

## Description

The HI5728EVAL1 evaluation board provides a quick and easy method for evaluating the HI5728, 125MSPS Dual High Speed DAC. Each converter outputs a current into a load resistor to form a voltage which can be measured by using the included SMA connectors. The amount of current out of the DAC is determined by an external resistor and either an internal or external reference voltage. The evaluation board also includes a VME digital interface that is compatible with the HSP-EVAL board, so DDS (Direct Digital Synthesis) can be performed with minimal setup time. A transformer is included to take advantage of differential signal drive.

## Ordering Information

PART NUMBER	TEMP. RANGE (°C)	PACKAGE	CLOCK SPEED
HI5728EVAL1	25	Evaluation Platform	125MHz

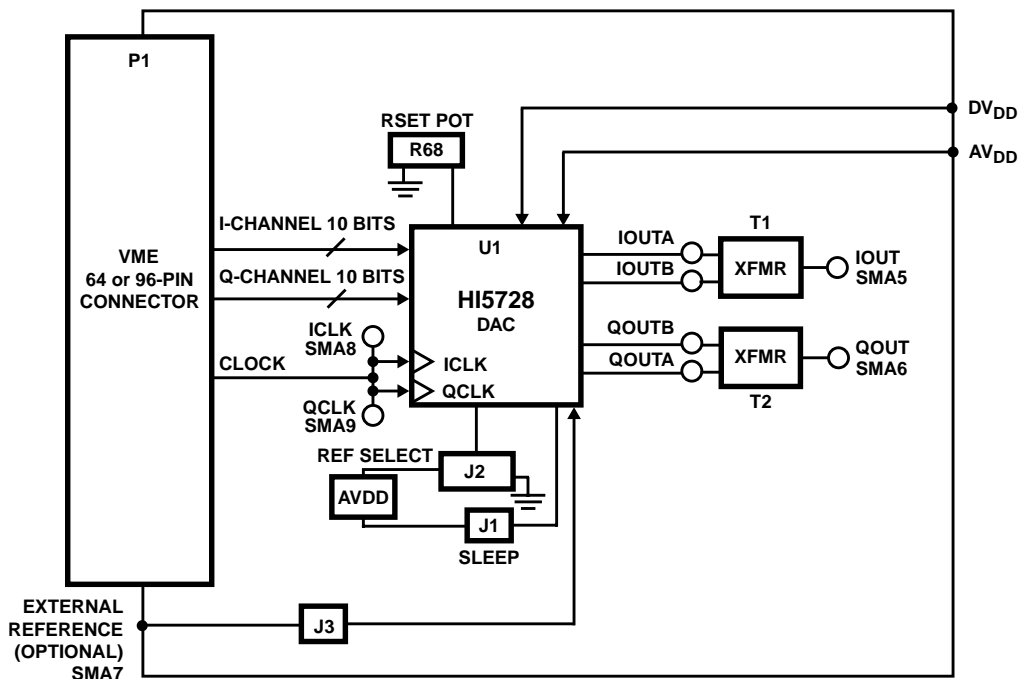
## Features

- HI5728, 125MSPS CMOS DAC
- Simple and Easy to Use
- Standard VME/DSP Interface, HSP-EVAL Compatible
- SMA Outputs with Transformer Option
- Easily Selectable Internal or External Reference

## Applications

- I and Q Signal Generation
- Modulated Carrier Generation
- General DAC Performance Evaluation
- Amplitude Modulation Via External Reference

## Functional Block Diagram



## Functional Description

### Overview

The evaluation board is configured to be interfaced using a VME connector. The data input lines are tied together using small, zero ohm resistors on the back side of the board (QD0 is tied to ID0, continued with QD9 connected to ID9; see the schematic, R54, 58-60, 62-67). This is done so that the data can be driven into both of the channels without having to generate two patterns. This aids in simplifying the evaluation of the part. If the user has the ability to generate dual patterns during the evaluation process, these resistors must be removed. Both series and parallel termination resistor footprints are provided, so that the user may customize the termination method. An internal voltage reference is available, as well as a variable resistor for customizing the output current. RF transformers are populated for taking advantage of the complimentary current outputs. They can be disabled from the circuit by removing several zero ohm resistors if a simple load resistor output is desired.

### Voltage Reference

The HI5728 has an internal voltage reference (1.16V typical) with a  $\pm 60\text{ppm}/^\circ\text{C}$  drift coefficient over the full temperature range of the converter. The REFLO pin (15) selects the reference. Access to pin 15 is provided through the center pin of Jumper J2. To enable the internal reference, it is necessary that the jumper be placed such that pin 15 is grounded (J2 is labeled on the board as INT and EXT, for internal and external). The REFIO pin (23) provides access to the internal voltage reference, or can be overdriven if the user wishes to use an external source for the reference. Notice that a 0.1 $\mu\text{F}$  capacitor is placed as close as possible to the REFIO pin. This capacitor is necessary for ensuring a quiet reference voltage.

