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Rev D

# Evaluation Board Instruction Manual

## ADC78H89 8- Channel, 500 KSPS, 12-Bit Analog-to-Digital Converter

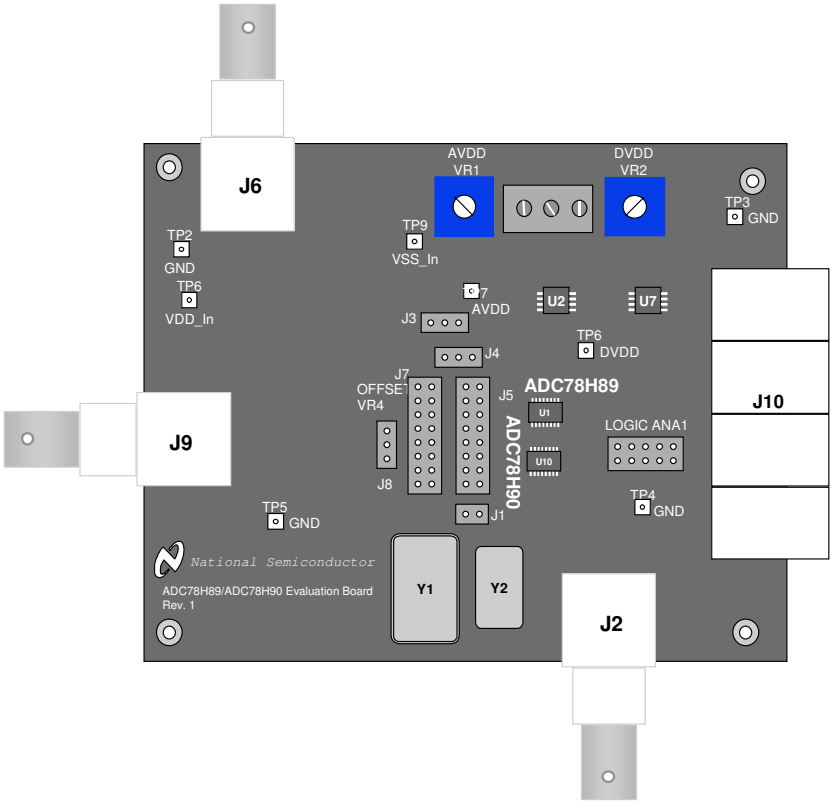

**Table of Contents**

## 1.0 Introduction

The ADC78H89EVAL Design Kit (consisting of the ADC78H89 Evaluation Board, National's WaveVision4 Capture Board and software and this manual) is designed to ease evaluation and design-in of National's ADC78H89 7-channel, 12-bit, 500 kilosamples per second Analog-to-Digital Converter. The ADC78H89 evaluation board includes one ADC78H89, along with input signal conditioning and power supply circuitry, and allows you to evaluate device performance while operating the board in either the standalone mode with a logic analyzer, or with the WaveVision4 Capture Board and a personal computer with WaveVision4 software.

For operation with a computer system, this evaluation board should be connected to a WaveVision4 Capture Board (National part number WAVEVSN BRD 4.0) The WaveVision software operates under Microsoft Windows. The analog signal(s) presented to the ADC78H89 are captured by the WaveVision data capture board, and displayed on the computer screen as a dynamic waveform, FFT, and histogram. The software also computes SNR, SINAD, THD, SFDR, and ENOB and displays them with the FFT plot.

The signal at the Analog Input to the board is digitized and is available at FutureBus connector J10. (See the board schematic and the Appendix).

Two board inputs are provided at BNC connectors J6 and J9. Jumper headers J5 and J7 allow these inputs to be connected to the desired input channel.

Provision is made to adjust the Analog and Digital supply voltages with potentiometers VR1 and VR2, respectively.

Note that there are two versions of this board. While they both are assembled such that the circuit is identical, one of these boards is intended only for the ADC78H89, while the other is intended for either the ADC78H89 and the ADC78H90. Each of these boards are labeled below the National Semiconductor logo as to device(s) supported.

