

## **Evaluation Kit Description**

The HI7188 Evaluation Kit (evaluation board and evaluation software) can be used to evaluate the performance of the HI7188 16-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. Also included are two single ended to differential converter circuits and two resistor ladder networks which can be used to provide inputs to the HI7188. In addition, the board provides means for the user to supply an external reference and an external clock.

## **HI7188 Description**

The HI7188 is a Monolithic 8-Channel Sigma-Delta A/D Converter which operates from  $\pm 5V$  supplies and is 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 an 8-channel multiplexer, Programmable Gain Instrumentation Amplifier (PGIA), Sigma-Delta modulator, digital filter, bidirectional serial port (compatible with many industry standard protocols), clock oscillator, a controller, and static RAMs used for calibration coefficients and conversion scan buffer.

The 8 to 1 multiplexer at the input, combined with the resettable modulator on the HI7188, allow for conversions of up to 8 channels of data with each channel being updated at a rate of 240 samples per second (with 60Hz line noise rejection enabled). After the signal has passed through the multiplexer it moves into the PGIA where it is gained up by a factor of 1 to 8 and then it passes to the sigma delta modulator. The data emerges from the modulator as a pulse train whose code density contains the analog signal information. The output of the modulator is fed into the digital integrating filter. Data out of the filter is available after 201 bits are received from the modulator. If the part is in line noise rejection mode, the integrator filter data is routed to one of eight averaging filters. The averaged data is then calibrated and stored in the data RAM.

If line noise rejection is disabled, the averaging filters are bypassed, calibration is performed on the data from the integrating filter, and the result is stored in the data RAM.

After all active channels are converted, the HI7188 generates an End-of-Scan interrupt,  $\overline{EOS}$ , that indicates all active channels have been updated and valid data is available to be read.

Converted data is read via the HI7188 serial I/O port which is compatible with most synchronous transfer formats including both the Motorola SPI and Intel 8051 series SSR protocols. Data is read from the HI7188 in "burst" mode. That is, the data for all active channels is read out of the HI7188 in a single read communication cycle.

## **Hardware Description**

The HI7188 Evaluation Board provides the user with a very simple way of interfacing to, and evaluating the Intersil HI7188 16-channel sigma delta ADC. The board features two reference voltage generators, 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 HI7188 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.

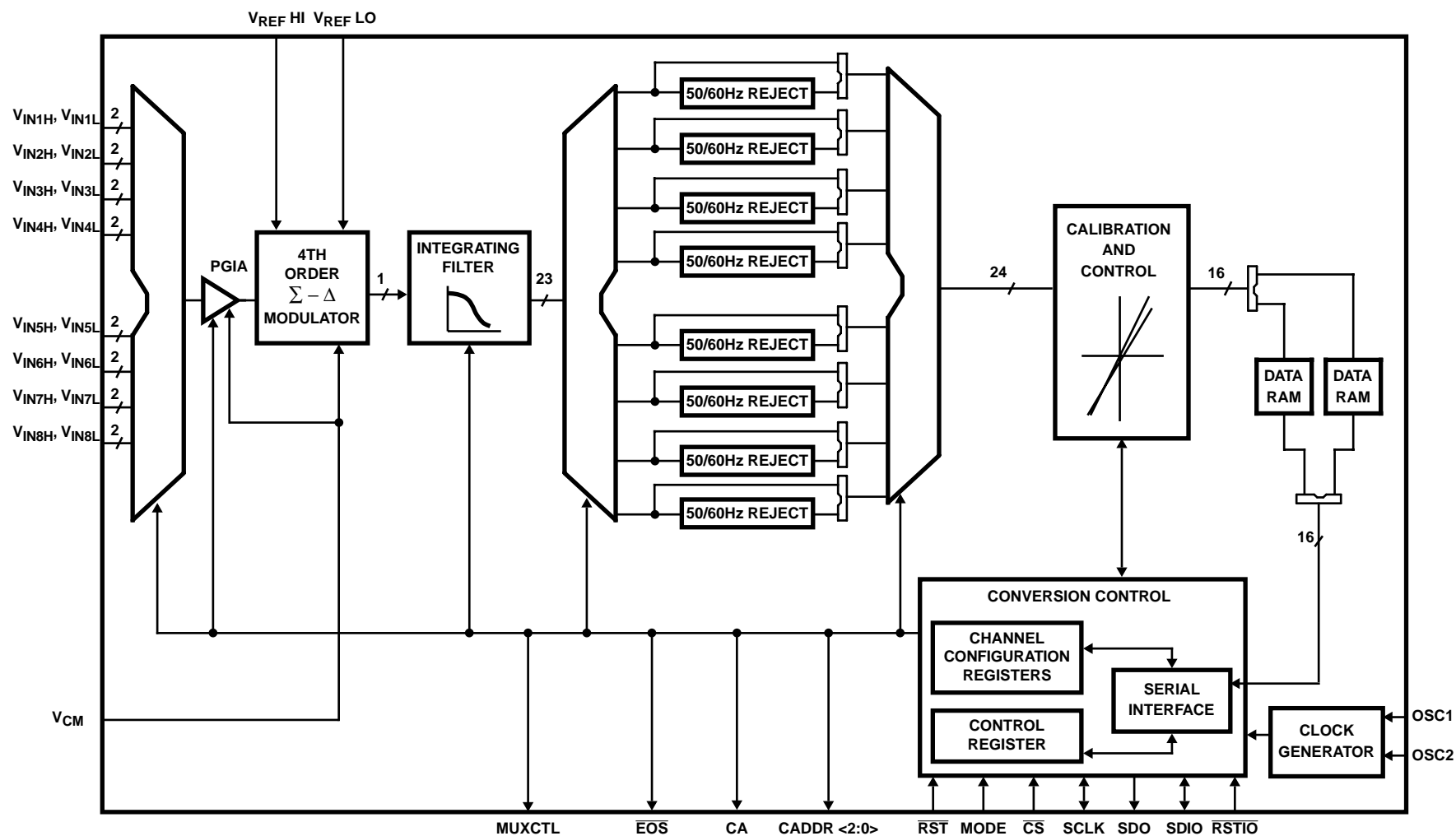
The power supplies are provided to the board via the edge connector located at the top of the board. It is recommended that twisted pair wires be used to connect the power supplies to the connector and that analog and digital grounds be tied together back at the power supplies. The separate supplies 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 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  $R_2$ ,  $R_4$ , and  $R_5$  provide a means of connecting the two ground planes together via 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 in front of the HI7188.

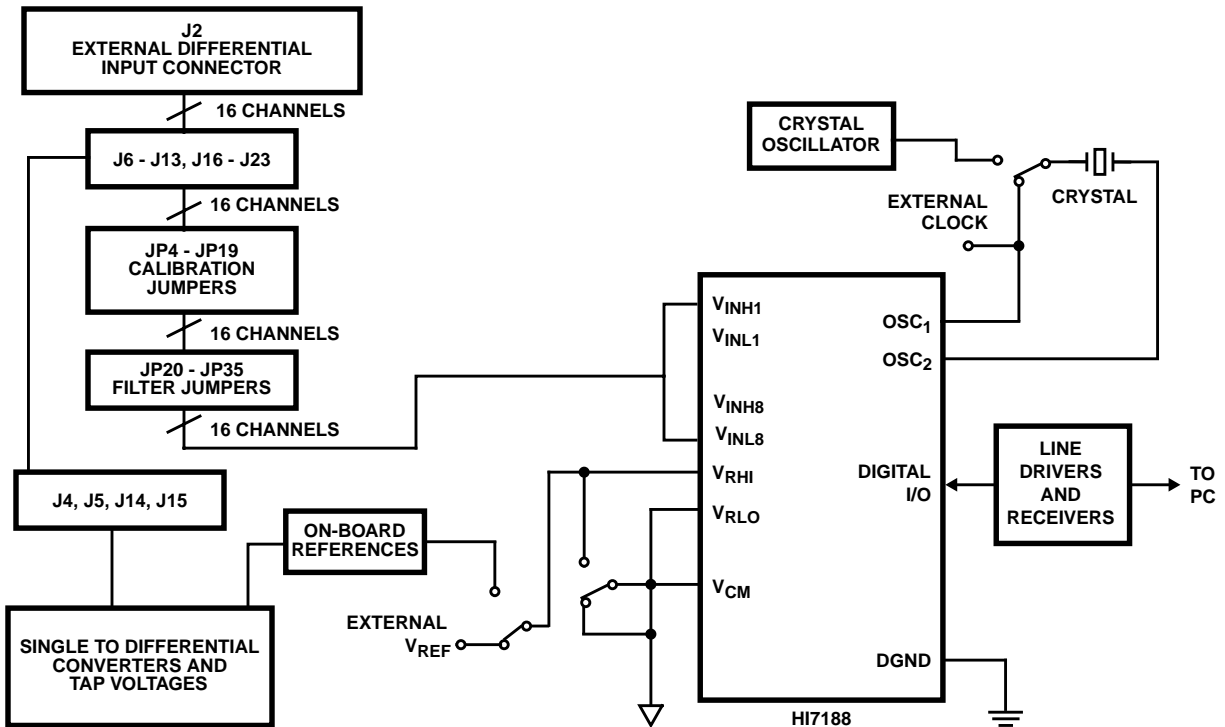
### **Reference Circuit**

The reference inputs of the HI7188,  $V_{RHI}$  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 HI7188.

## HI7188 Functional Block Diagram



## HI7188 Evaluation Board Simplified Block Diagram



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 HI7188 is 2.5V. Larger values of  $V_{REF}$  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 JP1 controls whether the  $V_{RHI}$  pin of the HI7188 is connected to an external reference, which connects to the  $V_{REFH}$  SMA pad, or to the on-board reference which is preset to 2.5V. If JP1 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  $R_1$  can be used to vary the on-board reference voltage. Please note that the specifications for the HI7188 are tested with  $V_{REF}$  set to 2.5V.  $V_{RHI}$  must always be greater than  $V_{RLO}$  for proper operation of the device.

### Analog Inputs

The 8 analog inputs on the HI7188 are fully differential inputs with programmable gain capabilities. The inputs accept both unipolar and bipolar input signals and gains range from 1 to 8. 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 PGA gain, and the input impedance is dependent upon the modulator clock rate. Please refer to the data sheet for more information.

External analog inputs come onto the board via the 34 pin connector (J2) located at the upper left hand corner of the board. Pin 1 is the bottom left pin on the connector.

The top row of jumpers (J6 - J13, J16 - J23) are used in conjunction with the single ended to differential converters. If an external input on J2 is being used for a particular channel then the top row jumpers for that channel must be removed from the board. For example, if external inputs are used for channels 1 and 5 and come into the board on J2, jumpers J6, J10, J16, and J20 must be removed from the board.

