

## USING THE HI7190 EVALUATION KIT

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### **Evaluation Kit Description**

The HI7190 evaluation kit (evaluation board and evaluation software) can be used to evaluate the performance of the HI7190 24-bit sigma delta analog-to-digital converter (ADC). The evaluation board includes a reference circuit, a crystal, an oscillator, and digital circuitry used to interface to a personal computer running the evaluation software. The board also provides a means for the user to supply an external reference and an external clock.

### **HI7190 Description**

The HI7190 is a 24-bit sigma delta ADC intended for use in applications such as industrial weight scales, process controls, and process measurement systems. The block diagram shows that the device consists of a programmable gain instrumentation amplifier (PGIA), a second order sigma delta modulator, a digital filter, a clock generator, and digital control and interface circuitry.

The input signal applied to the  $V_{INHI}$  and  $V_{INLO}$  pins comes into the PGIA where it is gained up by a factor of 1 to 8. The resulting signal is then passed into the oversampling second order sigma delta modulator for A/D conversion and noise shaping. The output of the modulator is a serial bit stream of "1"s and "0"s whose code density is a direct indication of the value of the input to the modulator. This bit stream is then input to the digital filter where it is band limited and decimated down to a lower frequency. The digital filter is also used (along with the PGIA) to implement gains up to 128. The clock generator and digital control circuits direct the internal conversion process while the serial interface unit provides access to the device from the outside world. For a detailed description of the operation of the converter, please refer to the HI7190 data sheet.

### **Hardware Description**

The HI7190 evaluation board provides the user with a very simple way of interfacing to and evaluating the Intersil HI7190 sigma delta ADC. The board features a reference voltage generator, a crystal oscillator, and digital line drivers and receivers for interfacing to a PC running the evaluation software. The board consists of 4 layers with separate analog and digital ground planes for obtaining optimum noise performance.

### **Layout and Power Supplies**

The HI7190 evaluation board consists of 4 layers laid out to optimize performance of the ADC. The figures at the end of this document include the various layers of the board and their layout, a list of the board components, and schematics. Users should feel free to copy this layout for use in their applications.

The power supplies are provided to the board via the edge connector located at the top of the board. It is recommended that twisted pair wires be used to connect the power supplies to the connector and that analog and digital grounds be tied together back at the power supplies. The separate supplies are necessary to keep the digital noise from coupling into the analog portions of the circuit. One of the internal layers of the board is the ground plane layer. This layer is roughly divided in half with one half of the layer being digital ground and the other half being analog ground. The other internal layer is the power plane. It is divided into three sections;  $AV_{DD}$ ,  $AV_{SS}$ , and  $DV_{DD}$ . Nominal values for the supplies are  $AV_{DD} = +5V$ ,  $AV_{SS} = -5V$ , and  $DV_{DD} = +5V$ . In some cases (for instance if there is a substantial offset between AGND and DGND) it may be necessary to tie the two grounds together on the board. Resistors R2, R8, and R9 provide a means of connecting the two ground planes together through a low impedance.

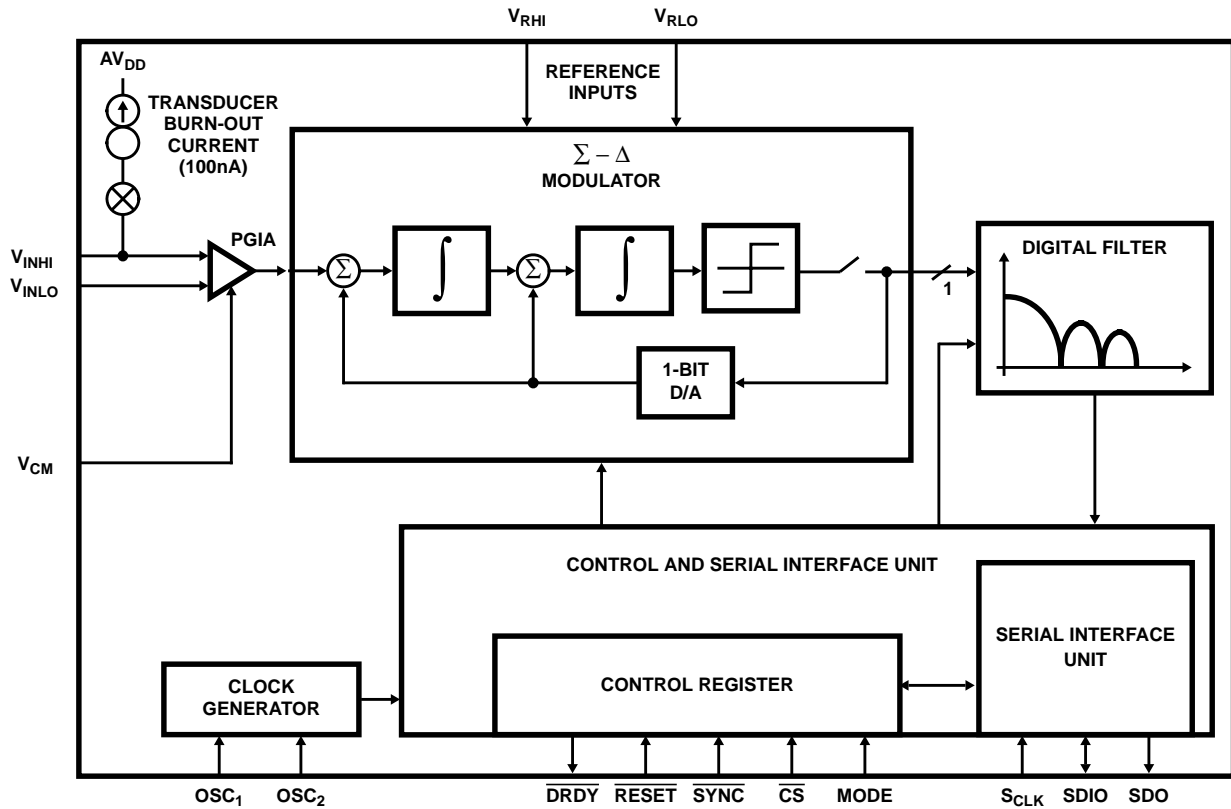
A prototype area is provided on the left side of the board. This area has a small section of analog ground plane in the center and may be useful for input signal conditioning before the HI7190.