## 2.0 Board Assembly

The ADC78H89 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 POWER1. Adjust power supply to a voltage of ±4.75V to ±5.25V before connecting it to the board. This voltage will be the maximum supply voltage for the ADC78H89. Section 4.7 describes what voltages are needed on each pin of power connector POWER1. Connect the power to the board.
3. Connect a voltmeter to TP7 and use VR1 to set the ADC78H89 analog supply voltage ($AV_{DD}$) for the desired value between +2.7V and +5.25V. Remember that the reference voltage is this supply voltage. Connect the voltmeter to TP6 and use VR2 to adjust the desired output driver voltage ($DV_{DD}$).
4. Put a jumper between pins 2 and 3 of J3, J4 and J8 of the board labeled for both the ADC78H89 **and** the ADC78H90, or between pins 3 and 4 of J3 and pins 2 and 3 of J8 for the board labeled only for the ADC78H89. Put a jumper between pins 1 and 2 of J5.
5. Connect a signal from a 50-Ohm source with a peak-to-peak value equal to the supply voltage set in step 3, above. Note that an appropriate filter should be used at the signal input to the board.
6. Observe the signal input to the ADC78H89 at the jumper of J5 and adjust the input signal level so that the signal at the jumper of J5 does not go below ground.
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, test all connections and be sure the power supply to the boards is turned on.
10. Click "Accept" then gather data by pressing F1 on the keyboard. Perform an FFT on the data by clicking on the FFT tab.
11. See the WaveVision Capture Board Manual for complete data gathering instructions.

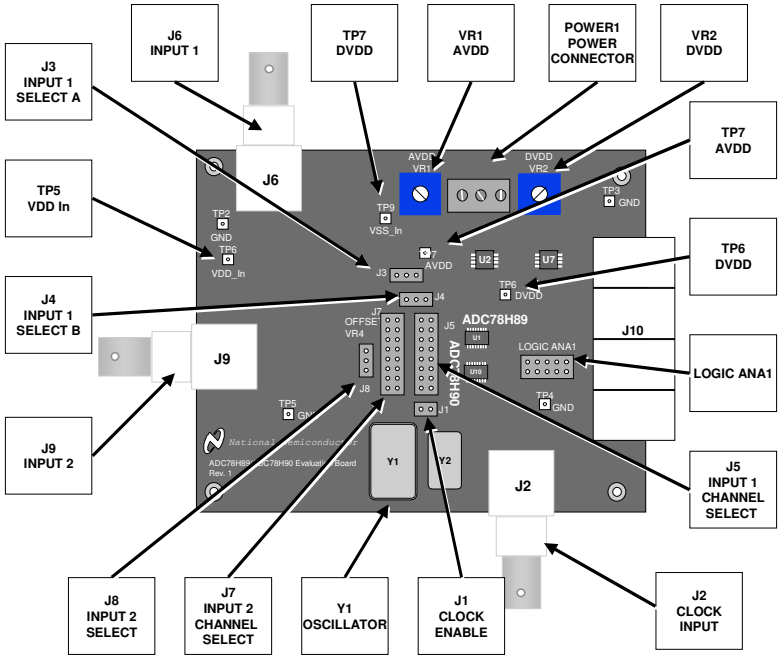


Figure 1. Component and Test Point Locations

## 4.0 Functional Description

The ADC78H89 Evaluation Board component and test point 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 J6 or J9 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 analog supply voltage. However, many signal generators can not provide a $5V_{P-P}$ signal, especially after that signal is passed through a filter. To accurately evaluate the ADC78H89 dynamic performance, the input test signal should be a single frequency passed through a high-quality bandpass filter as described in Section 5.0.

### 4.2 The ADC reference

The reference voltage for the ADC78H89 is the analog supply voltage. Therefore, adjusting the analog supply voltage (with VR1) will change the full scale range of the ADC78H89. Since the operational supply voltage range of the ADC78H89 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 connector J2 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 clock source should be mounted/connected at a time.

### 4.5 Digital Data Output.

The digital output data from the ADC78H89 is available at Header LOG ANA1 for connection to a logic analyzer. Data is transferred over FutureBus J10 for use with the WaveVision Capture Board.

### 4.6 Power Supply Connections

Power to this board is supplied through power connector POWER1. The only voltage needed for the ADC78H89 evaluation board is a +2.7V to +5.25V supply as described in Section 4.7, below.