The middle row of jumpers, JP4 - JP19 can be used to calibrate the HI7188 in the gain of 1 mode by using the on-board reference voltage. For example, to perform a positive full scale calibration on channel 3 jumper JP9 is in the upper position ( $V_{REF}$ ) while JP8 is in the lower position (AGND). For a negative full scale calibration on channel 3, jumper JP9 is in the lower position (AGND) and jumper JP8 is in the upper position ( $V_{REF}$ ). To offset calibrate channel 6 on the HI7188 jumpers JP13 and JP14 are in the lower position (AGND). If an external or on-board input is being used for a particular channel then the middle row jumpers for that channel must be removed from the board. For example, if exter-

nal inputs are used for channels 1 and 5, jumpers JP4, JP7, JP12, and JP15 must be removed from the board.

The bottom row of jumpers (JP20 to JP35) provide a simple single pole RC Filter for each channel input. Putting the jumper in the lower position means the input will be non-filtered while moving the jumper to the upper position will provide filtering.

### Single Ended to Differential Converters

The board also includes 2 single ended to differential converters for use with external or on-board analog input voltages. The external inputs to the converters are the  $V_{INX}$  and  $V_{INY}$  sockets on the boards. It is recommended that twisted pair wire be used to connect to external analog inputs to  $V_{INX}$  and  $V_{INY}$  on the evaluation board. Jumpers J4, J5, J14, and J15 used in conjunction with jumpers J6 - J13 and J16 - J23 connect the outputs of the single ended to differential converters to the inputs of the HI7188. The board is set up such that an inherent gain of 2 exists in these converters. So if  $V_{INX} = 1V$ , the output of the single ended to differential converter will be  $\pm 1V$ . Note that use of these single ended to differential converters may limit the performance of the HI7188.

The evaluation board also contains on-board resistor strings used to generate inputs to the single ended to differential converters. These on-board voltages provide the user with a quick method of checking operation of the setup as well as the various gains of the HI7188. With the on-board voltages  $V_{REFH}$  and  $V_{MINUS}$  set to +2.5V and -2.5V respectively, the following nominal "tap" voltages result:

TAP1 = 1.4996V  
TAP2 = 1.0004V  
TAP3 = 0.12478V  
TAP4 = -0.12478V

$V_{REFH}$  and  $V_{MINUS}$  are adjustable via  $R_1$  and  $R_{37}$  respectively.

### Common Mode Input

The jumper JP2 is provided to allow the  $V_{CM}$  Pin to be tied to either analog ground (lower position), or  $V_{RHI}$  (upper 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 HI7188 is specified for  $AV_{DD} = +5V$  and  $AV_{SS} = -5V$  operation only.

### Clock Input

The master clock into the HI7188 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, line noise rejection frequencies, output update rate, and calibration times are all directly related to the master clock frequency,  $f_{OSC}$ . For the recommended 3.6864MHz clock the available line noise rejection frequencies are 50Hz and 60Hz. If line noise rejection of 60Hz is chosen the output update rate is 16.67ms. Please note that the HI7188 Specifications are written for a 3.6864MHz clock only.

The HI7188 Evaluation Board allows for the HI7188 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 JP3 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 JP3 is in the left most position the 3.6864MHz crystal oscillator is selected and when JP3 is in the right most position the combination 3.6864MHz crystal and on-chip oscillator clocking method is selected.

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 HI7188 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 HI7188. Please refer to the HI7188 Data Sheet for a detailed description of the functionality of these pins.

U4 on the Evaluation Board is an "open socket" which is used in conjunction with the test modes of the HI7188 for Intersil internal testing and evaluation.

## Software Description

The HI7188 Evaluation Software is designed to work with the HI7188 Evaluation Hardware when connected to a printer port on a standard PC. Both the executable file and the source code are provided. The source code was compiled with Borland's Turbo C++, Version 3.

The HI7188 Evaluation Software allows the user to operate the device in most of the various configurations 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.

The HI7188 Evaluation Software includes capability that allows the user to quickly perform the following functions:

1. Program the HI7188 without detailed knowledge of the Serial Interface.
2. Determine and/or save the current HI7188 configuration.
3. Read/Write all registers without detailed knowledge of the Serial Interface.
4. Continuously read the Data RAM and display statistics based on the conversion results.
5. Move to any menu from any menu in a single keystroke.
6. Initialize the HI7188 in a single keystroke.

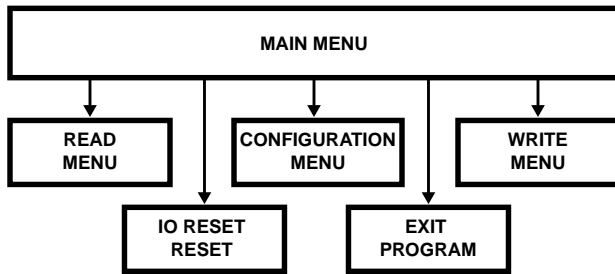


FIGURE 1. SIMPLIFIED SOFTWARE FLOW CHART

The Main Menu appears after invoking the HI7188 Evaluation Software. This menu is the gateway to other menus that allow the user to communicate with and evaluate the HI7188.

#### Main Menu:

- c Configuration Menu
- r Read Menu
- w Write Menu
- x EXIT PROGRAM

#### Reset Select:

- i I/O Reset
- s System Reset

#### Enter Selection:

- c Configuration Menu: Entering **c** from the Main Menu causes the HI7188 Configuration Menu to be displayed on the screen. The HI7188 Configuration Menu allows the user to easily program the HI7188 configuration, load preexisting configurations or quickly determine the current configuration. See the Configuration Menu description for details.
- r Read Menu: Entering **r** from the Main Menu causes the Read Menu to be displayed on the screen. The Read Menu allows read access to all registers without having knowledge of the specific instruction byte details. See the Read Menu description for details.
- w Write Menu: Entering **3** from the Main Menu causes the Write Menu to be displayed on the screen. The Write Menu allows write access to all registers without having knowledge of the specific instruction byte details. See the Write Menu description for details.
- i I/O Reset: Entering **i** from the Main Menu sends an active low signal to the HI7188 RST/I/O pin, clearing the Serial Interface Controller effectively aborting an ongoing communication cycle. The Main Menu remains displayed on the screen.
- s System Reset: Entering **s** from the Main Menu sends an active low signal to the HI7188 RST pin, which initializes the HI7188. The Main Menu remains displayed on the screen.
- x Exit Program: Entering **x** from the Main Menu causes the software to exit.

#### Configuration Menu:

The Configuration Menu allows the user to quickly program the HI7188 or to verify the current configuration. Capability includes: 1) Chip level and channel level programming via prompts to the user, 2) Configure the HI7188 from a file and save the current configuration to a file, 3) Interpret a configuration file and 4) Move from the Configuration Menu to any other menu.

#### Configuration Menu:

- 1 Set Chip Configuration
- 2 Set Channel Configuration
- 3 Set Full Configuration
- 4 Interpret Configuration File
- 5 Display/Save Current Configuration
- 6 Restore Full Configuration

#### Menu Select:

- m Main Menu
- r Read Menu
- w Write Menu

#### Reset Select:

- i I/O Reset
- s System Reset

#### Enter Selection:

- 1 Set Chip Configuration: Entering **1** from the Configuration Menu allows the user to perform chip level configuration of the HI7188. The user is asked a series of questions relating to the HI7188 Control Register bits. After completing these questions, the user is given the option of saving the information to a configuration file and actually executing the configuration. If the user requests writing a configuration file they are prompted to enter a filename. If the user confirms execution of the configuration, the software compiles the proper data and writes the Control Register, programming the HI7188 as desired. Executing this command, regardless of options chosen, returns the user to the Configuration menu. In addition, entering **c** at any of the prompts immediately returns the user to the Configuration menu.
- 2 Set Channel Configuration: Entering **2** from the Configuration Menu allows the user to program the channel(s) specific configuration of the HI7188. The user is asked a series of questions for each channel being converted. In the logical conversion order the user is prompted for 1) physical channel 2) unipolar/bipolar mode 3) operating/calibration mode and 4) gain. After completing these questions, the user is given the option of saving the information to a configuration file and actually executing the configuration. If the user requests writing a configuration file they are prompted to enter a filename. If the user confirms execution of the configuration, the software compiles the proper data and writes the Channel Config-

uration Register(s), programming the HI7188 as desired. Executing this command returns the user to the Configuration menu. In addition, entering **c** at any of the prompts immediately returns the user to the Configuration menu

- 3 Set Full Configuration: Entering **3** from the Configuration Menu allows the user to fully program the configuration of the HI7188 from a single menu pick. Choosing Set Full Configuration is functionally equivalent to choosing Set Chip Configuration followed by Set Channel Configuration. Executing this command returns the user to the Configuration Menu.
- 4 Interpret File: Entering **4** from the Configuration Menu allows the user to interpret a preset configuration file. The user is prompted for a file name from which the software determines what configuration would occur if this file were used to configure the HI7188. This information is displayed on the screen. The first screen output displays the chip level configuration. Hit any key to continue with the channel configuration information followed by the calibration coefficients. The number of keystrokes required to display all data in a configuration file is a function of the configuration file contents. Executing this command returns the user to the Configuration Menu.
- 5 Display/Save Current Configuration: Entering **5** from the Configuration Menu allows the user to quickly determine the present configuration of the HI7188. The software completes a read of the Control Register, Channel Configuration Registers and all Calibration RAMs, then displays the information on the screen. The user is then is given the option to save this configuration to a file. If saving to a file is selected, the user is prompted for a file name and a header comment. Please see the Helpful Hints Section of this document for a further explanation on using the Display/Save command. Executing this command returns the user to the Configuration Menu.
- 6 Restore Configuration: Entering **6** from the Configuration Menu allows the user to configure the HI7188 from a file. The user is prompted for a file name, from which the software executes the required communication cycles required to configure the HI7188 as described. Executing this command returns the user to the Configuration Menu.  
  
Towards the bottom of the Configuration Menu are picks that allow the user to quickly access the Main Menu, Read Menu, and Write Menu.
- m Main Menu: Entering **m** from the Configuration Menu returns software execution to the Main Menu.
- r Read Menu: Entering **r** from the Configuration Menu returns software execution to the Read Menu.
- w Write Menu: Entering **w** from the Configuration Menu returns software execution to the Write Menu.
- i I/O Reset: Entering **i** from the Configuration Menu sends an active low signal to the HI7188  $\overline{\text{RST}}/\text{I/O}$  pin, clearing the Serial Interface Controller effectively aborting an ongoing communication cycle. The Configuration Menu remains displayed on the screen.
- s Reset: Entering **s** from the Configuration Menu sends an active low signal to the HI7188  $\overline{\text{RST}}$  pin, which initializes

the HI7188. The Configuration Menu remains displayed on the screen.