### **Reference Circuit**

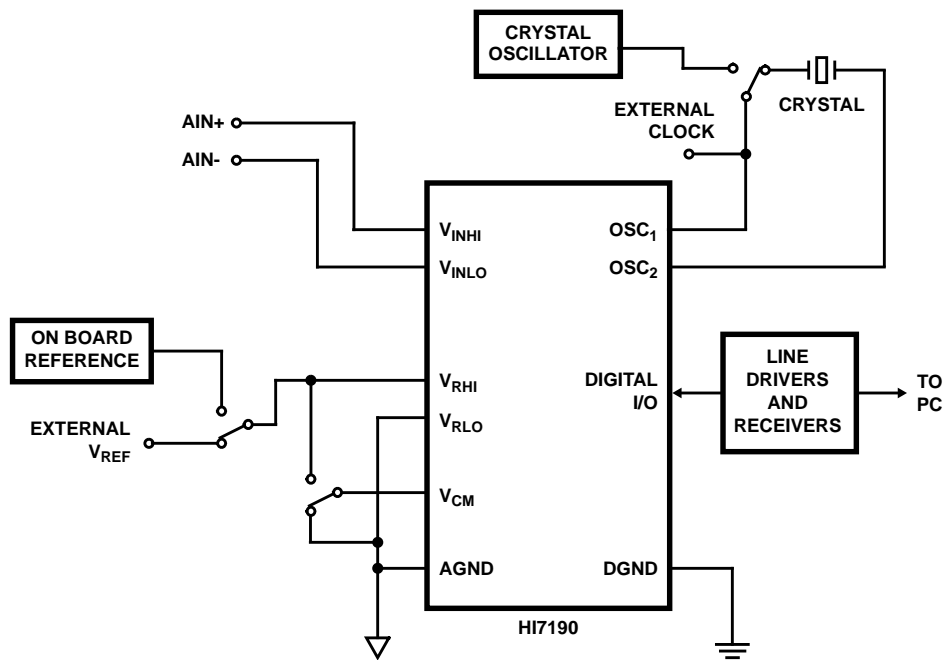
The reference inputs of the HI7190,  $V_{RHI}$  and  $V_{RLO}$ , provide a differential reference input capability. The reference inputs provide a high impedance dynamic load similar to the analog inputs. For proper circuit operation these pins must be driven by low impedance circuitry. Reference noise outside of the band of interest will be removed by the on chip digital filter but excessive reference noise inside the band of interest will degrade performance of the HI7190.

The actual reference voltage is given by  $V_{REF} = V_{RHI} - V_{RLO}$ . The  $V_{RLO}$  pin is hard wired to analog ground on the evaluation board which means that  $V_{REF} = V_{RHI}$ . The nominal reference voltage for the HI7190 is 2.5V. Larger values of  $V_{REF}$

HI7190 Functional Block Diagram



HI7190 Evaluation Board Block Diagram



can be used without degradation in performance. Smaller values of  $V_{REF}$  can also be used but performance will be degraded since the system noise becomes larger relative to the LSB size.

The jumper JP2 controls whether the  $V_{RHI}$  pin of the HI7190 is connected to an external reference, which connects to the  $V_{REF}$  SMA pad, or to the on board reference which is preset to 2.5V. If JP2 is in the far right position  $V_{RHI}$  is connected to the on board low noise reference and when JP2 is in the far left position  $V_{RHI}$  is connected to the external reference. If an external reference is used it is recommended that a twisted pair wire be used and soldered directly to the SMA pad on the evaluation board. The potentiometer R1 can be used to vary the on board reference voltage. Please note that the specifications for the HI7190 are tested with  $V_{RHI}$  set to 2.5V.  $V_{RHI}$  must always be greater than  $V_{RLO}$  for proper operation of the device.