When using the ADC78H89 Evaluation Board with the WaveVision Capture Board, the 5V logic power supply for that Capture board is passed to the ADC78H89 evaluation board through pins A1, B1, A2 and B2 of J10. However, that voltage is not connected to the power header POWER1. If it is desired to use the +5V from the WaveVision Capture board for the ADC78H89 evaluation

board, it is necessary to add a wire from A1, B1, A2 or B2 of J10 to pin 3 of POWER1.

### 4.7 Power Requirements

Voltage and current requirements for the ADC78H89 Evaluation Board are:

- Pin 1 of POWER1: +2.7V to 5.25V at 10 mA
- Pin 2 of POWER1: Ground
- Pin 3 of POWER1: Ground

### 4.8 Analog Inputs

The ADC78H89 evaluation board includes two complete input channels, each composed of termination and level shifting components.

You may select the input signal to be a.c. coupled or d.c. coupled to the input signal to the ADC78H89. See the schematics (Figures 2a and 2b) to determine connections of J3/J8 to a.c. couple or d.c. couple the input signal to the ADC78H89.

**Caution:** Be sure that the input signals to the ADC78H89 do not go more negative than -0.3V or go more than 0.3V above $AV_{DD}$.

The following table indicates how to use J5 and J7 to select the ADC input to which each signal is presented.

| Short Pins of J5/J7 | To Select Channel |
|---|---|
| 1 - 2 | AIN1 |
| 3 - 4 | AIN2 |
| 5 - 6 | AIN3 |
| 7 - 8 | AIN4 |
| 9 - 10 | AIN5 |
| 11 - 12 | AIN6 |
| 13 - 14 | AIN7 |

## 5.0 Installing and Using the ADC78H89 Evaluation Board

The evaluation board requires power supplies 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 BNCs, J6/J9. A bandpass filter should be inserted between the generator output and the input to the ADC78H89 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 manual for details.

#### 5.1 Software Installation

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

#### 5.2 Setting up the ADC78H89 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 ADC78H89. 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 connectors, test points and jumpers on the board.

1. Connect The ADC78H89 evaluation board to WaveVision Capture Board, WAVEVSN BRD 4.0.
2. Connect desired jumpers to J3, J5, J7 and J8.
3. Connect power to the board per requirements of paragraph 4.7.
4. Connect an USB cable between the Capture Board and an USB port on your computer.
5. Apply power to both the WaveVision Capture Board and the ADC78H89 evaluation board.
6. Connect an appropriate test signal source to BNC connector J6 of the ADC78H89 evaluation board through an appropriate filter. If d.c. coupling of the signal is used, adjust the signal source offset voltage for the proper signal range. See Section 4.8.

#### 5.2.2 Quick Check of Analog Functions

Refer to Figure 1 for locations of connectors, test points and jumpers 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 ADC78H89 analog supply voltage (and reference voltage) at TP7.
3. Adjust VR2 for the desired ADC78H89 digital output driver supply voltage at TP6.
4. Scope J5/J7 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 4 of Paragraph 5.2.2, above.
2. Adjust the signal source at Test Point TP1 for a peak-to-peak signal amplitude at J5/J7 very slightly below the value of the d.c. voltage at TP7.
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 clicking pressing the computer 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 click and drag (top left to bottom right) to select a 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 ADC78H89.

**Note:** Be sure to use a bandpass 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, but can lead to inconsistent results.

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. This is called coherent sampling, which 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. 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.

Furthermore, $f_{in}$ (signal input frequency) and $f_S$ (sampling rate) should be synchronized with each other to ensure the proper ratio of $f_{in}/f_S$.

Windowing (an FFT Option under WaveVision) should be turned off for coherent sampling.

#### 5.2.5 Troubleshooting

If 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 ADC78H89 evaluation board has power, and that the ADC78H89 evaluation board is properly connected to and properly seated with the WaveVision Capture Board.

If this does not resolve the problem, press the "TEST" button.

If the problem persists, under "Board Type" of the open window, select any board except WaveVision 4, then select WaveVision 4 again.

