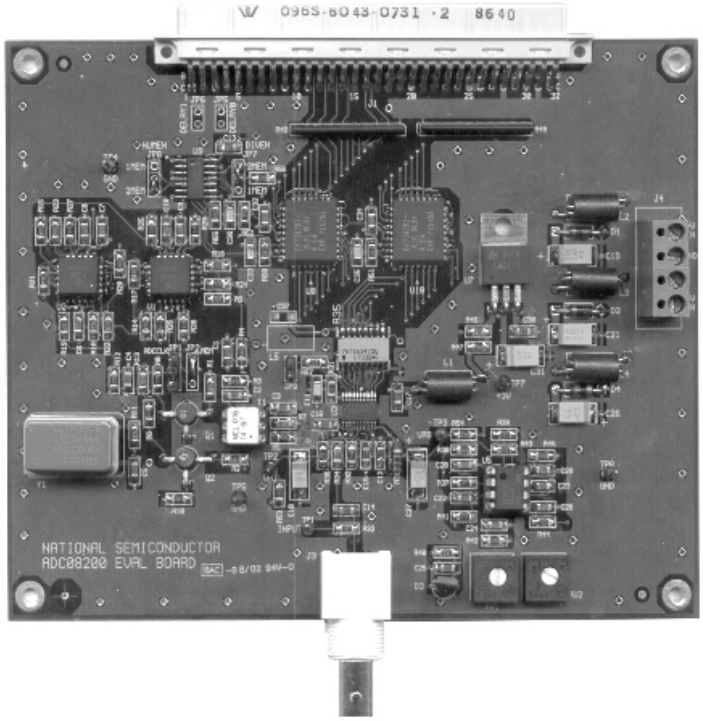
National Semiconductor

December 2005
Rev 7

Evaluation Board Instruction Manual

ADC08200 8-Bit, 10 MSPS to 230 Msps, Analog-to-Digital Converter with Internal Sample & Hold



[Blank Page]

Table of Contents

[Blank Page]

1.0 Introduction

The ADC08200EVAL Design Kit (consisting of the ADC08200 Evaluation Board, National Semiconductor's WaveVision© software and this manual) is designed to ease evaluation and design-in of Nationals ADC08200 8-bit Analog-to-Digital Converter, which operates at sample rates up to 230 Msps.

The WaveVision software operates under Microsoft Windows®. The signal at the Analog Input is digitized and can be captured and displayed on the computer monitor as dynamic waveforms. The digitized output is also available at Euro connector J1.

The software can perform an FFT on the captured data upon command. This FFT display also shows dynamic performance in the form of SNR, SINAD, THD and SFDR.

Evaluation with this system is simplified by connecting the board to the WaveVision Digital Interface Board (order number WAVEVSN BRD 3.0), which is connected to a personal computer through a serial communication port and running WaveVision software, operating under Microsoft Windows. Use program WAVEVSN2.EXE, available at National Semiconductor's web site.

The signal at the Analog Input to the board is digitized and is available at pins B16 through B19 and C16 through C19 of J1. Pins A16 through A21 of J1 are ground pins.

Provision is made for adjustment of the Reference Voltages, V_{RT} and V_{RB} with potentiometers VR1 and VR2, respectively. These voltages are regulated with an LM4040-2.5 reference.

2.0 Board Assembly

The ADC08200 Evaluation Board comes pre-assembled but may be obtained as a bare board that must be assembled. 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 Digital Interface Board (order number WAVEVSN BRD 3.0). See the Digital Interface Board Manual for operation of that board.
2. Install a 200 MHz (or lower) oscillator into socket Y1. While the oscillator may be soldered to the board, using a socket will allow you to easily change clock frequencies.
3. Connect a clean power supply to the terminals of connector P1. Adjust power supply to voltages of +4.75V to +5.25V at pins 1 and 3 and -5.2 to -5.3V at pin 4 (ground is pin 2) before connecting it to the board. Turn on the power and confirm that there is 3 Volts at TP7 or at the pins of inductor L1.
4. Use RV1 to set the top reference voltage (V_{RFT}) for the ADC to 1.9V ±0.05V at TP2. Use RV2 to set the bottom reference voltage (V_{RFB}) for the ADC to 0.3V ±0.05V at TP3.
5. Connect the jumper at JP1 to pins 2 and 3 (those closest to Q1) to use oscillator Y1 frequency without dividing it by 2.
6. If they are not hard wired, connect the jumper at JP2 and JP8 to pins 2 and 3 (those closest to input BNC J3) and the jumper at JP7 to pins 1 and 2 (those farthest fro input BNC J3) to use both FIFOs U8 and U10.
7. Connect a signal of $1.6V_{P-P}$ amplitude from a 50-Ohm source to Analog Input BNC J3. The ADC input signal can be observed at TP1. Because of isolation resistor R32 and the scope probe capacitance, the input signal at TP1 will not have the same frequency response as will the ADC input signal.
8. The Digital Interface Board should be set up for10 MHz operation with an 80MHz oscillator installed. See the Digital Interface Board manual.
9. See the Digital Interface Board Manual for data gathering instructions.