### Analog Inputs

The analog input on the HI7190 is a fully differential input with programmable gain capabilities. The input accepts both unipolar and bipolar input signals and gains range from 1 to 128. The user must pay careful attention to the input driver and/or input filter circuitry as the input sampling rate (or modulator clock rate) varies with the selected PGIA gain, and the input impedance is dependent upon the modulator clock rate. Please refer to the data sheet for more information.

The analog inputs come onto the board via the SMA pads labeled AIN+ and AIN-. Once again it is recommended that twisted pair wire be used to drive the positive and negative analog inputs.

### Common Mode Input

The jumper JP1 is provided to allow the  $V_{CM}$  pin to be tied to either analog ground (upper position), or  $V_{RHI}$  (lower position). The input voltage for  $V_{CM}$  should always be set at the midpoint between  $AV_{DD}$  and  $AV_{SS}$ . So if  $AV_{DD} = +5V$  and  $AV_{SS} = -5V$ ,  $V_{CM}$  should be at analog ground. Please note the HI7190 is specified for  $AV_{DD} = +5V$  and  $AV_{SS} = -5V$  operation only.

### Clock Input

The master clock into the HI7190 can be supplied by either a crystal connected between the  $OSC_1$  and  $OSC_2$  pins or a CMOS compatible clock signal connected to the  $OSC_1$  pin. The input sampling frequency, modulator clock frequency, filter -3dB frequency, output update rate, and calibration times are all directly related to the master clock frequency,  $f_{OSC}$ . For example, if a 1MHz clock is used instead of a 10MHz clock, what is normally a 10Hz conversion rate becomes a 1Hz conversion rate. Lowering the clock frequency will also lower the power supply currents. Please note that the HI7190 specifications are written for a 10MHz clock only.

The HI7190 evaluation board allows for the HI7190 master clock to be supplied externally, generated by the on board crystal oscillator, or generated by an on board crystal used in conjunction with the on chip oscillator circuitry. The jumper

J1 must be removed from the board when using an external clocking source and the external clocking source must be disconnected from the board when using either of the on board clocking methods. When J1 is in the right most position the 10MHz crystal oscillator is selected and when J1 is in the left most position the combination 10MHz crystal and on chip oscillator clocking method is selected. The external clock can be used from a minimum frequency of 1MHz up to a maximum frequency of 10MHz.

For the best noise performance the crystal should be removed from the board when using the crystal oscillator and vice versa. Both the crystal and crystal oscillator should be removed when using an external clock.

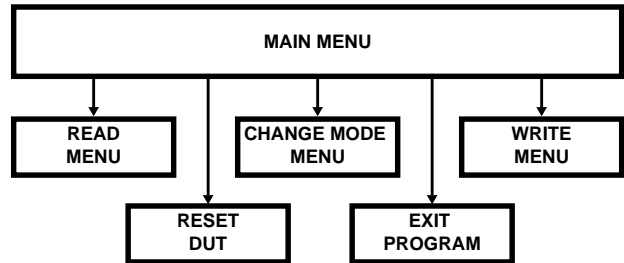
### Digital Inputs/Outputs

The digital input and output pins of the HI7190 are interfaced through line drivers and receivers to the 25 pin D connector at the right edge of the board. These pins are activated and deactivated by the evaluation software which controls the functionality of the HI7190. Please refer the HI7190 data sheet for a detailed description of the functionality of these pins.

U5 on the evaluation board is an "open socket" which is used in conjunction with the test modes of the HI7190 for Intersil internal testing and evaluation.

## Software Description

The software provided with the HI7190 evaluation kit allows the user to operate the device in many of the various modes the part supports. The software is menu driven for ease of use. The simplified flow diagram shown in Figure 1 gives a good feel for the structure of the software. Every menu allows access to all other menus.



**FIGURE 1. SIMPLIFIED SOFTWARE FLOW CHART**

The Main Menu appears after invoking the HI7190 evaluation software. This menu is the gateway to other menus that allow the user to communicate with the HI7190.

#### Main Menu:

- s Reset DUT
- c Change Mode Menu
- w Write Menu
- r Read Menu
- x Exit

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- s Entering s from the Main Menu sends an active low reset signal to the HI7190 which initializes the HI7190.
- c Entering c from the Main Menu brings the Change Mode Menu up. The Change Mode Menu allows the user to custom configure the HI7190 without having to know the bit positions of the Control Register.
- w Entering w from the Main Menu brings the Write Menu up. The Write Menu allows the user write access to all writable registers without having knowledge of specific Instruction Register address details.
- r Entering r from the Main Menu brings the Read Menu up. The Read Menu allows the user to read all registers without having knowledge of specific Instruction Register address details.
- x Entering x from the Main Menu exits the program.