If there is no output from the ADC78H89, perform the following:

- Be sure that shorting jumpers are appropriately on J3, J5, J7 and J8, plus J4 of board for both ADC78H89 and AND78H90.
- Be sure that the proper voltages and polarities are present at Power Connector P1.
- Be sure that a negative supply voltage is present at pin 2 of the power connector POWER1.
- Check to see that the ADC78H89 input signal does not go below ground or above the ADC78H89 analog supply voltage ($AV_{DD}$).
- Be sure a clock signal is present at ADC78H89 pin 16.

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

- Be sure that shorting jumpers are appropriately on J3, J5, J7 and J8, plus J4 of board for both ADC78H89 and AND78H90.
- Check to see that the ADC78H89 input signal does not go below ground or above the ADC78H89 analog supply voltage ($AV_{DD}$).
- Be sure that a minimum of +2.7V is at POWER1 connector pin 1 and that there is a minimum of +2.7V at TP7 (adjust with VR1) and at TP6 (adjust with VR2).

## 6.0 Evaluation Board Specifications

| | |
|---|---|
| Board Size: | 4.5" x 3.65" (11.4 cm x 9.3 cm) |
| Power Requirements: | + 5V ±5% @ 10 mA |
| Clock Frequency Range: | 800 kHz to 8 MHz |
| Analog Input | |
| Nominal Voltage: | $V_{P-P}$ equal to $AV_{DD}$ supply |