### Configuration Files

Configuration files are ASCII files that can be used to program the HI7188 using a single command. An example configuration file is shown below:

Comment lines can go anywhere

CNTL 0140

CCR2 17371737

CCR1 1737

ORAM 00000A 00000B 00000A 00000B 00000A 00000B

PRAM 00000C 00000D 00000C 00000D 00000C 00000D

NRAM 00000E 00000F 00000E 00000F 00000E 00000F

If the user invokes the restore configuration pick (**6**) of the Configuration Menu and uses the file displayed above, the following sequence occurs:

1. **CNTL 0140:** 0140 (hex) will be written to the Control Register. This will configure the part to convert on 6 channels with line noise rejection disabled and the two's complement data coding bit active.
2. **CCR2 17371737:** 17371737 (hex) will be written to the CCR #2 Register. This will configure the HI7188 such that the first and third logical channels converted in the 6 channel conversion scan will use physical channel 1, bipolar mode, offset calibration mode and a gain select of 8. Also, the second and fourth logical channels converted in the 6 channel conversion scan will use physical channel 2, bipolar mode, offset calibration mode and a gain select of 8.
3. **CCR1 1737:** 1737 (hex) will be written to the CCR#1 Register. This will configure the HI7188 such that the fifth logical channel converted in the 6 channel conversion scan will use physical channel 1, bipolar mode, offset calibration mode and a gain select of 8. Also, the sixth logical channel converted in the 6 channel conversion scan will use physical channel 2, bipolar mode, offset calibration mode and a gain select of 8.
4. **ORAM 00000A 00000B 00000A 00000B 00000A 00000B:** 00000A (hex) will be written to the first, third, and fifth logical offset RAM location. These offset coefficients would be used for offset calibration of logical channels 1, 3, and 5 which are physically described by the CCR register contents. 00000B (hex) will be written to the second, fourth, and sixth logical offset RAM location. These offset coefficients would be used for offset calibration of logical channels 2, 4, and 6 which are physically described by the CCR register contents.
5. **PRAM 00000C 00000D 00000C 00000D 00000C 00000D:** 00000C (hex) will be written to the first, third, and fifth logical positive gain calibration RAM location. These coefficients would be used for gain calibration of positive input voltages for logical channels 1, 3, and 5 which are physically described by the CCR register contents. 00000D (hex) will be written to the second, fourth, and sixth logical positive gain calibration RAM location. These coefficients would be used for gain calibration of positive input voltages for logical channels 2, 4, and 6 which are physically described by the CCR register contents.

## 6. NRAM 00000E 00000F 00000E 00000F 00000EC

**00000F:** 00000E (hex) will be written to the first, third, and fifth logical negative gain calibration RAM location. These coefficients would be used for gain calibration of negative input voltages for logical channels 1, 3, and 5 which are physically described by the CCR register contents. 00000F (hex) will be written to the second, fourth, and sixth logical negative gain calibration RAM location. These coefficients would be used for gain calibration of negative input voltages for logical channels 2, 4, and 6, which are physically described by the CCR register contents.

If the above configuration file were used to restore the HI7188 the part would convert physical channels 1 and 2 in alternating sequence after a system offset calibration were performed. It is up to the user to ensure that the offset calibration voltage is applied to the HI7188 inputs **before** restoring this file.

Configuration files are ASCII files that may be generated with a text editor of your choice or through the Configuration Menu. A valid configuration file does not require all memory elements be specified. That is, any number of the lines in the above example could have been omitted. The software inspects the first field of each line for a known key word. The key words are CNTL, CCR2, CCR1, ORAM, PRAM, and NRAM. These key words must be upper case. Any line that does not have one of these key words in the first field is considered a comment line. **It is important that the CNTL line occur before the calibration RAM lines as the software must know the active channel count before accessing RAMs.**

Please note that the calibration coefficients chosen for this example are not realistic values and are used only for clarification in describing the contents of a configuration file.

### Read Menu:

The Read Menu allows the user to quickly read the contents of all accessible registers of the HI7188, without knowledge of the instruction byte required.

Read Menu:

- 1 Data RAM (quick read)
- 2 Data RAM
- 3 Control Register
- 4 CCR #2
- 5 CCR #1
- 6 Offset RAM
- 7 Positive Gain RAM
- 8 Negative Gain RAM
- 9 Hex Input

Menu Select:

- m Main Menu
- c Configuration Menu
- w Write Menu

Reset Select:

- i I/O Reset
- s System Reset

Enter Selection:

- 1 Data RAM (quick read): Entering **1** from the Read Menu invokes a read communication cycle with the Data RAM. The data is displayed in binary (MSB to LSB format), hex, and volts for each active channel being converted. Touch any key to return execution to the Read Menu.
- 2 Data RAM: Entering **2** from the Read menu invokes a read communication cycle with the Data RAM. The user will be asked if a continuous read is required. If continuous read is not requested, a single Data RAM read will occur and the software enters a "single step" read mode. In this mode, entering [return] will execute another data RAM read. This action continues until any key other than [return] is entered at the prompt. Discontinuation of the single step read mode returns the user to the Read Menu. If a continuous read is requested, the software inquires about saving the data to disc. If continuous read without saving to disc is requested, the user is asked if they would like data to be averaged and if so, how many conversion results to average before displaying data (a running average is maintained). See the *Display of Data RAM in Continuous Mode* paragraph in the Software Clarifications section of this document for details on what is displayed whether averaging is requested or not. If the user requests continuous reads and saving the data to disc, details regarding file name, number of conversion scans to store and data format are asked for. The reads are completed and execution returns to the Read Menu. See the *Saving Conversion Results to a File* paragraph in the Software Clarifications section of this document for details on the order of the prompts and other capabilities
- 3 Control Register: Entering **3** from the Read Menu invokes a read communication cycle with the Control Register. The data is displayed in hex, MSB to LSB format. Touch any key to return execution to the Read Menu.
- 4 Channel Configuration Register #2: Entering **4** from the Read Menu invokes a read communication cycle with the Channel Configuration Register #2. The data is displayed in hex, MSB to LSB format. Touch any key to return execution to the Read Menu.
- 5 Channel Configuration Register #1: Entering **5** from the Read Menu invokes a read communication cycle with the Channel Configuration Register #1. The data is displayed in hex, MSB to LSB format. Touch any key to return execution to the Read Menu.
- 6 Offset Calibration RAM: Entering **6** from the Read Menu invokes a read communication cycle with the Offset Calibration RAM. The data is displayed in hex, MSB to LSB format, for each active channel being converted. Touch any key to return execution to the Read Menu.
- 7 Positive Gain Calibration RAM: Entering **7** from the Read Menu invokes a read communication cycle with the Positive Gain Calibration RAM. The data is displayed in hex, MSB to LSB format, for each active channel being converted. Touch any key to return execution to the Read Menu.
- 8 Negative Gain Calibration RAM: Entering **8** from the Read Menu invokes a read communication cycle with the Negative Gain Calibration RAM. The data is displayed in hex,

MSB to LSB format, for each active channel being converted. Touch any key to return execution to the Read Menu.

- 9 Hex Input: Entering **9** from the Read Menu invokes a series of prompts allowing read access to any HI7188 Register. The user must know the instruction byte information for this command to be useful. The user will first be asked to enter, in hex, the IR byte of the communication cycle. The IR byte entered will be analyzed. If a write has been requested (from the Read Menu), an error message is displayed and execution returns to the Read Menu. If the IR byte entered is a valid read operation, the data is displayed on the screen, in hex. Touch any key to return execution to the Read Menu.

Towards the bottom of the Read Menu are picks that allow the user to quickly access the Main Menu, Configuration Menu, and Write Menu.

- m Main Menu: Entering **m** from the Read Menu returns software execution to the Main Menu.
- c Configuration Menu: Entering **c** from the Read Menu returns software execution to the Configuration Menu.
- w Write Menu: Entering **w** from the Read Menu returns software execution to the Write Menu.
- i I/O Reset: Entering **i** from the Read Menu sends an active low signal to the HI7188  $\overline{\text{RSTI/O}}$  pin, clearing the Serial Interface Controller effectively aborting an ongoing communication cycle. The Read Menu remains displayed on the screen.
- s Reset: Entering **s** from the Read Menu sends an active low signal to the HI7188  $\overline{\text{RST}}$  pin, which initializes the HI7188. The Read Menu remains displayed on the screen.

### Write Menu:

The Write Menu allows the user to quickly write data into all accessible memory elements of the HI7188, without knowledge of the instruction byte required.

Write Menu:

- 1 Data RAM (No OP)
- 2 Data RAM (No OP)
- 3 Control Register
- 4 CCR #2
- 5 CCR #1
- 6 Offset RAM
- 7 Positive Gain RAM
- 8 Negative Gain RAM
- 9 Hex Input

Menu Select:

- m Main Menu
- c Configuration Menu
- r Read Menu

Reset Select:

- i I/O Reset
- s System Reset

Enter Selection:

1. No Data RAM Write Possible: Entering **1** or **2** from the Write Menu is a no operation. The Data RAM is not writable.
- 3 Control Register: Entering **3** from the Write Menu invokes a write communication cycle with the Control Register. The user is prompted for the number of bytes to write and the starting byte before being prompted for the data. The software requires the data be entered in hex, most significant to least significant format, first byte to last byte order. Recall that if the most significant byte is not chosen as the starting byte, the data written will not be in MSB to LSB format as input at the keyboard. Please see the Software Clarifications Section for further details. If the user does not fully understand the HI7188 Serial Interface functionality, it is advisable to use the Configuration Menu to write the Control Register. When the I/O cycle has been completed, execution returns to the Write Menu.
- 4 Channel Configuration Register #2: Entering **4** from the Write Menu invokes a write communication cycle with the Channel Configuration Register #2. The user is prompted for the number of bytes to write and the starting byte before being prompted for the data. The software requires the data be entered in hex, most significant to least significant format, first byte to last byte order. Recall that if the most significant byte is not chosen as the starting byte, the data written will not be in MSB to LSB format as input at the keyboard. Please see the Software Clarifications Section for further details. If the user does not fully understand the HI7188 Serial Interface functionality, it is advisable to use the Chip Configuration Menu to write the Channel Configuration Register #2. When the I/O cycle has been completed, execution returns to the Write Menu.
- 5 Channel Configuration Register #1: Entering **5** from the Write Menu invokes a write communication cycle with the Channel Configuration Register #1. The user is prompted for the number of bytes to write and the starting byte before being prompted for the data. The software requires the data be entered in hex, most significant to least significant format, first byte to last byte order. Recall that if the most significant byte is not chosen as the starting byte, the data written will not be in MSB to LSB format as input at the keyboard. Please see the Software Clarifications Section for further details. If the user does not fully understand the HI7188 Serial Interface functionality, it is advisable to use the Chip Configuration Menu to write the Channel Configuration Register #1. When the I/O cycle has been completed, execution returns to the Write Menu.
- 6 Offset Calibration RAM: Entering **6** from the Write Menu invokes a write communication cycle with the Offset Calibration RAM. The user will be prompted, per channel, to enter the data to write. The number of channels prompted for is determined by the CR<7:5> bits. The software requires the data be entered in hex, most significant to least significant format. An Offset Calibration RAM word is 3 bytes, all bytes must be entered at the prompt.