NOTE: The FFT will not indicate the correct frequencies because this information is derived from the clock frequency selected on the Digital Interface Board. To show the correct frequency information on the FFT, double click on the FFT window to open the FFT Dialog Box, then click on "Frequency", enter the sample rate in MHz, then click on "OK". Alternatively, you may double click on the data capture window before performing the FFT and change the frequency at "Sampling Rate of This Data (MHz)" to 200 to indicate a 200 MHz sample rate.

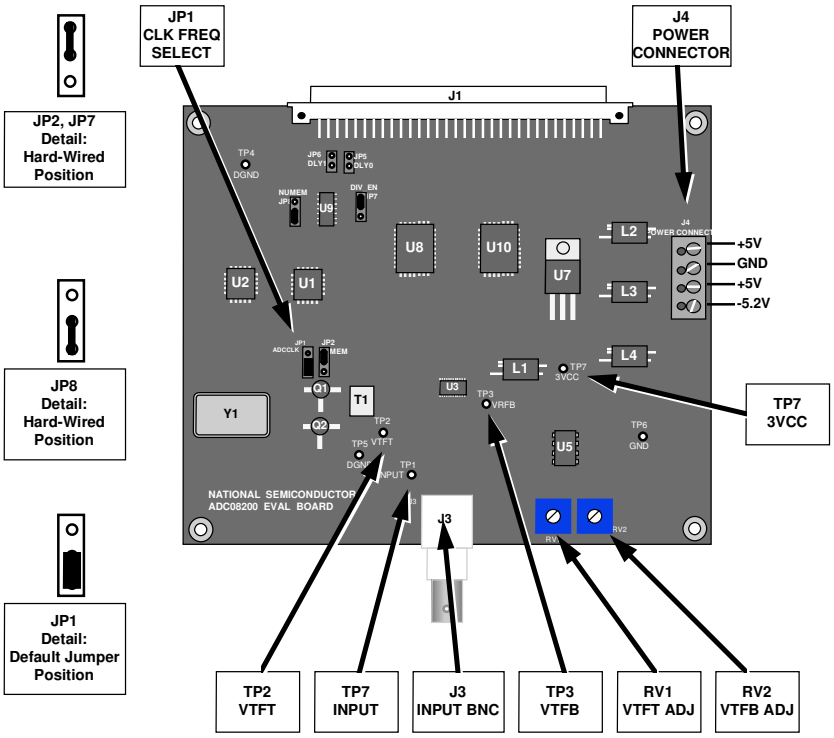


Figure 1. Component and Test Point Locations

4.0 Functional Description

The ADC08200 Evaluation 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. This 50 Ohm input is intended to accept a low-noise sine wave signal of 1.6V peak-to-peak amplitude. To accurately evaluate the ADC08200 dynamic performance, the input test signal should be passed through a high-quality bandpass filter (60dB minimum stop-band attenuation) as even the best signal sources do not provide a pure enough sine wave to properly evaluate an ADC.

The input to the ADC08200 is a.c. coupled through capacitor C14. Resistors R33A and R33B provide the needed input bias to the ADC08200. If d.c. coupling is desired, be sure that the input signal remains within the limits set by V_{RT} at TP2 and V_{RB} at TP3.

4.2 ADC reference circuitry

The provided reference circuitry will provide nominal reference voltage ranges of 1.3V to 2.5V for V_{RFT} and 0V to 1.3V for V_{RFB}, Providing for nominal input ranges of 0V to 2.5V peak-to-peak.