### Change Mode Menu:

- 1 Self Calibration - 10Hz
  - 2 Self Calibration - 2kHz
  - 3 System Offset Calibration - 10Hz
  - 4 System Positive Full Scale Calibration - 10Hz
  - 5 System Negative Full Scale Calibration - 10Hz
  - c Custom Menu
  - r Read Menu
  - w Write Menu
  - m Main Menu
  - x Exit Program
- 1 Entering 1 from the Change Mode Menu initiates a communication cycle with the HI7190 that invokes the Self Calibration Mode with a notch frequency of 10Hz. Other operating parameters are offset binary coding, bipolar mode and a gain of one. Executing this command returns the user to the Main Menu.
  - 2 Entering 2 from the Change Mode Menu initiates a communication cycle with the HI7190 that invokes the Self Calibration Mode with a notch frequency of 2kHz. Other operating parameters are offset binary coding, bipolar mode and a gain of one. Executing this command returns the user to the Main Menu.
  - 3 Entering 3 from the Change Mode Menu initiates a communication cycle with the HI7190 that invokes the System Offset Calibration Mode with a notch frequency of 10Hz. Other operating parameters are offset binary coding, bipolar mode and a gain of one. Please note, the user should apply 0V to the HI7190 inputs before issuing this command. Executing this command returns the user to the Main Menu.
  - 4 Entering 4 from the Change Mode Menu initiates a communication cycle with the HI7190 that invokes the System Positive Full Scale Calibration Mode with a notch frequency of 10Hz. Other operating parameters are offset binary coding, bipolar mode and a gain of one. Please note, the user should apply the positive full scale voltage to the HI7190 inputs before issuing this command. Executing this command returns the user to the Main Menu.

- 5 Entering 5 from the Change Mode Menu initiates a communication cycle with the HI7190 that invokes the System Negative Full Scale Calibration Mode with a notch frequency of 10Hz. Other operating parameters are offset binary coding, bipolar mode and a gain of one. Please note, the user should apply the negative full scale voltage to the HI7190 inputs before issuing this command. Executing this command returns the user to the Main Menu.
- c Entering c from the Change Mode Menu allows the user to customize the operational parameters of the HI7190. The user will be asked a series of questions relating to HI7190 operation. After completing these questions, the software compiles the proper data and writes the Control Register to invoke the desired operating mode. Executing this command returns the user to the Main Menu.
  - r Entering r from the Change Mode Menu invokes the Read Menu.
  - w Entering w from the Change Mode Menu invokes the Write Menu.
  - m Entering m from the Change Mode Menu invokes the Main Menu.
  - x Entering x from the Change Mode Menu exits the program.

### Write Menu:

- 1 Command Register
  - 2 Offset Register
  - 3 Positive Full Scale Register
  - 4 Negative Full Scale Register
  - m Main Menu
  - r Read Menu
  - x Exit Program
- 1 Entering 1 from the Write Menu invokes a write communication cycle with the Control Register. The user will be prompted for the data to write. The software requires the data be entered in hex, most significant to least significant format. The Control Register is 3 bytes. All three bytes must be entered at the prompt.
  - 2 Entering 2 from the Write Menu invokes a write communication cycle with the Offset Calibration Register. The user will be prompted for the data to write. The software requires the data be entered in hex, most significant to least significant format. The Offset Calibration Register is 3 bytes. All three bytes must be entered at the prompt.
  - 3 Entering 3 from the Write Menu invokes a write communication cycle with the Positive Full Scale Calibration Register. The user will be prompted for the data to write. The software requires the data be entered in hex, most significant to least significant format. The Positive Full Scale Calibration Register is 3 bytes. All three bytes must be entered at the prompt.
  - 4 Entering 4 from the Write Menu invokes a write communication cycle with the Negative Full Scale Calibration Register. The user will be prompted for the data to write. The software requires the data be entered in hex, most

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significant to least significant format. The Negative Full Scale Calibration Register is 3 bytes. All three bytes must be entered at the prompt.

- m Entering m from the Write Menu invokes the Main Menu.
- r Entering r from the Write Menu invokes the Read Menu.
- x Entering x from the Write Menu exits the program.

### Read Menu:

- 1 Data Output Register, 'Read Once'
  - 2 Data Output Register, 'Read Continuous'
  - 3 Command Register
  - 4 Offset Calibration Register
  - 5 Positive Full Scale Register
  - 6 Negative Full Scale Register
  - m Main Menu
  - w Write Menu
  - x Exit Program
- 1 Entering 1 from the Read Menu invokes a read communication cycle with the Data Output Register. The Data Output Register will be read one time, the data will be displayed, and the program will return to the Main Menu.
  - 2 Entering 2 from the Read Menu invokes continuous read communication cycles with the Data Output Register. Refer to the Software Clarifications section of this document for details on the displayed data. Continuous data reads will be displayed until any key is pressed. When a key is pressed, the program returns to the Main Menu.
  - 3 Entering 3 from the Read Menu invokes a read communication cycle with the Control Register. The user will be asked if a continuous read is required. If continuous read is not requested, executing this command will invoke a single read of the Control Register, display the data and return execution to the Main Menu. If continuous read is requested, the read executions will continue until any key is touched to abort reads. It is generally not expected that this register will be read in continuous mode.
  - 4 Entering 4 from the Read Menu invokes a read communication cycle with the Offset Calibration Register. The user will be asked if a continuous read is required. If continuous read is not requested, executing this command will invoke a single read of the Offset Calibration Register, display the data and return execution to the Main Menu. If continuous read is requested, the read executions will continue until any key is touched to abort reads. It is generally not expected that this register will be read in continuous mode.
  - 5 Entering 5 from the Read Menu invokes a read communication cycle with the Positive Full Scale Calibration Register. The user will be asked if a continuous read is required. If continuous read is not requested, executing this command will invoke a single read of the Positive Full Scale Calibration Register, display the data and return execution to the Main Menu. If continuous read is requested, the read executions will continue until any

key is touched to abort reads. It is generally not expected that this register will be read in continuous mode.