| | |
|---|---|
| Impedance: | 50 Ohms |

## 7.0 Hardware Schematic

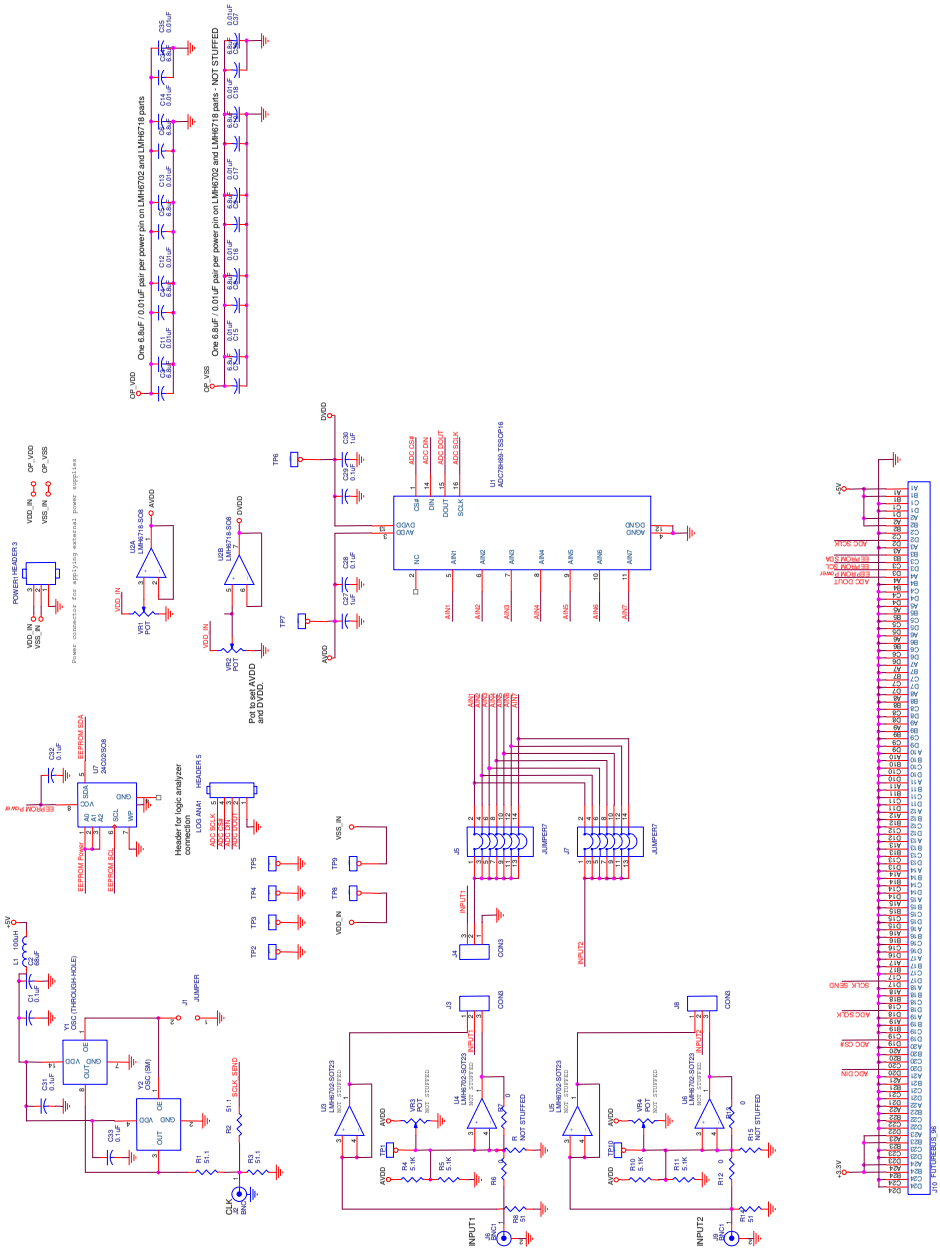

Figure 2a. ADC78H89/ADC78H90 Evaluation Board Schematic, Board for ADC78H89 only

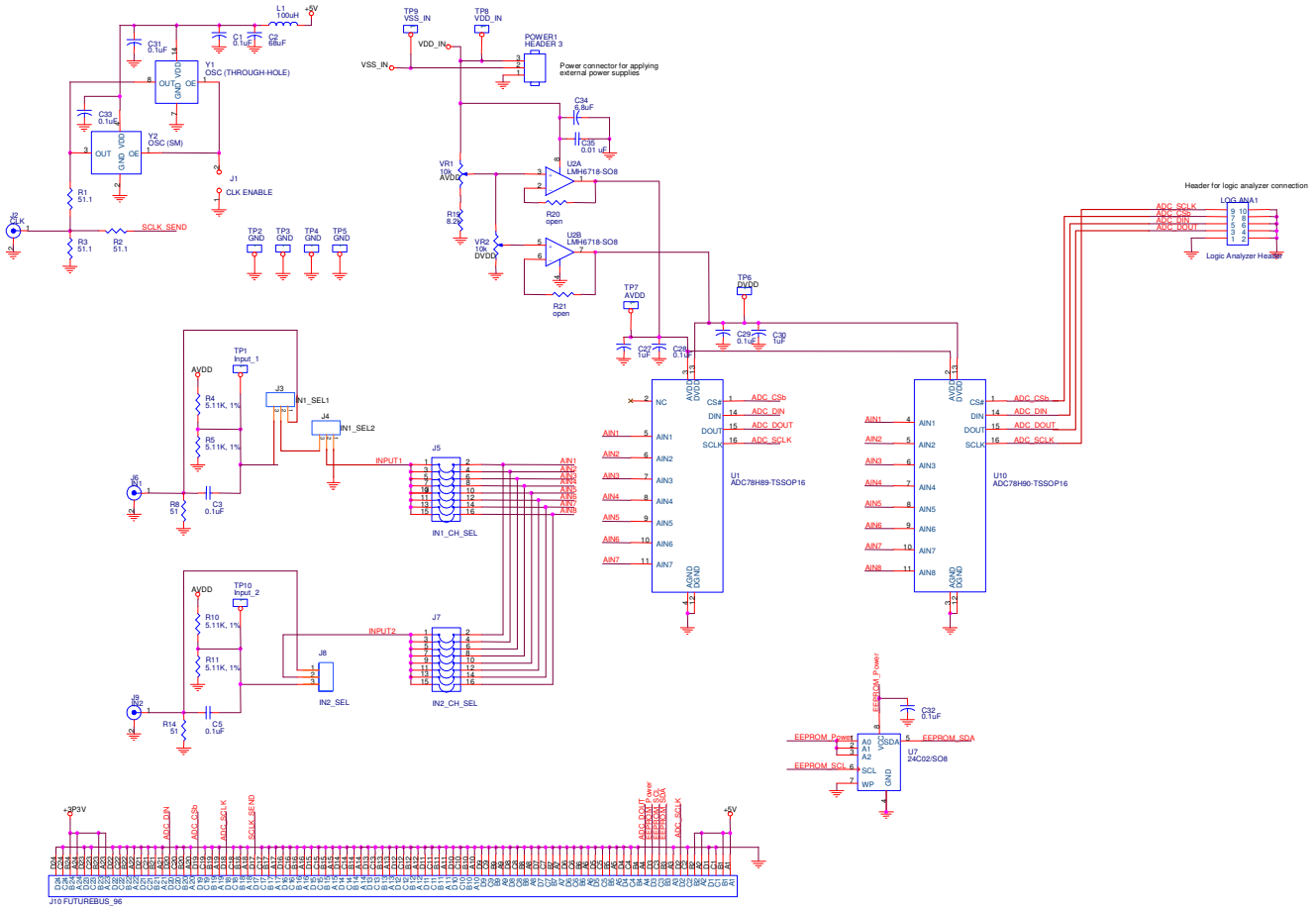

Figure 2. ADC78H89 / ADC78H90 Evaluation Board Schematic

## 8.0 ADC78H89 Evaluation Board Bill of Materials

October 12, 2005

| Item | Qty | Reference | Part | Source |
|---|---|---|---|---|
| 1 | 8 | C1, C3, C5, C28, C29, C31, C32, C33 | 0.1uF | Size 0402, Type X7R |
| 2 | 1 | C2 | 68uF | Size 7343 |
| 3 | 1 | C34 | 6.8uF | Size 3216 |
| 4 | 1 | C35 | 0.01uF | Size 0402 |
| 5 | 2 | C27, C30 | 1uF | Size 0805 |
| 6 | 1 | C19 | 0 Ohm Resistor | Size 1206 |
| 7 | - | C4, C6, C8, C10, C12, C14, C16, C18, C36, C37 | Not Used | n/a |
| 8 | 1 | J1 | 2-Pin Post Header | DigiKey # A19350-ND |
| 9 | 3 | J2, J6, J9 | BNC Connector | DigiKey # ARF1177-ND |
| 10 | 2 | J3, J4 (bd rev 1 only) | 3-Pin Post Header | DigiKey # A19351-ND (bd rev 1 only) |
| 11 | 1 | J8 | 3-Pin Post Header | DigiKey # A19351-ND |
| 12 | 1 | J3 (bd rev 2 only) | 2 x 3-Pin Header | DigiKey # WM6806-ND (bd rev 2 only) |
| 13 | 2 | J5, J7 | 2 x 7 pin Post Header | DigiKey # 10-89-2141-ND |
| 14 | 4 | J10 | FUTUREBUS Connector | AMP/Tyco 536501-1 |
