 (LLP)	50 $\Omega$ [Gain Adjust]	DigiKey # 3386F-50-ND
VR2, VR3	2k $\Omega$ [Offset Adjust, DUT V <sub>DD</sub> Adjust]	DigiKey # 3386F-202-ND
Y1	20MHz Oscillator	DigiKey # CTX-119-ND
Socket	for U1	DigiKey # AE8914-ND
Socket	for Y1	DigiKey # A462-ND



## APPENDIX

### WaveVision and Computer Mode Operation with the Digital Interface Board

#### A1.0 Operating in the Computer (Automatic) Mode

When using the ADC08351 evaluation board with the Digital Interface Board for Computer mode operation, you should short pins 1 and 2 of Jumper J4 on the ADC08351 evaluation board. This connects the clock oscillator from the Digital Interface Board to the ADC08351's clock input pin. It is also a good idea to remove the crystal from the ADC08351 eval board for Computer mode operation to prevent noise problems.

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 VR3 for until 3.0V is seen at TP2. Adjust VR1 and VR2 for gain and offset, as desired.
3. Use WaveVision to set up the board (See the Digital Interface Board Manual). Remember that the clock frequency on the board is set by Program Switch of the Digital Interface Board. See the Digital Interface Board manual for more information.
4. Select the desired number of samples to acquire (ALT, P, B or CTRL-B. See the Digital Interface Board manual).
5. 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. Restore the full display by right clicking over the display.

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 Digital Interface Board manual).

#### A2.0 The Digital Interface Board and WaveVision Software

To fully evaluate the ADC08351 with minimal external equipment, you need the WaveVision Evaluation Kit (order number WAVEVISION BRD, WAVEVSN BRD 2.0 or WAVEVSN BRD 3.0). This kit consists of a Digital Interface Board that connects to the ADC08351 Evaluation board through the 96-pin DIN connector and a 3.5" program diskette with all the software needed to control the combined Digital Interface Board and ADC08351 Evaluation board. A serial cable is needed to connect the Digital Interface Board to an available serial port on the PC in use.

#### A3.0 Exploring the Video Waveform

WaveVision software and the ADC08351 Evaluation Board add a new tool to the video designer's toolbox. The evaluation board, together with the Digital Interface Board, can be used to capture a video signal. The captured data can then be displayed and performance parameters can be measured. See the Appendix of the Digital Interface Board manual for WaveVision screen drawings that show software operation.

**A3.1 Basic Waveform** After the ADC08351 Evaluation Board has uploaded a captured waveform to the PC, WaveVision displays this waveform on the computer monitor. The WaveVision software can be used to evaluate the ADC08351'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.

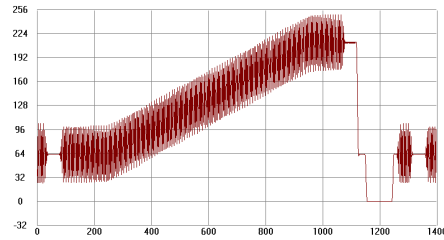


Figure 3. Modulated ramp of a video signal. The chroma level near black, subtracted from the chroma level near white will give an estimate of overall differential gain of the circuit.

Figures 4 and 5 show enlargements of the black level and the white level, respectively, of the signal in Figure 3.

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<sub>P-P</sub> with a 2V reference span.

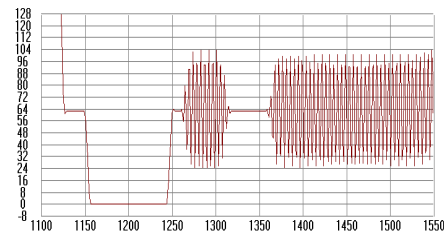


Figure 4. Enlargement of the black level area of the modulated ramp of Figure 3 showing the digital values of the chroma information.

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 3.0V at the reference input. 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 1 and Figure 2). 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.

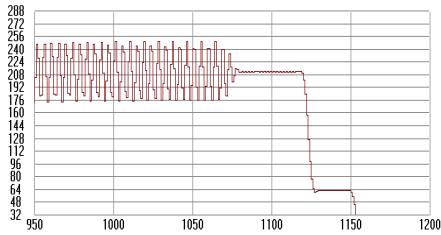


Figure 5. Enlargement of the white level area of the modulated ramp to be compared with the black level. The percentage difference between the two chroma levels is differential gain.