- 6 Entering 6 from the Read Menu invokes a read communication cycle with the Negative Full Scale Calibration Register. The user will be asked if a continuous read is required. If continuous read is not requested, executing this command will invoke a single read of the Negative Full Scale Calibration Register, display the data and return execution to the Main Menu. If continuous read is requested, the read executions will continue until any key is touched to abort reads. It is generally not expected that this register will be read in continuous mode.

### Examples:

1. **Write 8 (hex) to the Offset Calibration Register and then read it back.** To accomplish this task, choose the Write Menu option from the Main Menu, choose the Offset Register option from the Write Menu. Enter 000008 at the prompt. The program returns to the Main Menu. Now select the Read Menu option from the Main Menu, choose the Offset Register option from the Read Menu. The user will be prompted to decide upon a single read or continuous read. Enter n for a single read. The data read will be displayed on the screen and the program will return to the Main Menu.
2. **Configure the device for bipolar mode, offset binary coding, 10Hz filter notch frequency, gain of 1, and conversion mode operation.** Select the Change Mode Menu option from the Main Menu and then the Custom Menu option from the Change Mode Menu. When prompted for data coding enter 0 for offset binary. The next prompt is to enter the notch frequency, enter 10 for 10Hz. Next, the operational mode table is displayed, choose 0 for conversion mode. The next prompt is for bipolar/unipolar operation, enter 1 for bipolar mode. The next screen displays the gain selection table, enter 1 for gain equal 1. The program determines the data required to configure the HI7190 as the user specified and invokes the proper communication cycle. Execution returns to the Main Menu.

### Software Execution

The PORT\_ID.DAT file contains the port identification for the parallel printer port interfacing the HI7190 Evaluation board to the PC. This file needs to be edited (as discussed in the HI7190RDME.TXT file) before running the software. The DOS MSD command can be used to find the printer port identification.

**Loading Software:** Copy the four files (7190BTA5.CPP, 7190BTA5.EXE, PORT\_ID.DAT, and 7190RDME.TXT) from the diskette onto your PC hard drive into the directory of your choice. The file 7190BTA5.CPP is the evaluation software source code. The file 7190BTA5.EXE is the executable program and 7190RDME.TXT is a README file containing valuable information. Please read the 7190RDME.TXT file before continuing.

**Executing the Program:** Change directory (cd) into the directory containing the 7190BTA5.EXE file. At the DOS prompt type 7190BTA5 [return]. The software reminds the user to apply power to the board before continuing. At this point the software is menu driven and self explanatory. However, it is important that the user has read the previous section, Software Description, before starting the evaluation.

## Software Clarifications

### Resetting the DUT

Entering **s** from the Main Menu resets the HI7190 to its initial state. The initial state of the HI7190 is as follows: offset binary data coding, notch frequency of 30Hz, Self Calibration mode, gain = 1, bipolar mode. The burn-out current and sleep mode bits are inactive. The Serial Interface configuration is MSB first bit positioning, descending byte order, bidirectional I/O pin.

### Writing the Control Register

Caution should be taken when writing the Control Register via the Write Menu. The least significant byte contains information regarding the Serial Interface configuration that must be maintained when running the software provided. To insure proper functionality of the evaluation software, the Serial Interface must be configured in MSB first mode, descending byte order and bidirectional I/O pin operation. This configuration is maintained by writing logic zeros into the 3 least significant bits of the Control Register.

### Invalid Inputs

Entering invalid inputs at some menu prompts will lock up the software. Generally a CTL-C will return the user to the DOS prompt.

### Notch Frequency Input

When executing from the Custom Menu (of Change Mode Menu) the notch frequency value must be entered in decimal. That is, 2kHz is entered as 2000.

## Bypassing Calibration

The HI7190 calibration algorithm can be effectively bypassed by writing all zeros into the Offset Calibration Register and 800000 (hex) into the Positive and Negative Full Scale Calibration Registers if operating in bipolar mode. If operation is in unipolar mode write all zeros into the Offset Calibration Register and 800000 (hex) into the Positive Full Scale Calibration Register.

## Display of Data Register in Continuous Mode

Entering 2 from the Read Menu invokes a continuous read of the Data Register. The following data is displayed: 1) The binary output stream read from the HI7190, 2) The binary output stream converted to hex, 3) The binary output stream converted to volts, 4) The mean voltage of the last 10 conversion results, 5) The maximum voltage result, 6) the minimum voltage result, 7) The difference between the maximum voltage and minimum voltage, and 8) standard deviation, dynamic range and ENOB, which is updated in groups of 10 conversions.

NOTE: The CTRL input on the keyboard is used to "normalize" the statistical output. For example, the maximum voltage is set to 5.5V and the minimum is set to -5.5V. The maximum/minimum results displayed from then on will include only those conversions read since "normalization".