The reference voltages for the ADC08200 can be monitored at test points TP2 and TP3 and are set with RV1 and RV2. Signal offset can be provided by adjusting both of these potentiometers.

4.3 ADC clock circuit

The board is shipped ready to accept an ECL clock oscillator at a frequency of your choosing and is shipped without an oscillator in its socket. 200 MHz oscillators are not readily available, but a suitable 200 MHz oscillator is available from Pletronics, Inc. as their part number EC1145ME-200.0MPST.

Note that the divide by 2 function (JP1) does not function. A lower clock frequency requires the use of a lower frequency oscillator.

An ECL-level crystal oscillator may be installed at Y1, or the desired frequency may be applied to pin 8 of the Y1 socket. The signal level should be ECL levels.

Caution: Be sure that the oscillator used has the above suggested levels. We have found oscillators with levels outside of this range will not work properly in the circuit designed for this board.

R31 and C11 are used for high frequency termination of the clock line. An 80MHz clock oscillator should be used on the Digital Interface Board with that board's clock divider set for 4. See the Digital Interface Board manual for details on setting the clock divider.

Note that the reported sample rate is the rate at which the FIFO is read, so it is necessary to manually change this by double clicking on the data window after each data capture and changing the sample rate to that actually used.

4.4 Digital Data Output.

The digital output data from the ADC08200 is available at the 96-pin Euro connector J1. The series resistors of R35 isolate the ADC from the load circuit to reduce noise coupling into the ADC.

4.5 Power Supply Connections

Power to this board is supplied through power connector J4. The ADC08200 evaluation board requires +5V at pins 1 and 3 and -5.2V at pin 4. Pin 2 is ground.

When using the ADC08200 Evaluation Board with the Digital Interface Board, the 5V logic power supply for the interface board is passed through the ADC08200 evaluation board from pin 3 of Power Connector J4. The supply voltages are protected by shunt diodes D1, D2 and D4. The +3 Volts needed for the ADC08200 is provided with voltage regulator U7, an LM317T.

4.6 Power Requirements

Voltage and current requirements for the ADC08200 Evaluation Board are:

- Pin 1 of P1: +5.0V ±5% at 3 mA
- Pin 3 of P1: +5.0V ±5% at 1.0 A.
- Pin 4 of P1: - 5.2V to -5.3V at 250 mA.

Pin 2 of J4 is ground. The +5V supply at pin 3 of the Power Connector P1 provides the power to the Digital Interface Board, where most of the power through this pin is consumed.

5.0 Installing and Using the ADC08200 Evaluation Board

The evaluation board requires power supplies as described in Section 4.6. An appropriate signal source (such as the HP3325B, HP8662A or the Tektronix TSG130A) with 50 Ohm source impedance should be connected to the Analog Input BNC J3. The generator output should be filtered by a bandpass filter when evaluating sinusoidal signals to be sure there are no unwanted frequencies (harmonics and noise) presented to the ADC. A cable with a DB-9 connector must be connected between the Digital Interface Board and the host computer. See the Digital Interface Board manual for details.

5.1 Software Installation

The WaveVision software provided requires 300k bytes of hard drive space and will run under Windows.

1. Insert the disk into a 3.5" floppy drive.
2. Copy the program WAVEVSN2.EXE to the desired subdirectory on you computer's hard disk and RUN it.

Alternatively, you may download the shoftware from national Semiconductor's ADC web site.

5.2 Setting up the ADC08200 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 ADC08200. 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.

5.2.1.1 Computer Mode Operation

1. Be sure a 200MHz clock oscillator (Y1) is in place on the ADC08200 evaluation board and an 80MHz oscillator is on the Digital Interface board.
2. Set jumper JP1 to its default position, as shown in *Figure 1* so that the clock oscillator frequency is NOT divided by two for the ADC08200.
3. Connect The ADC08200 evaluation board to Digital Interface Board, WAVEVSN BRD 3.0.
4. Connect a cable with DB-9 connector between the Digital Interface Board connector P1 and a serial port on your computer.
5. Connect power to the board per requirements of section 4.6.
6. Connect an appropriate signal source to BNC connector J3 of the ADC08200 evaluation board. Rebember to use an appropriate filter, as discussed in sections 4.1 and 5.0.
7. Capture data by clicking on the sine wave icon of the WaveVision software, or press CTRL-X on the keyboard.