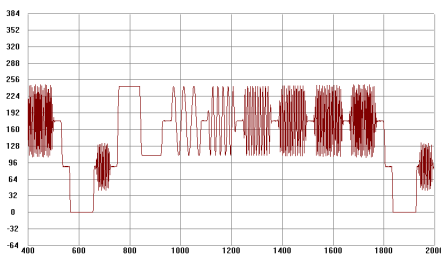


Figure 6. This multiburst signal shows the gain flatness of the overall circuit. Notice that all frequencies have about equal amplitude.

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

### 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 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 6 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 7). The individual frequencies are, in this case, 0.5 1, 2, 3, 3.58 and 4.2 MHz. The dynamic data to the right of the spectrum plot is useless for such data.

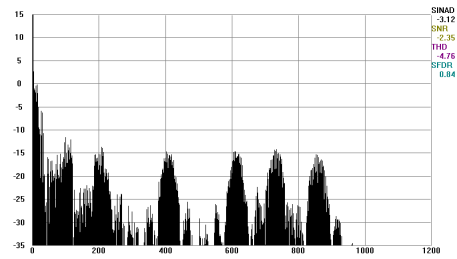


Figure 7. This FFT of the multiburst signal shows frequency on the horizontal axis, allowing a measurement of the bandwidth required for the burst of each frequency. This spectrum of the whole video signal indicates the bandwidth required to pass this signal without distortion.

### A3.1.3 Low Frequency Triangle Wave Input

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

#### A3.1.3.1 Monotonicity and Uncertainty

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 whether the slope of the ramp. A waveform with always increasing or decreasing codes is said to be monotonic, as in Figure 8a.

A converter that has one or more instances of codes consistently going in the wrong direction is said to be non-monotonic. See Figure 8b.

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. See Figure 9.

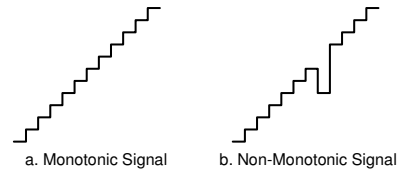


Figure 8. Monotonicity means codes are continually increasing or decreasing.

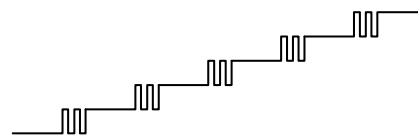


Figure 9. Code uncertainty when the ADC input voltage is near a code transition point.

**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 FFT plot are dynamic performance estimates of SINAD, SNR, THD and SFDR (Spurious-Free Dynamic Range). These readings are meaningful only for a sine wave input to the ADC and are accurate only to the extent that the input waveform is stable and contains a single frequency.

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 10 and 11 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.

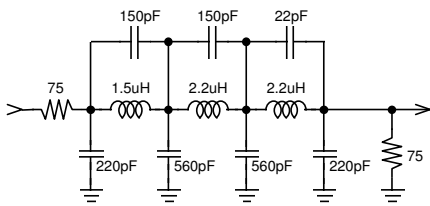


Figure 10 This 4MHz cutoff elliptic filter can be used for input frequencies of 1MHz to 4MHz. It should be driven by a generator of 75 Ohms source impedance and terminated with 75 Ohms. This termination is provided by the ADC08351 evaluation board. The input resistor shown here is normally the generator output impedance.

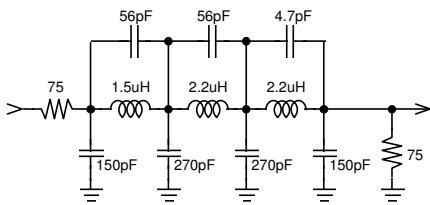


Figure 11 This elliptic filter has a cutoff frequency of about 11MHz and is suitable for input frequencies of 5MHz to 10MHz. Other comments relating to Figure 10 apply here.

The FFT plot, however, can provide other information from captured signals other than single frequency sinusoids. One example is shown in Figure 7.

**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 ADC08351's dynamic input range is used, and how many samples are taken.

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. 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 ADC08351's output, THD, SFDR and SINAD will be degraded.

Furthermore, apparent performance may be limited by the purity of the input signal used.

**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 Digital Interface Board manual.

**A4.1 Binary Files**

To save a binary file for use later by WaveVision, you can either 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, you may click on the Open File icon, enter ALT, E, 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, E, 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, E, 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 binary weighted number of samples.

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