The Dynamic Range and ENOB Equations are as follows:

$$\text{Dynamic Range} = 10 \log_{10} \frac{(2.5)^2 / 2}{V_{\text{RMS}}^2 - V_{\text{REFNOISE}}^2}$$

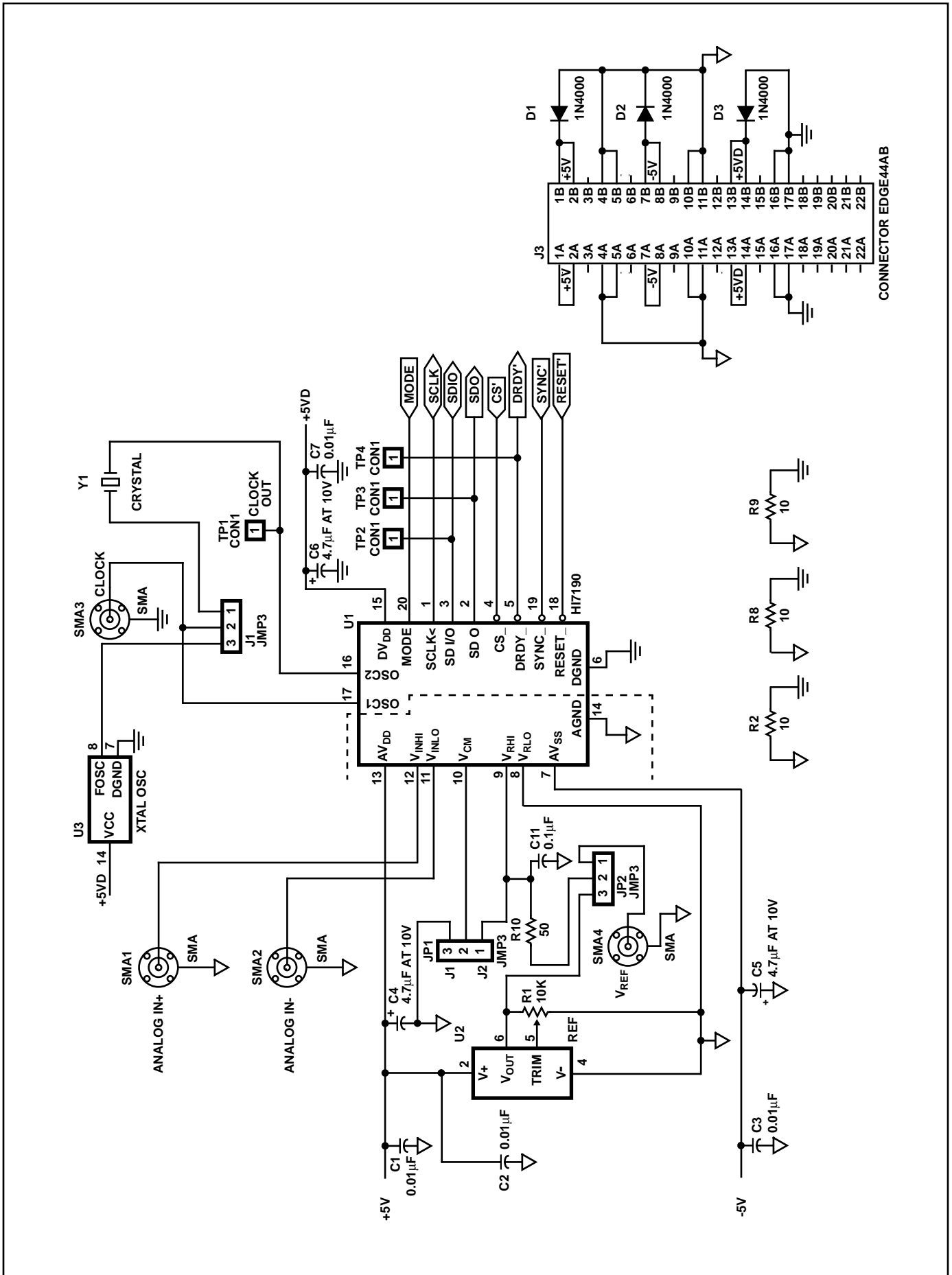
$$\text{ENOB} = \frac{\text{Dynamic Range} - 1.76}{6.02}$$