5.2.1.2 Manual Mode Operation

1. Perform steps 1, 2 and 5 of section 5.2.1.1, above.
2. Monitor the ADC08200 output at 96-pin connector J1 pins B16 through B19 and C16 through C19 (see appendix for pin assignments).
4. Clock the data out with a TTL clock of any speed up to 200 MHz at pin B15 of 96-pin connector J1.

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 5.2.6 on Troubleshooting.

1. Perform steps 1 through 6 (steps 3 and 4 are optional here) of Section 5.2.1.1.
2. Checl for the presence of correct d.c. voltages at power connector J4, as called for in section 4.6.
3. Check TP7 or either terminal of L1 for the presence of a voltage between 2.7V and 3.3V.
4. JP1 - Short the two pins closest to Q1 (pins 2 & 3) to NOT divide the on-board clock oscillator by 2.
5. Adjust RV1 for a voltage of 1.87V to 1.93V at TP2.
6. Adjust RV2 for a voltage of 0.27V to 0.33V at TP4.
7. Adjust the signal source at Analog Input J3 for a signal amplitude of approximately $1.6V_{P-P}$ and check for the presence of that signal at TP1.

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 5 of Section 5.2.1.1, above.
2. Supply a 1.6Vp-p sine wave of 1 MHz to 50MHz at Analog Input BNC J3.
3. Be sure there is an interconnecting cable between the board and your computer serial port.
4. RUN program WAVEVSN2.EXE.
5. After turning on the power, be sure to wait for yellow LED D4 on the Digital Interface Board to go out (about 5 seconds) before trying to acquire data or the board will "freeze" and you will have to cycle the power.
6. Acquire data by clicking on the ACQUIRE icon or by pressing ALT, P, A or CTRL-X. Data transfer can take a few seconds.
7. 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.
8. Double click on the data window and change the "Sampling Rate of this data (MHz)" to 200. This must be done each time another data capture is done or the frequency information in the FFT will not be correct.
9. With the mouse, you may click and drag to select a portion of the displayed waveform for better examination.
10. Click on the FFT icon or type ALT, P, F or CTRL-F to calculate the FFT of the data and display a frequency domain plot.

The FFT data will provide a measurement of SINAD, SNR, THD and SFDR, easing the performance verification of the ADC08200. Note that the readings may not accurately reflect the ADC08200's actual performance unless an input filter is used, as explained in sections 4.1 and 5.0, and unless the sampling is coherent, as explained below.

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 the measurements would indicate.

We can eliminate the need for windowing and get more consistent results if we observe the proper ratios between the input and sampling frequencies. This greatly increases the spectral resolution of the FFT, allowing 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 an integer number and SS, the number of samples in the data record, must be a factor of 2 integer. For optimum results, CY should also be a prime number.

Further, f_{in} (signal input frequency) and f_S (sampling rate) should be locked to each other. 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 be turned off for coherent sampling.

5.2.5 Jumper Information

Table 1 indicates the function and use of the jumpers on the ADC08200 evaluation board. JP2, JP7 and JP8 are hard-wired for 2 memory chips.

JUMPER	FUNCTION	PINS 1 & 2 SHORTED	PINS 2 & 3 SHORTED
JP1	Clock Select	Divide Clock by 2	Do not Divide Clock
JP2	No of Mem Chips	1 Mem Chip	2 Mem Chips
JP7	No of Mem Chips	2 Mem Chips	1 Mem Chip
JP8	No of Mem Chips	1 Mem Chip	2 Mem Chips

Table 1. Jumper settings.

5.2.6 Troubleshooting

"Comm Check Failed", "Error Transmitting", "Parallel Port Time Out Error" and/or "Failed to communicate with the board on LPT1" errors mean communication was unsuccessful. Try the following:

- Be sure to wait for yellow LED D4 on the Digital Interface Board to go out after turning on power before trying to capture data.
- Be sure that the Digital Interface Board is connected to a serial printer port and has power.
- Be sure the proper port is selected (type ALT-O).
- Ascertain that an 80MHz clock oscillator is properly inserted into the socket at Y1 of the Digital Interface Board and that the DIP switches on the Digital Interface Board are properly set (see the Digital Interface Board manual). Check to see that LEDs D1 and D3 of the Digital Interface Board are on. See the Digital Interface Board manual for their functions.
- Be sure cable connections are solid.
- Be sure that the board to computer cable is not a Null Modem type. If it is, swap the jumpers J8 and J10 on the Digital Interface Board.