- 7 Positive Gain Calibration RAM: Entering **7** from the Write Menu invokes a write communication cycle with the Positive Gain Calibration RAM. The user will be prompted, per channel, to enter the data to write. The number of channels prompted for is determined by the CR<7:5> bits. The software requires the data be entered in hex, most significant to least significant format. A Positive Gain Calibration RAM word is 3 bytes, all bytes must be entered at the prompt.
- 8 Negative Gain Calibration RAM: Entering **8** from the Write Menu invokes a write communication cycle with the Negative Gain Calibration RAM. The user will be prompted, per channel, to enter the data to write. The number of channels prompted for is determined by the CR<7:5> bits. The software requires the data be entered in hex, most significant to least significant format. A Negative Gain Calibration RAM word is 3 bytes, all bytes must be entered at the prompt.
- 9 Hex Input: Entering **9** from the Write Menu invokes a series of prompts allowing write access to any HI7188 Register. The user must know the instruction byte information for this command to be useful. The user will first be asked to enter, in hex, the IR byte of the communication cycle. The IR byte entered will be analyzed. If a read has been requested (from the Write Menu), an error message is displayed and execution returns to the Write Menu. If the IR byte entered is a write operation, the IR is analyzed for register destination and the user is prompted to input the data, in hex. The number of hex digits required at the input prompt is a function of the destination register and the instruction byte entered. When the I/O cycle has been completed, execution returns to the Write Menu.

Towards the bottom of the Write Menu are picks that allow the user to quickly access the Main Menu, Configuration Menu, and Read Menu.

- m Main Menu: Entering **m** from the Write Menu returns software execution to the Main Menu.
- c Configuration Menu: Entering **c** from the Write Menu returns software execution to the Configuration Menu.
- w Read Menu: Entering **w** from the Write Menu returns software execution to the Read Menu.
- i I/O Reset: Entering **i** from the Write Menu sends an active low signal to the HI7188  $\overline{\text{RSTI/O}}$  pin, clearing the Serial Interface Controller effectively aborting an ongoing communication cycle. The Write Menu remains displayed on the screen.
- s Reset: Entering **s** from the Write Menu sends an active low signal to the HI7188  $\overline{\text{RST}}$  pin, which initializes the HI7188. The Write Menu remains displayed on the screen.

## Software Execution

The PORTADR.DAT file contains the port identification for the parallel printer port interfacing the HI7188 Evaluation Board to the PC. Check the printer port address you are using and if required, update the PORTADR.DAT file. The DOS MSD command can be used to find the printer port address. **Communication between the Evaluation Board and the PC is not possible without the proper printer port address in the PORTADR.DAT file.**

Also on the diskette is the directory SRCCODE, which contains the evaluation software source code. The source code was compiled with Borland's Turbo C++, Version 3. The project file used for compilation is 88EVAL.PRJ. If disc space is limited, do not load this directory onto the PC disc.

**Loading Software** - Copy the four files (88EVAL.EXE, TESTALL5.CFG, TESTALLA.CFG and PORTADR.DAT) from the diskette onto your PC hard drive into the directory of your choice. The file 88EVAL.EXE is the executable program. The TEST\*.CFG files are configuration files used during the boot-up test. They must remain at the same hierarchical level as the 88EVAL.EXE file.

**Executing the Program** - Change directory (cd) into the directory containing the 88EVAL.EXE file. At the DOS prompt type 88EVAL [return]. The software reminds the user to apply power to the board before continuing with a automatic test that checks the communication capability between the PC and evaluation board. After completing this test, the Main Menu is displayed and evaluation of the HI7188 may continue.

If errors occur during the boot-up test routine, the on chip memory element that cannot be read will be displayed on the screen and the user must hit the return key for each failure to complete the test. If errors occur, an incorrect printer port identification is usually the problem.

## Software Clarifications

### Interrupting Configuration Menu Prompts

When programming the HI7188 configuration via the Configuration Menu entering **c** at any of the prompts will return the user to the Configuration Menu. This feature is useful if an undesired input is made allowing the user to quickly restart configuring the product without having to answer any further questions.

### Active Channels Display

The upper right corner of the screen displays the current number of active channels programmed into the DUT, regardless of the current menu. This is helpful as a quick check on the current configuration of the HI7188.

### Writing the Control Register

Caution should be taken when writing the Control Register via the Write Menu or Configuration Menu. The least significant byte contains information regarding the serial interface configuration that must be maintained when running the software provided. To ensure 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.

### Software Defaults

Every effort has been made to ease data input when writing the HI7188 memory elements. Default inputs have been chosen and the latest input is recorded in memory and used as the default the next time that prompt is issued. Its important to note that the defaults do not necessarily indicate the current state of the HI7188 or the state of the HI7188 after a power up reset. If the user is unsure of the current configuration of the HI7188, use the display/save current configuration menu pick.

### Bypassing Calibration

The HI7188 calibration algorithm can be effectively bypassed by writing all zeros into the Offset Calibration RAM and 800000 (hex) into the Positive and Negative Full Scale Calibration RAMs. This causes zero offset and forces a gain slope factor of 1.0. Please Note: If the calibration algorithm is bypassed in this manner, the data displayed when reading the Data RAM will convert the binary output to volts incorrectly. Without proper calibration, the HI7188 Evaluation Software cannot be used to determine accurate voltage as well as dynamic range and ENOB.

### Write Menu Data Entry

When entering data from prompts of the Write Menu the data must be entered in hex, MSB to LSB format with no spaces. Error detection is provided for invalid hex digits. A space or missing hex digit is flagged as an error and the user is re-prompted for the data.

### Reading the Configuration Registers

Recall that the Configuration Register bits associated with the calibration mode automatically return to normal mode after calibration is completed. If the user programs a calibration mode, then completes a read of the Configuration Menu (or invokes a display/save current configuration), the operating mode bits usually will be in the normal mode due to the fact that calibration is complete.

### Saving Conversion Results to a File

Entering 2 from the Read Menu allows the user to save conversion results to a file. If the user requests continuous reads and answers yes to the save to a file prompt, the following sequence occurs: The user is prompted for the number of

conversion readings to save followed by the data format. The user is then prompted as to whether a header should be included in the file and is then prompted for the file name in which the data is saved. If a header is requested, the user is prompted for a one line comment. The complete header will include a date stamp line, the current state of the Control Register, Configuration Registers and all calibration RAMs as well as the one line comment. If no header is selected, only the conversion result data is included in the file.

Choosing the **Binary** format writes the conversion results, in binary, for each channel being converted. The first field of each line is the logical channel number of that conversion scan, while the second field is the data. The number of data lines in the file is equal to the number of conversions the user has requested to save times the number of logical channels being converted.

Choosing the **Hex** format writes the conversion results, in hex, for each channel being converted. The first field of each line is the logical channel number of that conversion scan, while the second field is the data. The number of data lines in the file is equal to the number of conversions the user has requested to save times the number of logical channels being converted.

Choosing the **Volts** format writes the conversion results, in volts, for each channel being converted. The first field of each line is the logical channel number of that conversion scan, while the second field is the data. The number of data lines in the file is equal to the number of conversions the user has requested to save times the number of logical channels being converted. Please note, the conversion to volts will not be accurate unless accurate calibration coefficients are used by the HI7188.

Choosing the **Binary, Hex, Volts** format writes the conversion results, in all three formats, for each channel being converted. The first field of each line is the logical channel number of that conversion scan. The second, third and fourth fields are the data in binary, hex and volts; respectively. The number of data lines in the file is equal to the number of conversions the user has requested to save times the number of logical channels being converted. Please note, the conversion to volts will not be accurate unless accurate calibration coefficients are used by the HI7188.

### Display of Data RAM in Continuous Mode

Entering 2 from the Read Menu allows the user to request continuous read of the Data RAM. If continuous read mode is chosen, the user is asked if averaging is required and if so, how many points to use while maintaining a running average. If averaging is requested, the following information is displayed, per active channel: 1) The binary output stream read from the HI7188, 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. If averaging is not requested, only the binary output, binary conversion to hex and volts is displayed, per active channel:

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:

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

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

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

### Resetting the DUT

Entering **s** from the Main Menu resets the HI7188 to its initial state. The initial state of the HI7188 is as follows: Convert 1 logical channel (physical channel 1, bipolar inputs, gain of 1, conversion mode), bypass line noise rejection filters. The serial interface configuration is MSB first bit positioning, descending byte order, bidirectional I/O Pin. This reset function is also accessible from the sub-menus as previously described in the Software Description Section of this document.

### Resetting the I/O of DUT

Entering **i** from the Main Menu resets the HI7188 serial interface controller. This has no affect on the HI7188 configuration, only the synchronization of the serial interface is affected. As this hardware and software has been tested and I/O synchronization is automatically maintained, this menu pick will seldom be used. This serial interface reset function is also accessible from the sub-menus as previously described in the Software Description Section of this document.

## Helpful Hints

### Start with the Configuration Menu

Novice users should consider reviewing and exercising the Configuration Menu picks first. The Configuration Menu offers a wide range of functions that allow the user to quickly program and report on the HI7188 configuration.

When programming the initial configuration, use pick 3. This will prompt for both chip level and channel configuration information. After the initial configuration is complete it is generally useful to use picks 1 or 2 when making configuration revisions. Use of picks 1 or 2 allow chip level or channel specific programming, respectively.

### Make use of Configuration Files

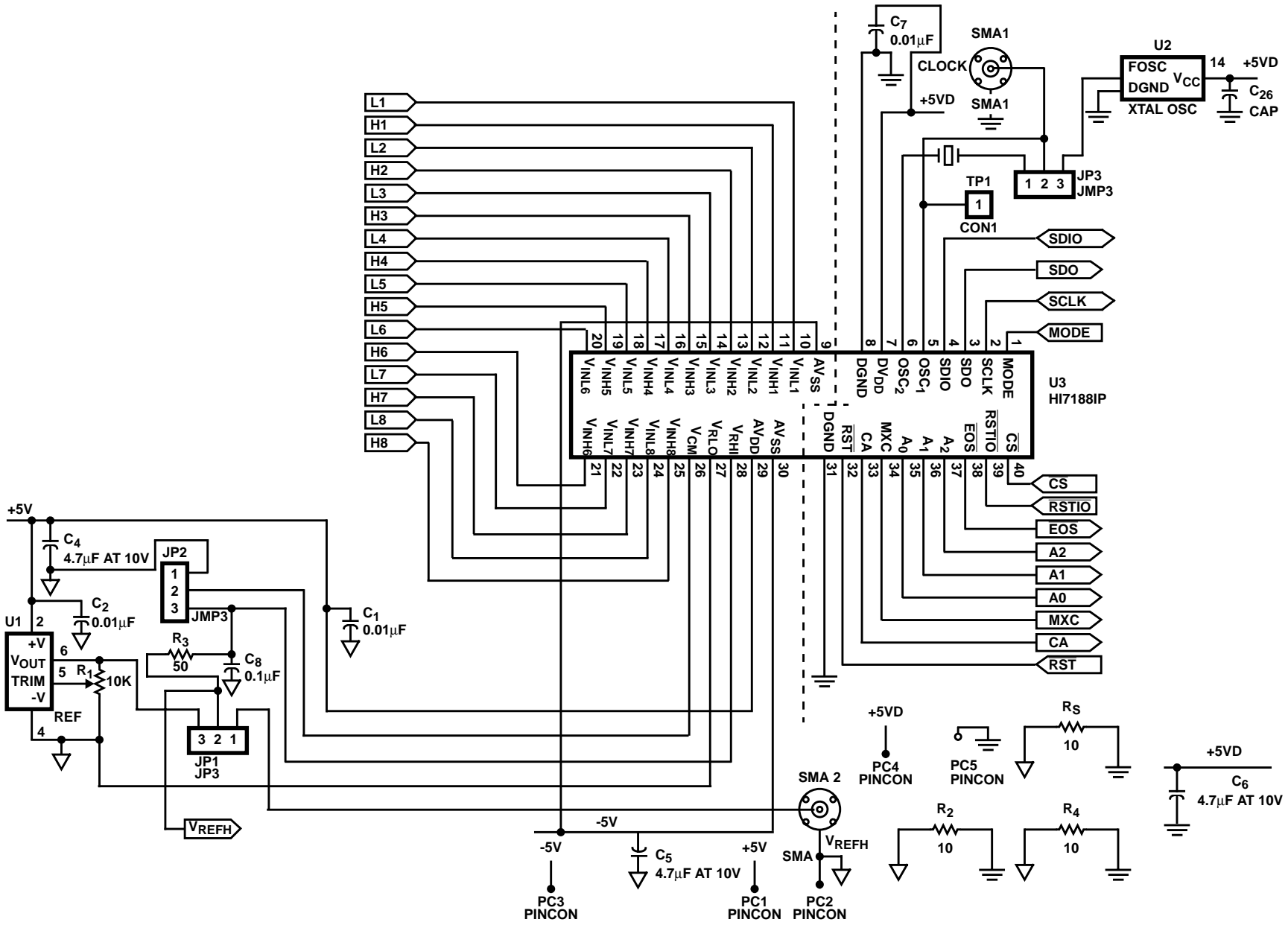
Understand and make use of the configuration file restore capability. This capability allows the user to “fully” configure the HI7188 with a single command.