$$V_{\text{RMS}} = \frac{V_{\text{MAX}} - V_{\text{MIN}}}{6.6}$$

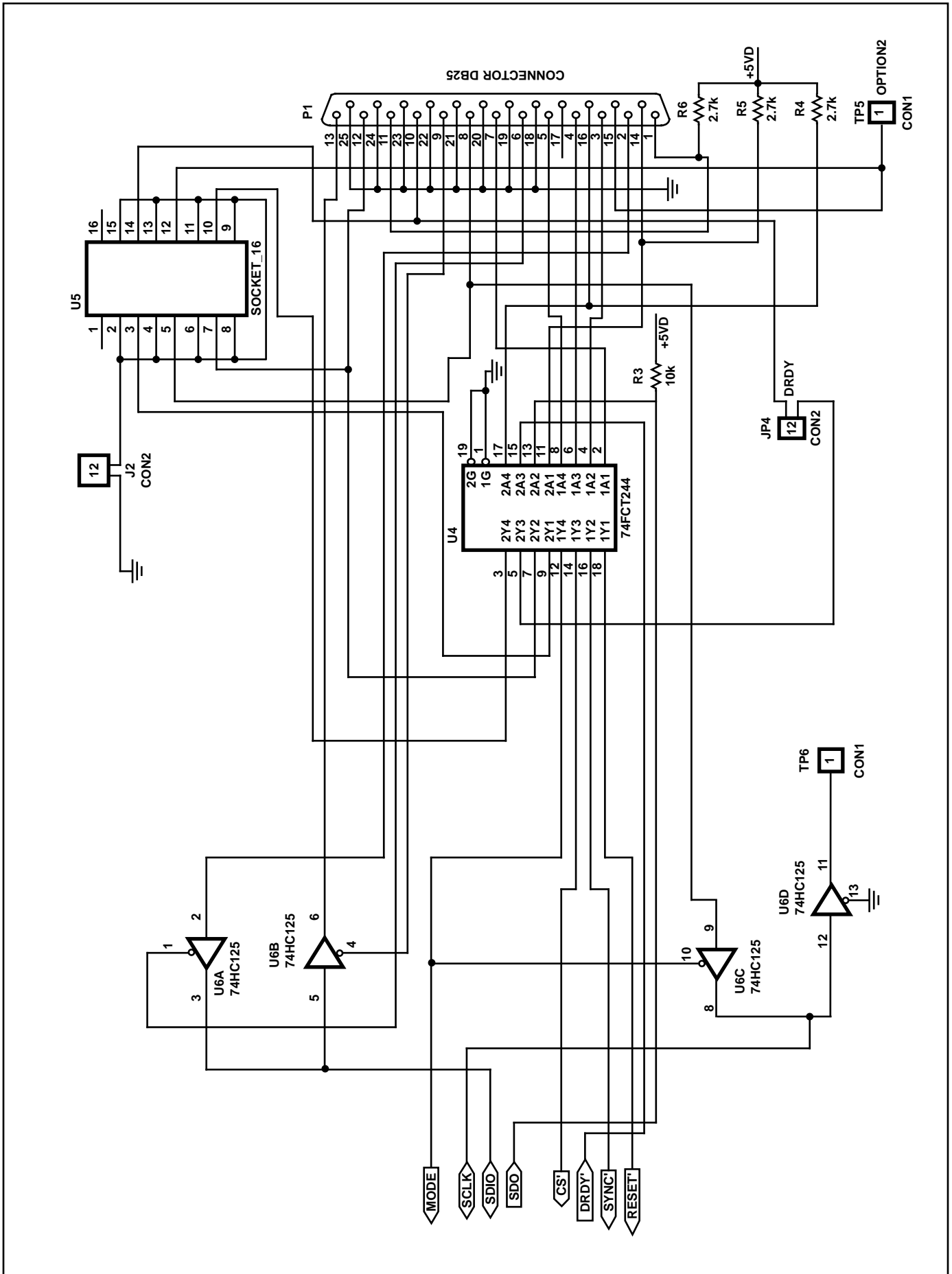
$$V_{\text{REFNOISE}} = \sqrt{\left(4.452 \times 10^{-14}\right) (0.275 F_N)}$$

$$F_N = \text{Notch Frequency}$$

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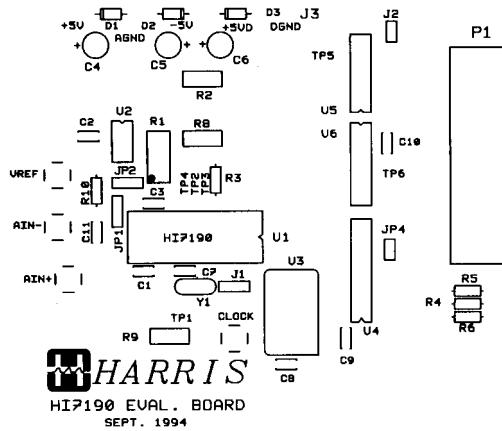


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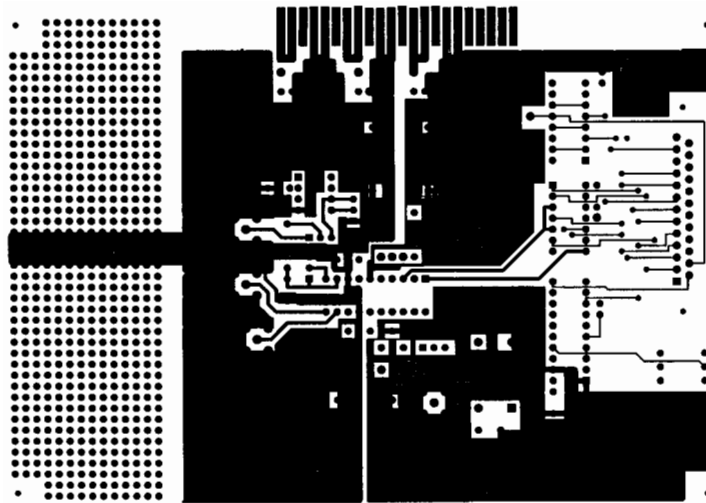