If there is no output from the ADC08200, perform the following:

- Be sure that the proper voltages and polarities are present at Power Connector P1 (especially the -5.2V).
- Be sure +3 Volts is present on terminals of L1, or at TP7.
- Be sure that R57 is mounted correctly. See http://www.national.com/appinfo/adc/files/ADC08200-R57.pdf.
- Be sure there is an input signal at J3 and TP1 and that the signal source and input filter are of compatible frequencies.
- Be sure positions JP2, JP7 and JP8 are wired.

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

- Be sure clock Y1 is of the proper frequency (200MHz) and type (ECL with output swing between -0.6V and -1.3V).
- Be sure positions JP2, JP7 and JP8 are wired.

Problem Opening Comm Port" or "Error Setting Comm State" errors mean that the comm port selected is not the one to which the eval board is connected.

Inconsistent or poor performance could be caused by reading the FIFO too fast. Reading fo the FIFO should be done at 10 MHz. See Digital Interface Board manual for information on setting the sampling frequency of that board.

6.0 Evaluation Board Specifications

Board Size:	4.8" x 6.0" (12.2cm x 15.2 cm)
Power Requirements:	+ 5V ±5% @ 3.0 mA
(see Section 4.6)	+ 5V ±5% @ 1 Amp
	- 5.2V to -5.3V @ 250 mA
Clock Frequency Range:	10 MHz to 230 MHz
Analog Input	
Nominal Voltage:	$1.6V_{P-P}$
Frequency Range	50 KHz to 400 MHz
Impedance:	50 Ohms