Configuration files may be hand crafted with a text editor of your choice or they may be generated via the Configuration Menu. Recall that when the HI7188 is configured for a calibration mode that the CCR bits will return to normal mode automatically. Therefore, it is recommended that when using the Configuration Menu to generate a configuration file, the user save the configuration file before executing the command.

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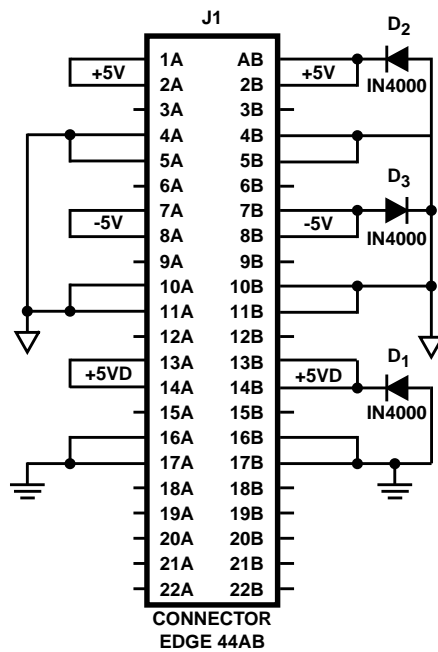
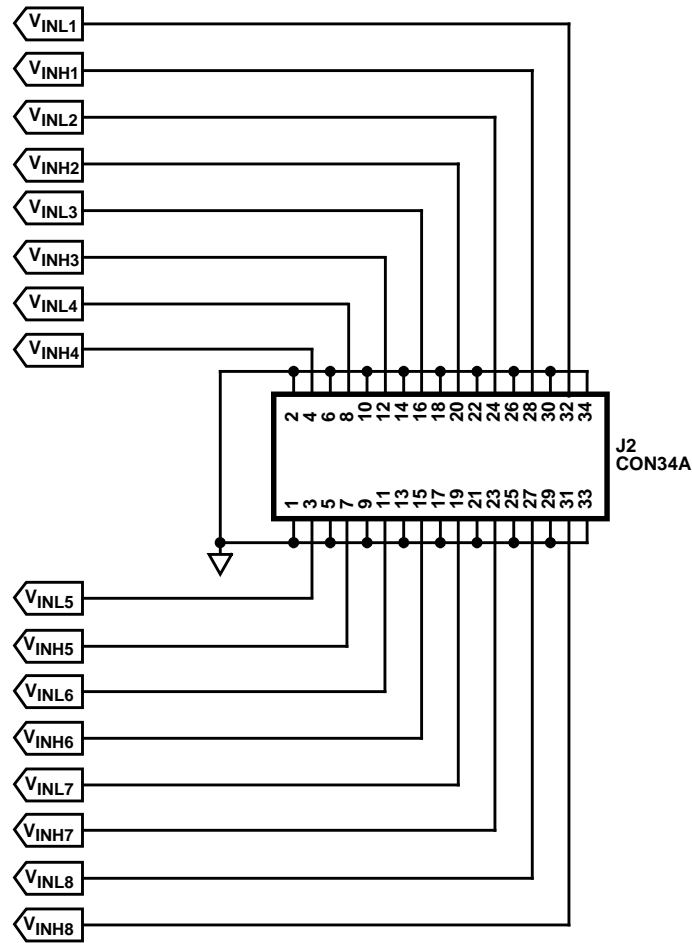


FIGURE 2. SCHEDULE 1 SCHEMATIC (Continued)