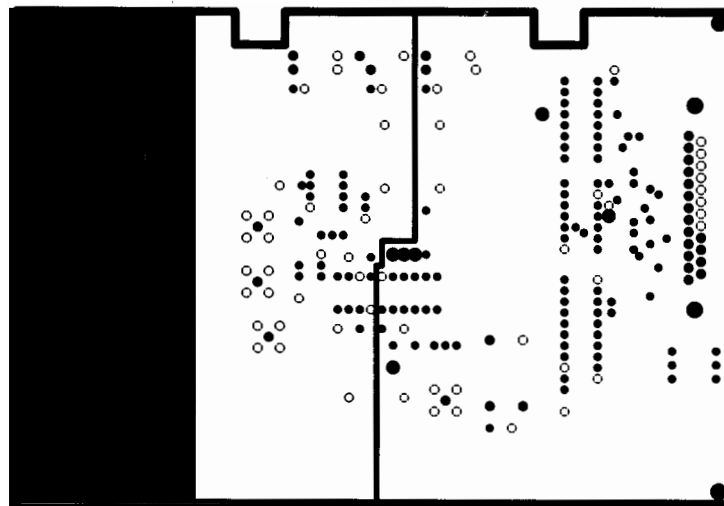
HI7090 Evaluation Board



COMPONENTS LAYOUT

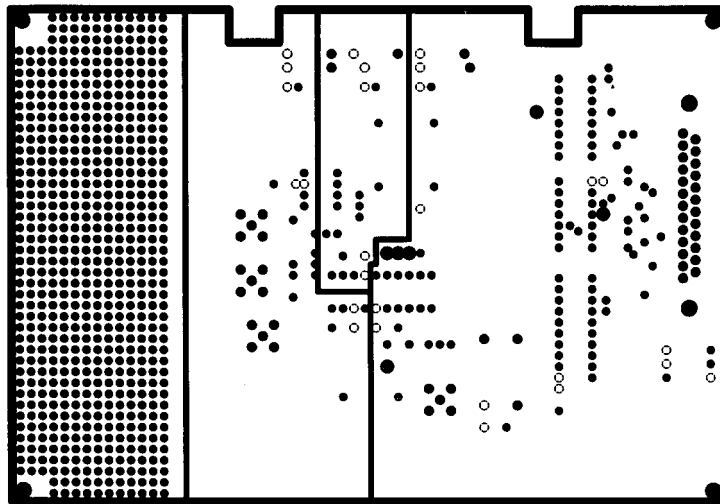


COMPONENT SIDE

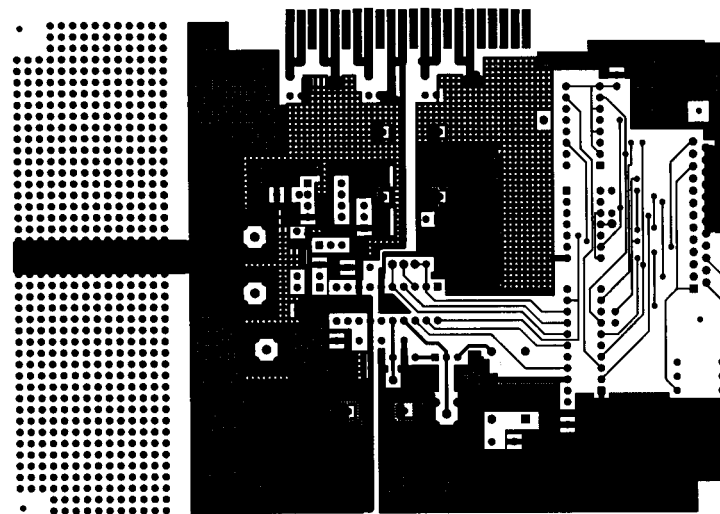


GROUND PLANES

HI7090 Evaluation Board (Continued)



POWER PLANE



SOLDER SIDE

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### HI7190 EVALUATION BOARD COMPONENT LIST

ITEM	QUANTITY	REFERENCE	PART
1	7	C1, C2, C3, C7, C8, C9, C10	0.01 $\mu$ F
2	3	C4, C5, C6	10 $\mu$ F at 16V Tantalum
3	1	C11	0.1 $\mu$ F
4	3	D1, D2, D3	1N4000
5	3	JP1, J1, JP2	JMP3 - Strip 1 x 3
6	2	JP4, J2	CON2 Wire Strap
7	1	J3	Connector Edge 44AB
8	1	P1	Connector DB25
9	1	R1	10K 5%, 1/4 $\Omega$
10	3	R2, R8, R9	10 5%, 1/4 $\Omega$
11	3	R4, R5, R6	2.7K 5%, 1/4 $\Omega$
12	1	R10	49.9 1%, 1/4 $\Omega$
13	1	U1	HI7190
14	1	U2	REF (LT1019CN8-2.5)
15	1	U3	XTAL OSC 10MHz
16	1	U4	74HC244 (INTERSIL)
17	1	U6	74HC125 (INTERSIL)
18	1	Y1	Crystal 10MHz

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