7.0 Hardware Schematic

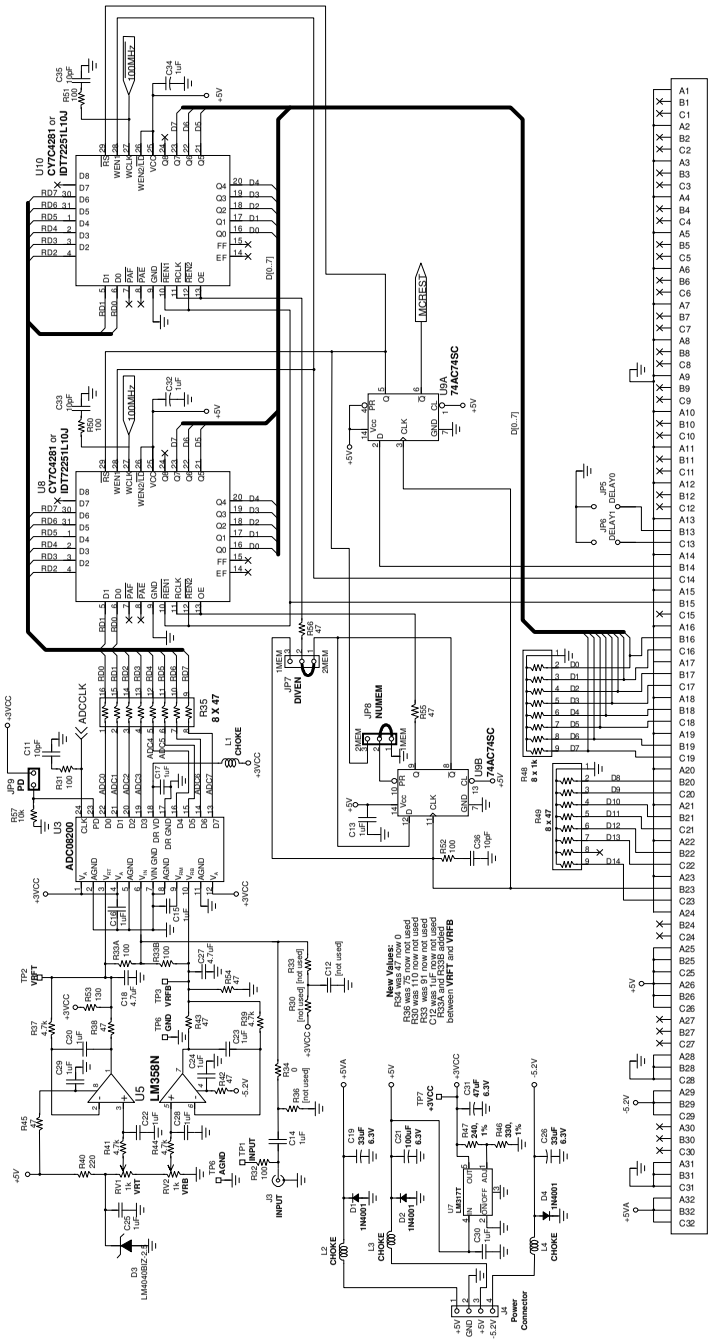


Figure 2a. ADC 08200 Evaluation Board Schematic

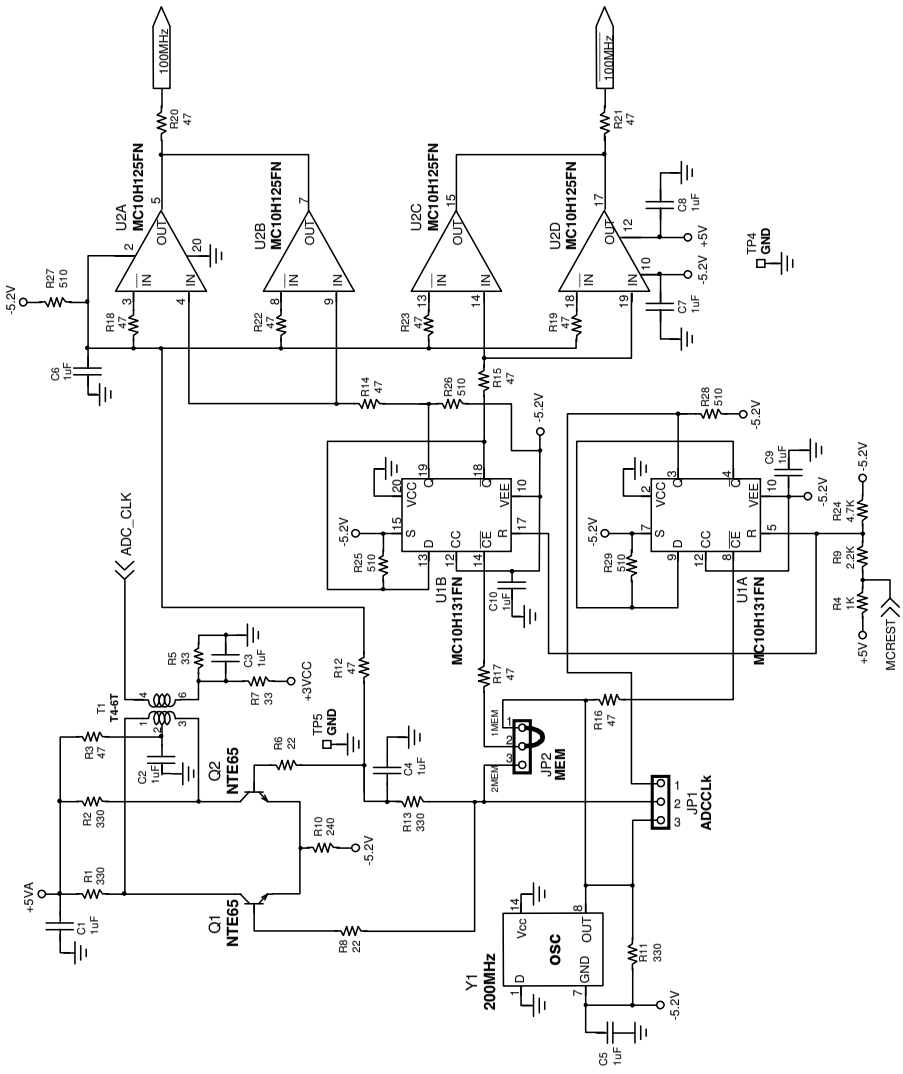


Figure 2b. ADC 08200 Evaluation Board Clock source

8.0 Evaluation Board Bill of Materials

Item	Qty	Reference	Part	Source
1	24	C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C13, C14, C15, C16, C17, C20, C22, C23, C24, C25, C28, C29, C30, C32, C34	1uF	Type 1206
2	4	C11, C33, C35, C36	10pF	Type 1206
3	2	C18, C27	4.7uF	Type 7343 (D Size)
4	2	C19, C26	33uF, 6V	Type 7343 (D Size)
5	1	C21	100uF, 6V	Type 7343 (D Size)
6	1	C31	47uF, 6V	Type 7343 (D Size)
7	-	C12, C37	**not populated**	n/a
8	3	D1, D2, D4	1N4001	Various
9	1	D3	LM4040EIZ-2.5	National Semiconductor
10	1	J1	96-Pin Female	DigiKey # H7096-ND
11	1	JP1	3-Pin Post Header	DigiKey # A19351-ND
12	1	Shorting Jumper	Shorting Jumper	DigiKey # S9001-ND
13	-	JP2, JP7, JP8, JP9	**3-Pin Post Header - Bd Rev A.**	DigiKey # A19351-ND
			Factory Set - Board Rev B	n/a
14	-	JP10	**Factory Set - board rev A**	n/a
			Doesn't exist - Board Rev B	
15	1	J3	BNC Connector	DigiKey # ARF1177-ND
16	2	J4	Terminal Block	DigiKey # ED1609-ND
17	1	JP5, JP6	**not populated**	n/a
18	4	L1, L2, L3, L4	Choke	DigiKey # M2204-ND
19	-	L5	**not populated**	n/a
20	2	Q1, Q2	NTE65	NTE Electronics
21	1	R34	0 (short)	
22	2	R6, R8	22	Type 1206
23	2	R5, R7	33	Type 1206
24	19	R3, R12, R14, R15, R16, R17, R18, R19, R20, R21, R22, R23, R38, R42, R43, R45, R54, R55, R56	47	Type 1206