| 15 | 1 | LOG ANA1 | 2 x 5 pin Post Header | DigiKey # 10-89-2101-ND |
| 16 | 1 | L1 | 100uH Inductor | DigiKey # 445-1152-1-ND |
| 17 | 1 | POWER1 | 3-Pin Terminal Block | DigiKey # ED1610-ND |
| 18 | 2 | R8, R14 | 51 Ohms, 0.1W, 5% | Size 0402 |
| 19 | 2 | R2, R3 | 51.1 Ohms, 0.1W, 1% | Size 0402 |
| 20 | 4 | R4, R5, R10 R11 | 5.1k Ohms, 0.1W, 5% | Size 0402 |
| 21 | 2 | R6, R12 | 0.1 uF capacitor | Size 0402 |
| 22 | 2 | R19 | 8.2K Ohms, 0.1W, 5% | Size 0402 |
| 23 | 4 | R1, R7, R13, R16, | 0 Ohms | Size 0402 |
| 24 | - | R9, R15, R17, R18 R20, R21 | open - not used | n/a |
| 25 | 1 | TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10 | Breakaway Header | DigiKey # S1012-36-ND |
| 26 | 1 | U1 | ADC78H89CIMT | n/a |
| 27 | 1 | U2 | LMH6718-SO8 | National Semiconductor |
| 28 | 2 | U4, U6 | Not Used | n/a |
| 29 | 1 | U7 | 24C02/SO8 | Various |
| 30 | 1 | U10 | Not Used | National Semiconductor |
| 31 | 2 | VR1, VR2 | 10K Ohm Potentiometer | DigiKey # 3386F-103-ND |
| 32 | - | VR3, VR4 | Not Used | n/a |
| 33 | 1 | Y1 | 8 MHz OSC (Through-Hole) | Pletronics #P1145-HC-8.0M or DigiKey # CTX112-ND |
| 34 | - | Y2 - optional, not provided | OSC (Surface Mount) | DigiKey # XC320-ND |
| 35 | 1 | OSC Socket | For Y1 | DigiKey # A400-ND |
| 36 | 6 | Shorting Jumpers | for J3, J5, J7, J8 | DigiKey #S9601-ND |