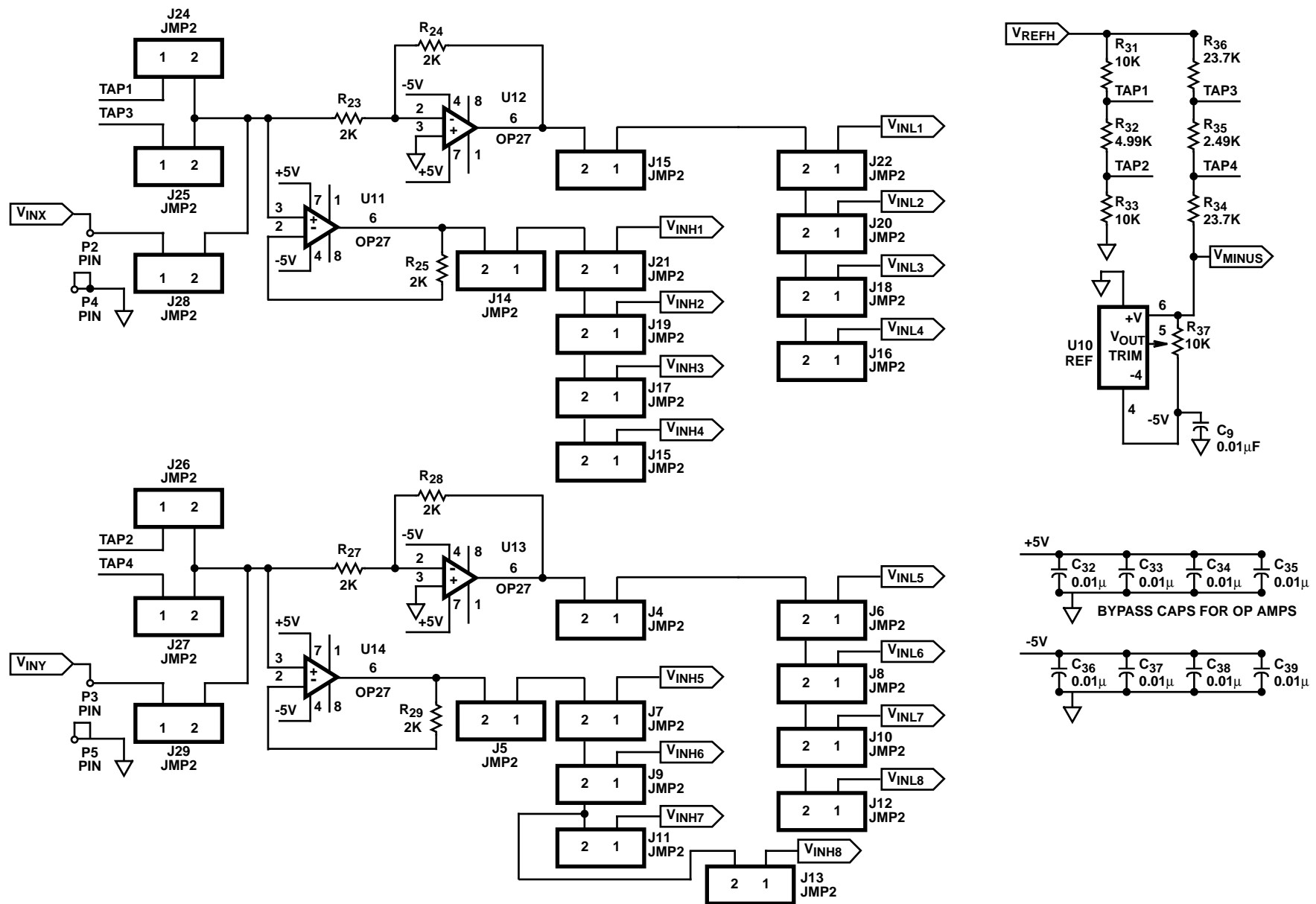


FIGURE 3. SCHEDULE 2 SCHEMATIC

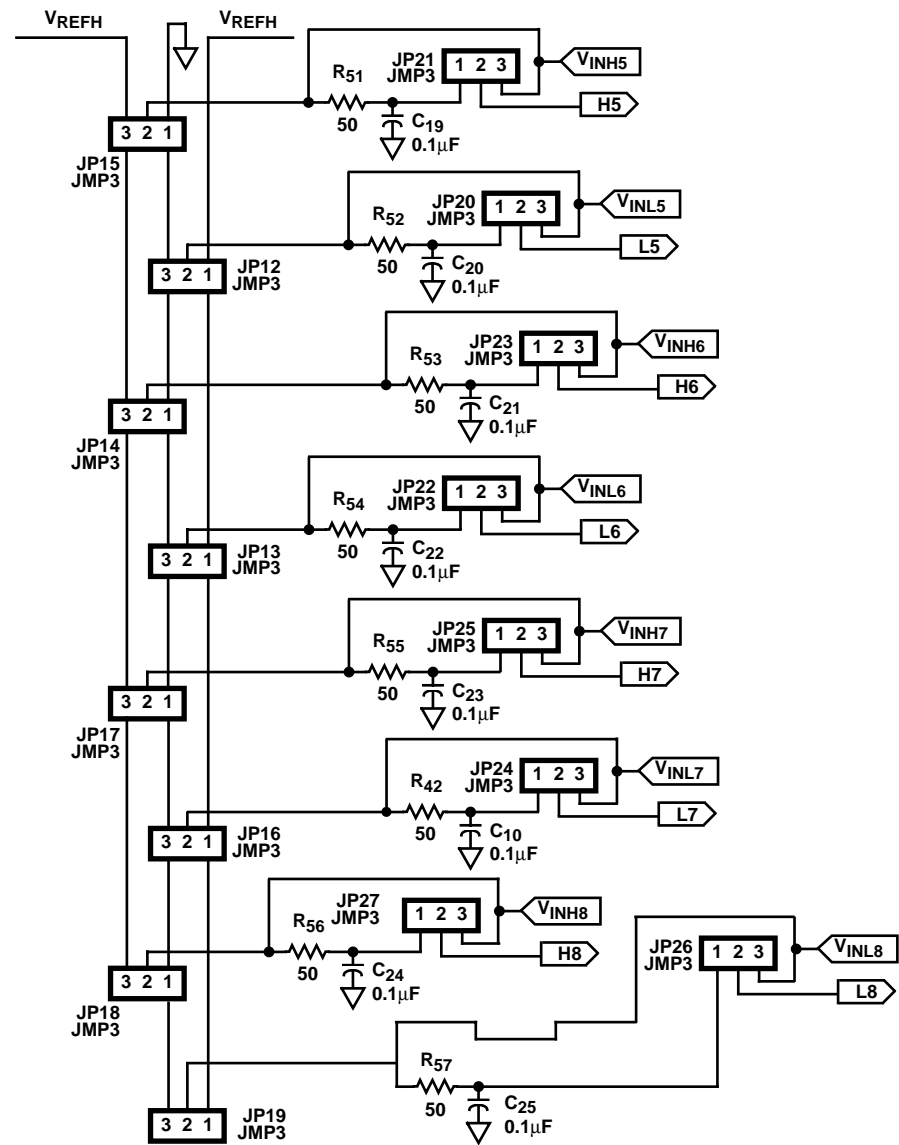
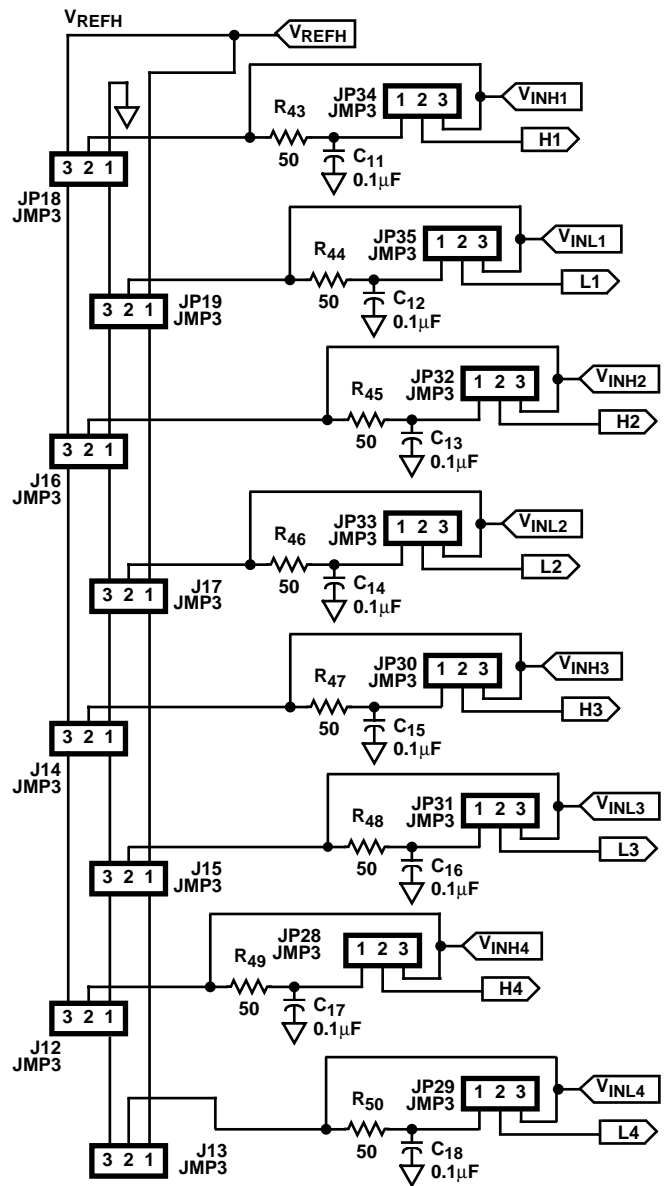


FIGURE 4. SCHEDULE 3 SCHEMATIC

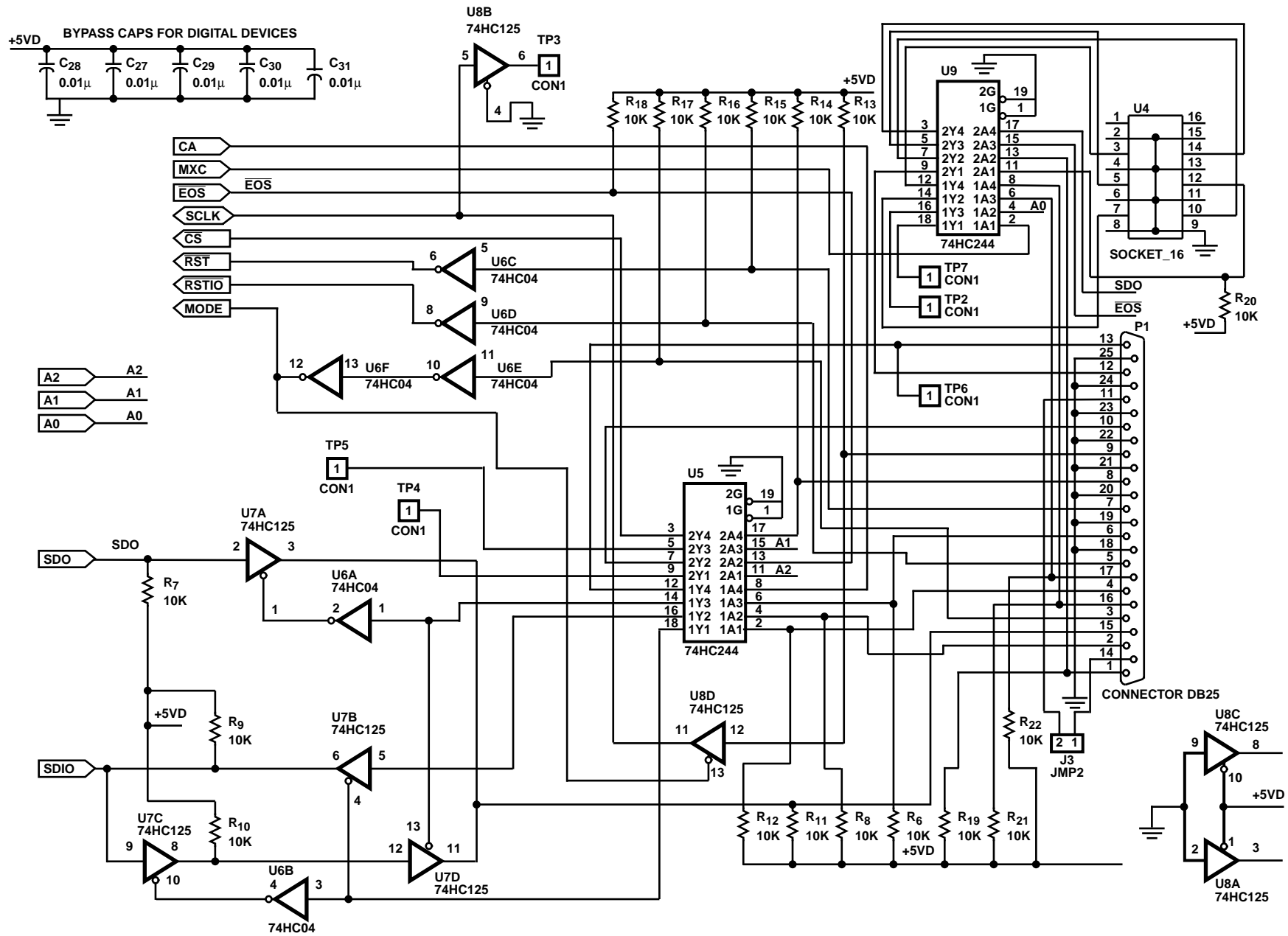


FIGURE 5. SCHEDULE 4 SCHEMATIC



## Application Note 9518

**TABLE 1. PARTS LIST**

ITEM	QUANTITY	REFERENCE	PART
1	19	C <sub>1</sub> , C <sub>2</sub> , C <sub>3</sub> , C <sub>7</sub> , C <sub>9</sub> , C <sub>26</sub> , C <sub>27</sub> , C <sub>28</sub> , C <sub>29</sub> , C <sub>30</sub> , C <sub>31</sub> , C <sub>32</sub> , C <sub>33</sub> , C <sub>34</sub> , C <sub>35</sub> , C <sub>36</sub> , C <sub>37</sub> , C <sub>38</sub> , C <sub>39</sub>	0.01μF
2	3	C <sub>4</sub> , C <sub>5</sub> , C <sub>6</sub>	10μF at 10V
3	18	C <sub>8</sub> , C <sub>10</sub> , C <sub>11</sub> , C <sub>12</sub> , C <sub>13</sub> , C <sub>14</sub> , C <sub>15</sub> , C <sub>16</sub> , C <sub>17</sub> , C <sub>18</sub> , C <sub>19</sub> , C <sub>20</sub> , C <sub>21</sub> , C <sub>22</sub> , C <sub>23</sub> , C <sub>24</sub> , C <sub>25</sub> , C <sub>26</sub>	0.1μF
4	3	D <sub>1</sub> , D <sub>2</sub> , D <sub>3</sub>	1N4001
5	62	JP <sub>1</sub> , JP <sub>2</sub> , JP <sub>3</sub> , JP <sub>4</sub> , JP <sub>5</sub> , JP <sub>6</sub> , JP <sub>7</sub> , JP <sub>8</sub> , JP <sub>9</sub> , JP <sub>10</sub> , JP <sub>11</sub> , JP <sub>12</sub> , JP <sub>13</sub> , JP <sub>14</sub> , JP <sub>15</sub> , JP <sub>16</sub> , JP <sub>17</sub> , JP <sub>18</sub> , JP <sub>19</sub> , JP <sub>20</sub> , JP <sub>21</sub> , JP <sub>22</sub> , JP <sub>23</sub> , JP <sub>24</sub> , JP <sub>25</sub> , JP <sub>26</sub> , JP <sub>27</sub> , JP <sub>28</sub> , JP <sub>29</sub> , JP <sub>30</sub> , JP <sub>31</sub> , JP <sub>32</sub> , JP <sub>33</sub> , JP <sub>34</sub> , JP <sub>35</sub> , J <sub>3</sub> , J <sub>4</sub> , J <sub>5</sub> , J <sub>6</sub> , J <sub>7</sub> , J <sub>8</sub> , J <sub>9</sub> , J <sub>10</sub> , J <sub>11</sub> , J <sub>12</sub> , J <sub>13</sub> , J <sub>14</sub> , J <sub>15</sub> , J <sub>16</sub> , J <sub>17</sub> , J <sub>18</sub> , J <sub>19</sub> , J <sub>20</sub> , J <sub>21</sub> , J <sub>22</sub> , J <sub>23</sub> , J <sub>24</sub> , J <sub>25</sub> , J <sub>26</sub> , J <sub>27</sub> , J <sub>28</sub> , J <sub>29</sub>	JMP2, JMP3
6	1	J <sub>1</sub>	CONNECTOR EDGE44AB
7	1	J <sub>2</sub>	CON34A
8	1	P <sub>1</sub>	CONNECTOR DB25
9	2	R <sub>1</sub> , R <sub>37</sub>	10K
10	17	R <sub>6</sub> , R <sub>7</sub> , R <sub>8</sub> , R <sub>9</sub> , R <sub>10</sub> , R <sub>11</sub> , R <sub>12</sub> , R <sub>13</sub> , R <sub>14</sub> , R <sub>15</sub> , R <sub>16</sub> , R <sub>17</sub> , R <sub>18</sub> , R <sub>19</sub> , R <sub>20</sub> , R <sub>21</sub> , R <sub>22</sub>	10K
11	17	R <sub>3</sub> , R <sub>42</sub> , R <sub>43</sub> , R <sub>44</sub> , R <sub>45</sub> , R <sub>46</sub> , R <sub>47</sub> , R <sub>48</sub> , R <sub>49</sub> , R <sub>50</sub> , R <sub>51</sub> , R <sub>52</sub> , R <sub>53</sub> , R <sub>54</sub> , R <sub>55</sub> , R <sub>56</sub> , R <sub>57</sub>	49.9
12	3	R <sub>2</sub> , R <sub>4</sub> , R <sub>5</sub>	10
13	4	R <sub>23</sub> , R <sub>24</sub> , R <sub>25</sub> , R <sub>27</sub> , R <sub>28</sub> , R <sub>29</sub>	2.0K
14	2	R <sub>26</sub> , R <sub>30</sub>	2.0K
15	2	R <sub>31</sub> , R <sub>33</sub>	10K
16	1	R <sub>32</sub>	4.99K
17	2	R <sub>34</sub> , R <sub>36</sub>	23.7K
18	1	R <sub>35</sub>	2.49K
19	2	SMA <sub>1</sub> , SMA <sub>2</sub>	SMA
20	2	U <sub>1</sub> , U <sub>10</sub>	LT1019CN8-2.5
21	1	U <sub>2</sub>	XTAL OSCILLATOR
22	1	U <sub>3</sub>	HI7188IP
23	2	U <sub>5</sub> , U <sub>9</sub>	74HC244
24	1	U <sub>6</sub>	74HC04
25	2	U <sub>7</sub> , U <sub>8</sub>	74HC125
26	4	U <sub>11</sub> , U <sub>12</sub> , U <sub>13</sub> , U <sub>14</sub>	HA5170
27	1	Y <sub>1</sub>	CRYSTAL
28	42		Shunts
29	6		Bumpers
30	1		Cable
31	136		Pin Sockets
32	3		14 Pin IC sockets