25	5	R31, R32, R50, R51, R52	100	Type 1206
26	2	R33A, R33B	100	¼ W, Leaded
27	1	R53	130	Type 1206
28	1	R40	220	Type 1206
29	2	R10, R47	240	Type 1206
30	5	R1, R2, R11, R13, R46	330	Type 1206
31	5	R25, R26, R27, R28, R29	510	Type 1206
32	1	R4	1k	Type 1206
33	1	R9	2.2k	Type 1206
34	5	R24, R37, R39, R41, R44	4.7k	Type 1206
35	1	R57	10k	Type 1206
36	3	R30, R33, R36	**not populated**	n/a
37	1	R35	Resistor Pack - 8 x 47	DigiKey # 767-163-R47-ND
38	1	R49	Resistor Pack (SIP) - 8 x 47	DigiKey # 750-101-R47-ND
39	1	R48	Resistor Pack (SIP) - 8 x 1k	DigiKey # 750-101-R1k-ND
40	2	RV1, RV2	1k Pot	DigiKey # 3386P-102-ND
41	1	TP1, TP2, TP3, TP4, TP5, TP6, TP7	Breakable Header	DigiKey # S1012-36-ND
42	1	T1	Transformer	MiniCircuits T4-6T
43	1	U1	MC10H131FN	ON Semiconductor
44	1	U2	MC10H125FN	ON Semiconductor
45	1	U3	ADC08200CIMT	National Semiconductor
46	1	U5	LM358N	National Semiconductor
47	1	U7	LM317T	National Semiconductor
48	2	U8, U10	IDT72251L10J or	IDT
			CY7C4251V-10JC or	Cypress Semiconductor
			CY7C4281V-10JC	Cypress Semiconductor
49	1	U9	74AC74SC / 74ACT74SC	Fairchild Semiconductor
50	1	Y1	200 MHz Oscillator	Pletronics type
			NOT POPULATED	EC1145ME-200.0MPST
51	1	6-Pin DIP Socket	Transformer Socket	DigiKey # AE8906-ND
52	1	Full-Size 4-Pin Oscillator Socket	Oscillator Socket for Y1	DigiKey # A462-ND
53	1	8-Pin DIP Socket	For U5	DigiKey # A400-ND
54	1	PC Board	ADC08200, Rev B	Bay Area Circuits