# APPENDIX

## Summary Tables of Test Points and Connectors

### Test Points on the ADC78H89 Evaluation Board

| | |
|---|---|
| TP 1 | Offset Adjust 1 (J6 Input signal appears here) |
| TP 2 | Ground |
| TP 3 | Ground |
| TP 4 | Ground |
| TP 5 | Ground |
| TP 6 | $DV_{DD}$ |
| TP 7 | $AV_{DD}$ |
| TP 8 | $V_{DD}$ Input |
| TP 9 | $V_{SS}$ Input (Ground) |
| TP 10 | Offset Adjust 2 (J9 Input signal appears here) |

### P1 Connector - Power Supply Connections

| | | |
|---|---|---|
| POWER1-1 | GND | Power Supply Ground |
| POWER1-2 | 0V | Negative Supply (Ground) |
| POWER1-3 | +2.7V to +5.25V | Positive Power Supply |

### LOG ANA1 - Logic Analyzer Header

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

### J1 - Clock Enable

| | |
|---|---|
| none | Clock at Y1 or Y2 is disabled **IF** oscillator has enable pin |
| 1 - 2 | Clock at Y1 or Y2 is enabled |

### J3 - Input Select from J6 (Board for ADC78H89 only)

| | |
|---|---|
| 1 - 2 | Select direct connection without level shifting |
| 2 - 3 | Select level shifting amplifier |

### J3 - Input Select from J6 (Board for either ADC78H89 or ADC78H90)

| | |
|---|---|
| 1 - 2 | Select direct connection without level shifting |
| 3 - 4 | Use level shifting |
| 5 - 6 | Ground the input |

### J4 - Input Select from J9 (Board for ADC78H89 only)

| | |
|---|---|
| 1 - 2 | Ground Input selected with J5 |
| 2 - 3 | Input selected with J5 has signal from BNC J6 |

### J5 - Input 1 Select

| | |
|---|---|
| pins 1, 3, 5, 7, 9, 11, 13, 15 | Input from J6 |
| pin 2 | AIN1 ADC78H89/ADC78H90 Input |
| pin 4 | AIN2 ADC78H89/ADC78H90 Input |
| pin 6 | AIN3 ADC78H89/ADC78H90 Input |
| pin 8 | AIN4 ADC78H89/ADC78H90 Input |
| pin 10 | AIN5 ADC78H89/ADC78H90 Input |
| pin 12 | AIN6 ADC78H89/ADC78H90 Input |
| pin 14 | AIN7 ADC78H89/ADC78H90 Input |
| pin 16 | AIN8 ADC78H90 Input |

### J7 - Input 2 Select

| | |
|---|---|
| pins 1, 3, 5, 7, 9, 11, 13, 15 | Input from J9 |
| pin 2 | AIN1 ADC78H89/ADC78H90 Input |
| pin 4 | AIN2 ADC78H89/ADC78H90 Input |
| pin 6 | AIN3 ADC78H89/ADC78H90 Input |
| pin 8 | AIN4 ADC78H89/ADC78H90 Input |
| pin 10 | AIN5 ADC78H89/ADC78H90 Input |
| pin 12 | AIN6 ADC78H89/ADC78H90 Input |
| pin 14 | AIN7 ADC78H89/ADC78H90 Input |
| pin 16 | AIN8 ADC78H90 Input |

### J8 Input Select

| | |
|---|---|
| 1 - 2 | Select d.c. connection without level shifting for input at J9 |
| 2 - 3 | Use input level shifting for input at J9 |

### 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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