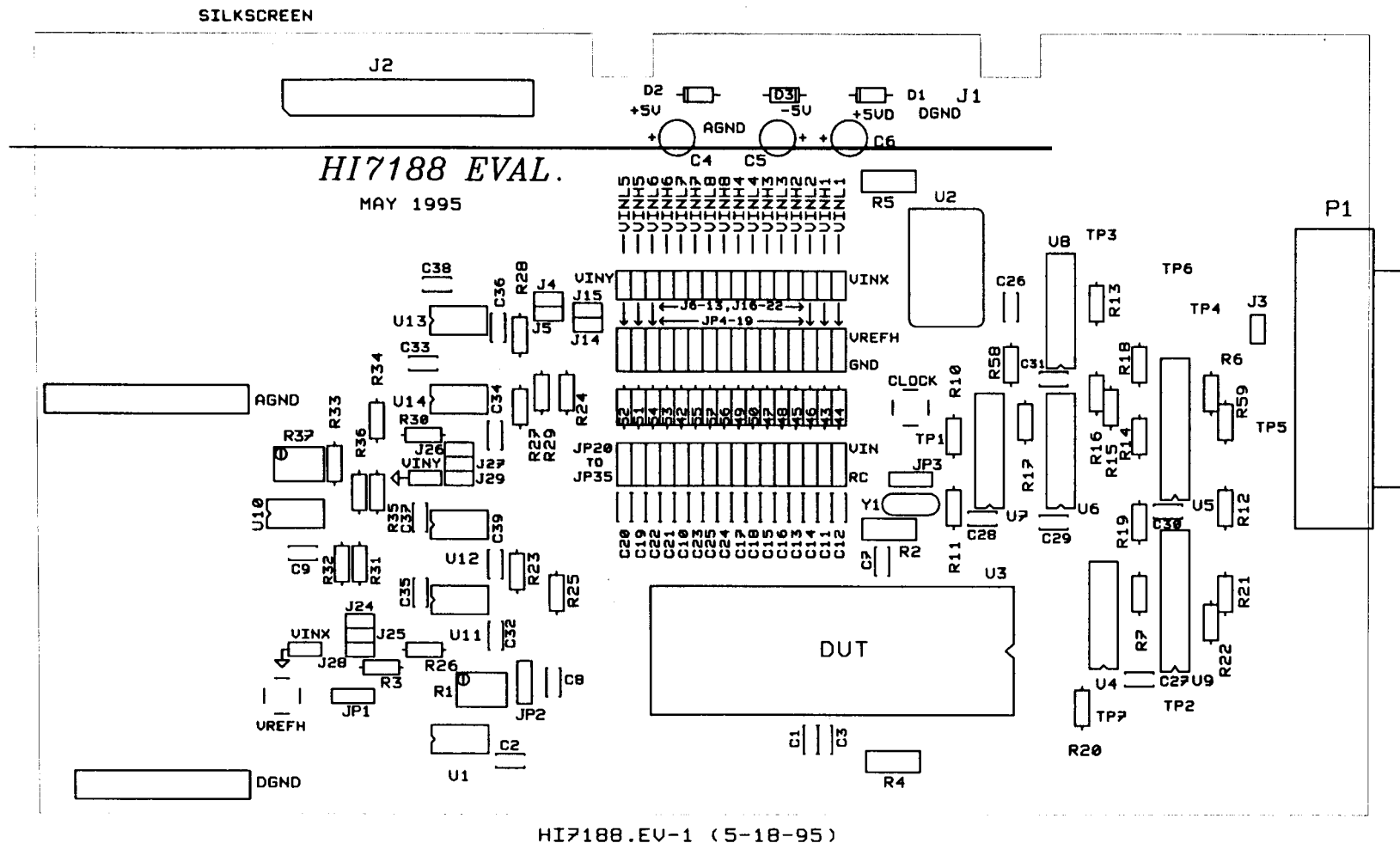


FIGURE 6. COMPONENTS LAYOUT

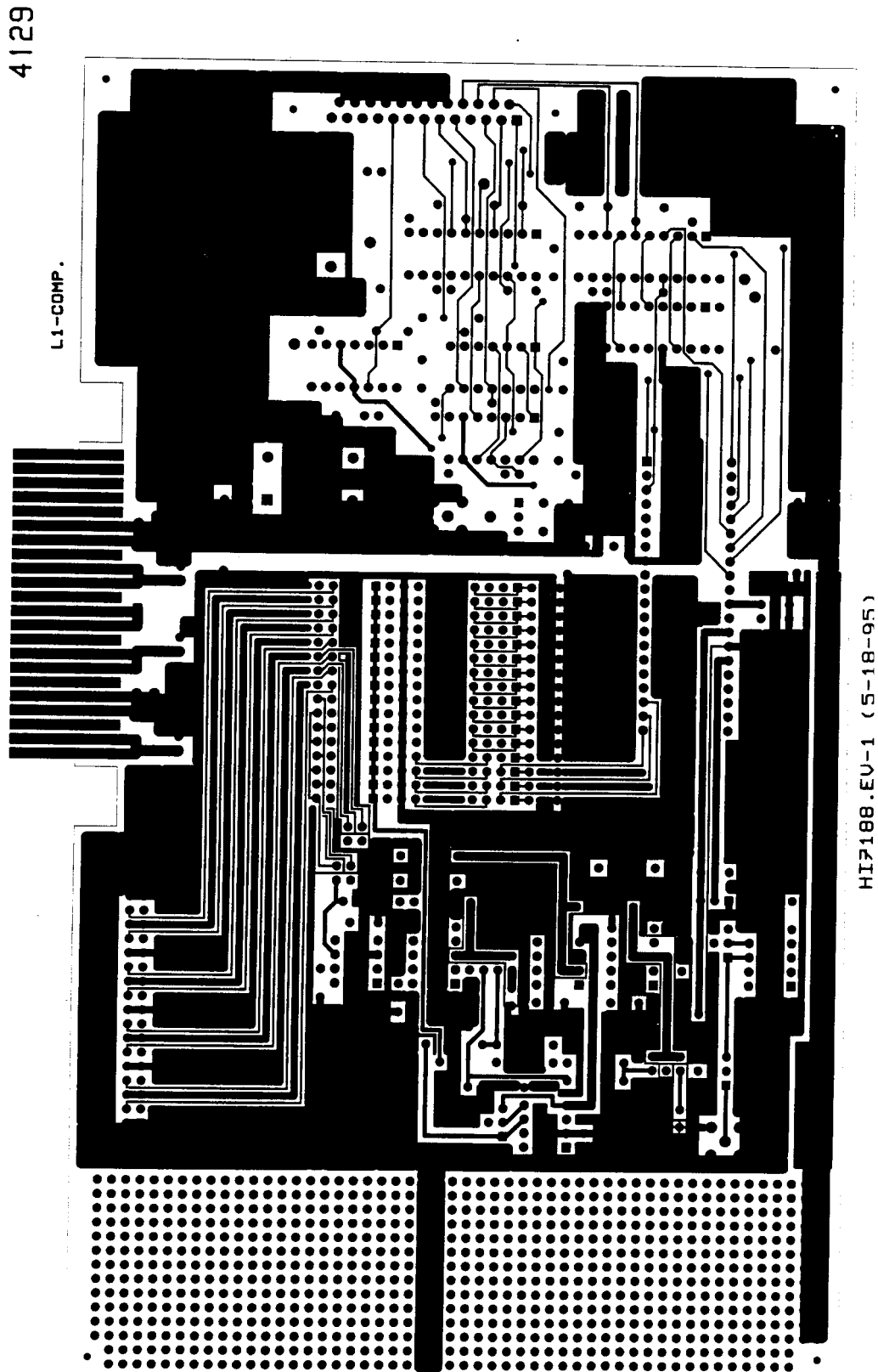


FIGURE 7. COMPONENT SIDE

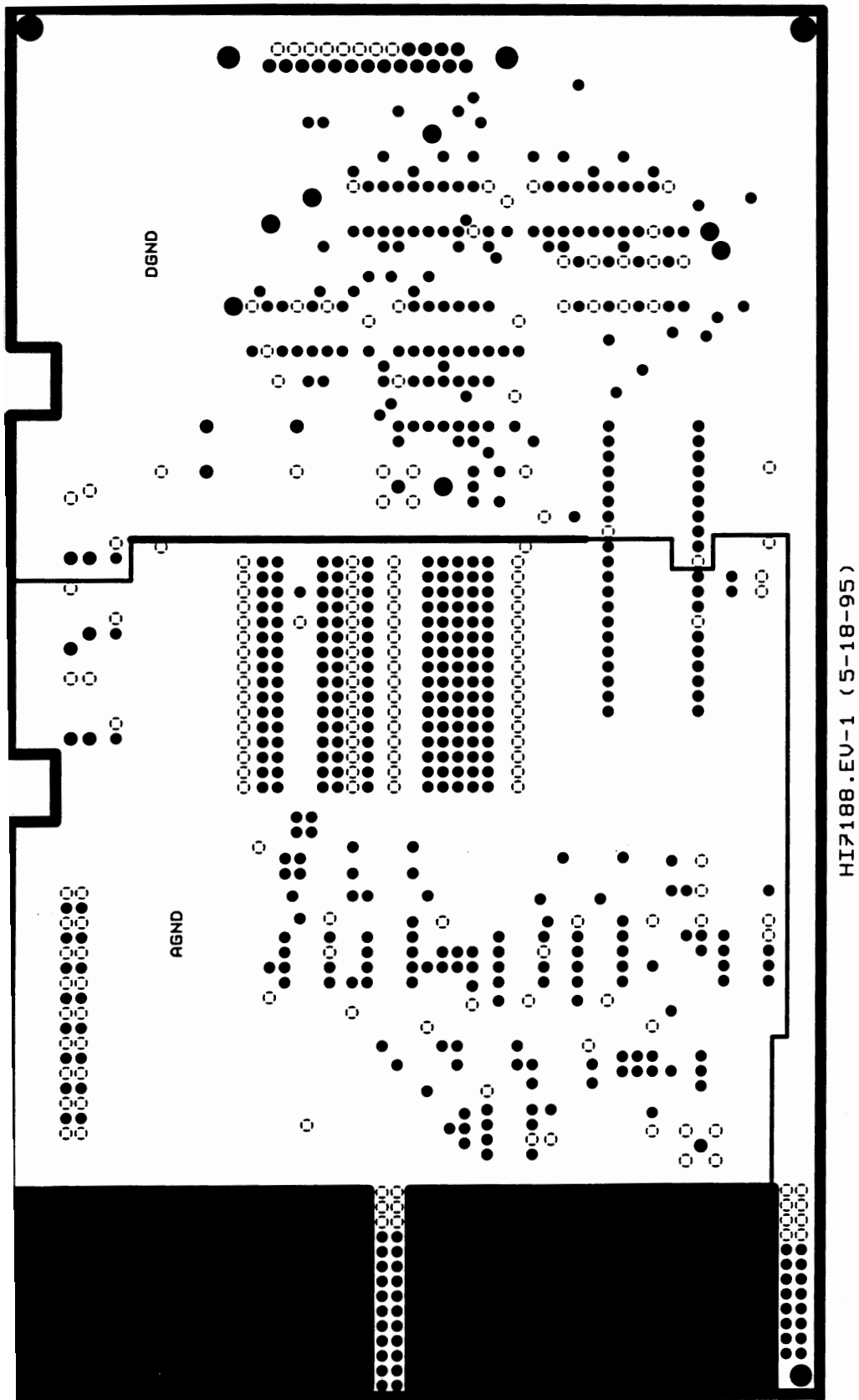


FIGURE 8. GROUND PLANES

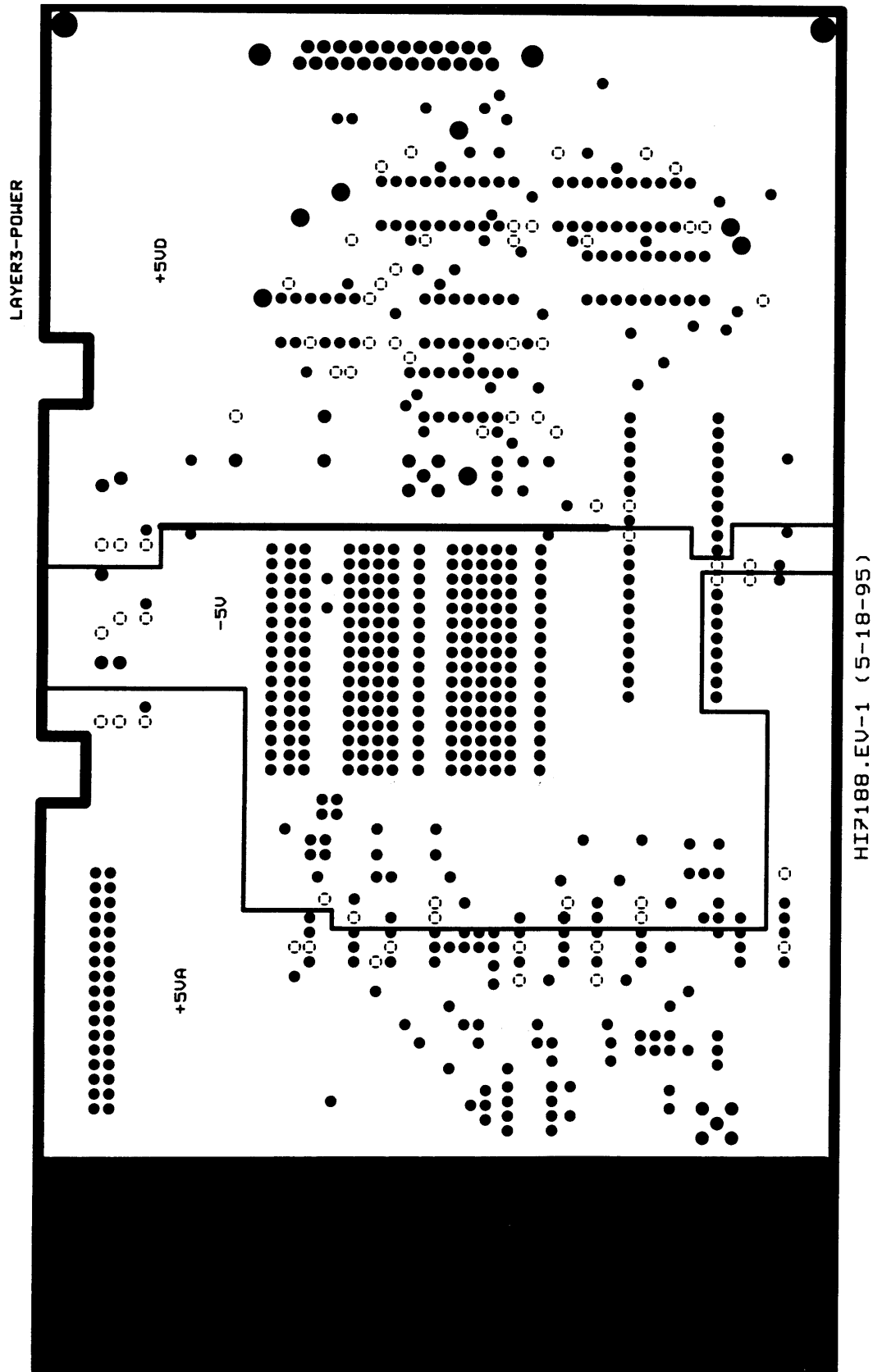


FIGURE 9. POWER PLANES

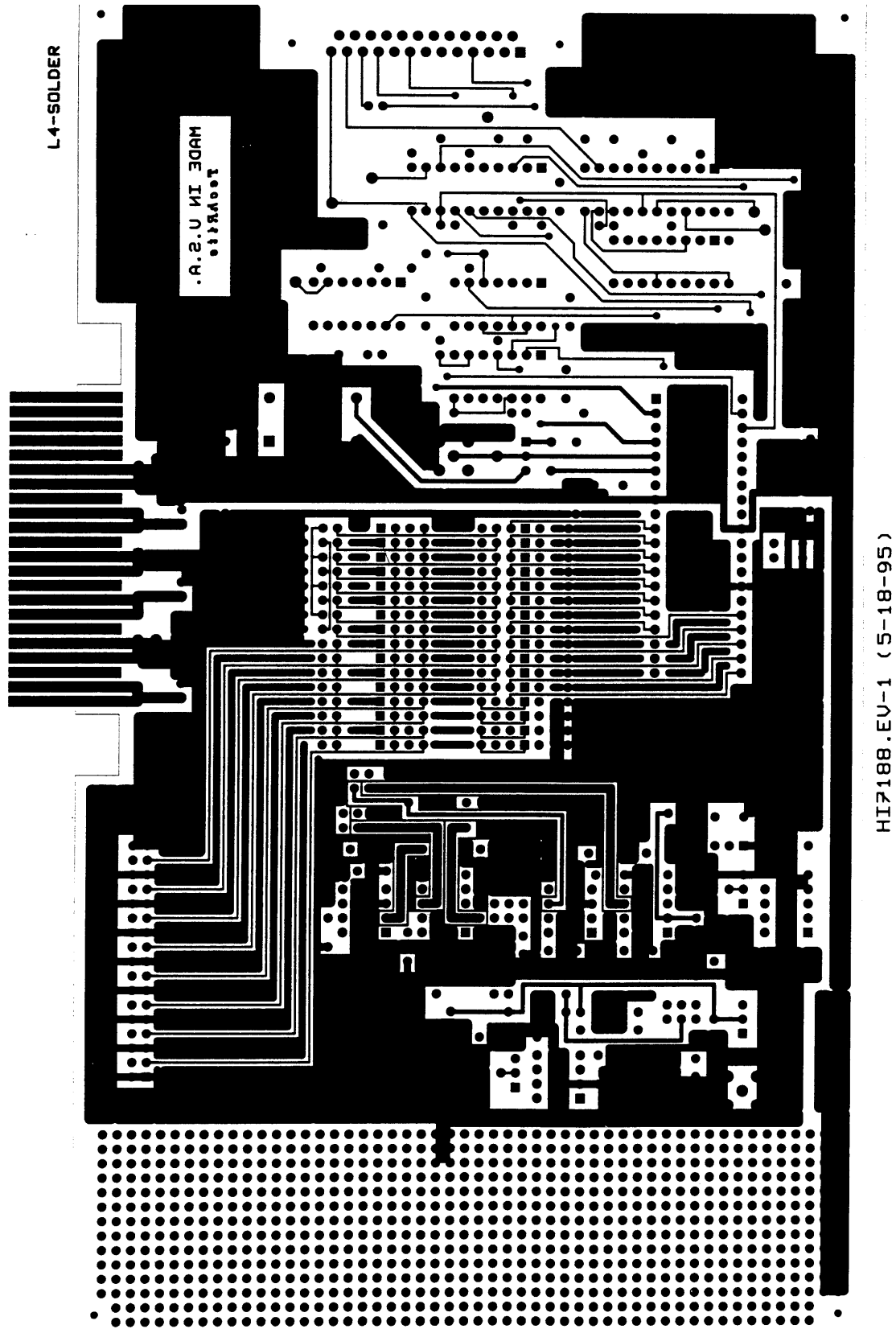


FIGURE 10. SOLDER SIDE

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