APPENDIX

Summary Tables of Test Points and Connectors

Test Points on the ADC08200 Evaluation Board

TP 1	Signal Input test point
TP 2	ADC Top Reference Voltage, V_{RT}
TP 3	ADC Bottom Reference Voltage, V_{RB}
TP 4	Ground
TP 5	Ground
TP 6	Ground
TP 7	+3V test point (Groundedd on initial board version)

P1 Connector - Power Supply Connections

J4-1	+5V	Positive Power Supply
J4-2	GND	Power Supply Ground
J4-3	+5V	Logic and Digital Interface Board Supply
J4-4	-5.2	Negative Power Supply

JP1 Jumper - ADC Clock

Connect 1-2	Divide Clock Oscillator (Y1) frequency by 2
Connect 2-3	Use Clock Oscillator (Y1) frequency without dividing it (Default)

JP2 Jumper - Memory

Connect 1-2	Use one FIFO chip
Connect 2-3	Use both FIFO chips (Default hard-wired position)

JP3 thru JP6 - Not Used

JP7 Jumper - Divide Enable

Connect 1-2	Use both FIFO chips - divide FIFO read signal frequency by 2 (Default hard-wired position)
Connect 2-3	Use one FIFO chip - do not divide FIFO read signal

JP8 Jumper - Number of Memory Chips

Connect 1-2	One Memory Chip
Connect 2-3	Two Memory Chips (Default hard-wired position)

JP9 Jumper - Power Down

No Jumper	ADC080200 in active state
Jumper Present	ADC080200 in Power Down mode

J1 Connector - ADC Data Outputs - Connection to WaveVision Digital Interface Board

Signal	J1 pin number
ADC output D0	B16
ADC output D1	C16
ADC output D2	B17
ADC output D3	C17
ADC output D4	B18
ADC output D5	C18
ADC output D6	B19
ADC output D7	C19
ADC output D8	not used
ADC output D9	not used
ADC output D10	not used
ADC output D11	not used
GND	A1 thru A24, A28, B28, C28, A31, B31, C31
Memory Read Clock	B15
Reserved, Signal	B22, C22, C23
Reserved, Power	A25, A26, B25, B26, C25, C26 (+5V Logic Power Supply to Digital Interface Board)
Reserved, Power (–5.2V)	A29, B29, C29
Reserved, Power (+5V)	A32, B32, C32

[Blank Page]

BY USING THIS PRODUCT, YOU ARE AGREEING TO BE BOUND BY THE TERMS AND CONDITIONS OF NATIONAL SEMICONDUCTOR'S END USER LICENSE AGREEMENT. DO NOT USE THIS PRODUCT UNTIL YOU HAVE READ AND AGREED TO THE TERMS AND CONDITIONS OF THAT AGREEMENT. IF YOU DO NOT AGREE WITH THEM, CONTACT THE VENDOR WITHIN TEN (10) DAYS OF RECEIPT FOR INSTRUCTIONS ON RETURN OF THE UNUSED PRODUCT FOR A REFUND OF THE PURCHASE PRICE PAID, IF ANY.

The ADC08200 Evaluation Board is intended for product evaluation purposes only and is not intended for resale to end consumers, is not authorized for such use and is not designed for compliance with European EMC Directive 89/336/EEC.

WaveVision is a trademark of National Semiconductor Corporation. National does not assume any responsibility for use of any circuitry or software supplied or described. No circuit patent licenses are implied.

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

National Semiconductor Corporation Americas
Tel: 1-800-272-9959
Fax: 1-800-737-7018
Email: support@nsc.com

National Semiconductor Europe
Fax: +49 (0) 1 80-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 699508 6208
English Tel: +49 (0) 870 24 0 2171
Français Tel: +49 (0) 1 41 91 87 90
Email: europe.support@nsc.com

National Semiconductor Asia Pacific Customer Response Group
Tel: 65-254-4466
Fax: 65-250-4466
Email:ap.support@nsc.com

National Semiconductor Japan Ltd.
Tel: 81-3-5639-7560
Fax: 81-3-5639-7507
Email: nsj.crc@jksmtp.nsc.com

www.national.com