If the user wishes to use an external reference voltage, jumper J3 must be in place and an external voltage reference provided via SMA7, labeled 'EXT REF'. Jumper J2 must be changed so that pin 16 is tied high (the supply voltage, which is the EXT position of J2) when using an external reference. The recommended limits of the external reference are between 15mV and 1.2V, which provides over 36dB of multiplying capability. Performance of the converter can be expected to decline as the reference voltage is reduced due to the reduction in LSB current size.

If the user wishes to amplitude modulate the reference, the REFIO pin can be overdriven with a waveform. The input multiplying bandwidth of the REFIO input is approximately 1.4MHz. It is necessary that the multiplying signal be DC offset so that the minimum and maximum peaks of the signal are above 0V and less than 1.2V. The output current of each converter is a function of the voltage reference used and the value of  $R_{\text{SET}}$  (R68 or R35 on the schematic). R68 is a potentiometer that can be used to vary the  $R_{\text{SET}}$  if the user wishes to explore various output current levels. The board is

shipped with R68 set to  $\sim 2\text{k}\Omega$ . The converter's performance sometimes improves with reduced output current. R35 is provided if the user wishes to set the output current using a set value. See the 'Outputs' section for more information on setting the output current.

The footprints for SMA10 and SMA11 were provided on the evaluation board so that separate multiplying signals could be attached, along with alternate op amps, to overdrive the internal reference op amps via ICOMP1 and QCOMP1 to increase the multiplying bandwidth of the references for DACs I and Q independently. SMA11 was placed next to prototyping area so that an external op amp could be placed between E11 and E7, which provides access to QCOMP1 via a zero ohm resistor, R69. It was intended that this capability also exist between E10 and E6 for access to ICOMP1 so that it could be driven independently if desired, but E6 was mistakenly grounded. So the ability to overdrive ICOMP1 and QCOMP1 exists on this board, but it must be done with a single op amp and signal simultaneously via SMA11, E7, and E11. ICOMP1 cannot be driven independently using SMA10, E6, and E10. R56 should never be populated. See the functional block diagram of the HI5728 in the data sheet and the evaluation board schematic located in this document for more information.

### Outputs

The output current of the device is set by choosing  $R_{\text{SET}}$  and  $V_{\text{FSADJ}}$  such that the resultant of the following equation is less than 20mA:

$$I_{\text{OUT}} = 32 \times V_{\text{FSADJ}} / R_{\text{SET}}$$

For example, using the internal  $V_{\text{FSADJ}}$  of 1.16V nominal and an  $R_{\text{SET}}$  (R35 on the schematic) value of 1.86k $\Omega$  results in an  $I_{\text{OUT}}$  of approximately 20mA (maximum allowed). Choose the output loading so that the 'Output Voltage Compliance Range' is not violated (-0.3 to 1.25V). If an external  $V_{\text{REF}}$  is chosen, it should not exceed +1.2V.

The output can be configured to drive a load resistor, a transformer, an operational amplifier, or any other type of output configuration so long as the output voltage compliance range and the maximum output current is not violated.

### Load Resistor Output

If the user wishes to use only a load resistor and no transformer, they should remove the zero ohm resistors that connect the outputs to the transformers. These resistors are R51, R57, R70, and R72. See the schematic for details. The output voltage developed is simply a function of the output current multiplied by the output load. Care should be taken to ensure that this voltage does not violate the output compliance range of -300mV to 1.25V.

### Differential Output

The board is also configured with the following transformer output which will result in an output voltage amplitude that is twice that of  $I_{OUT} \times R_{EQ}$ , where  $R_{EQ}$  is the equivalent resistive loading seen by the current outputs ( $\sim 12.5\Omega = (50//50//25)$ ). The transformer used in this circuit is a Mini-Circuits 1:1 RF Transformer, T1-1T. The impedance looking back into the transformer from the  $50\Omega$  spectrum analyzer is  $50\Omega$  ( $100\Omega/2$ ), so proper termination is achieved and reflections are minimized. The transformer benefits the user by reducing the even-order harmonics and therefore increasing the SFDR (Spurious Free Dynamic Range). It can be taken out of the output by removing the zero ohm jumpers, R51, 57, 70, and 72. With the transformers removed, SMAs 1-4 should be used to measure the output voltages across the included  $50\Omega$  loads.

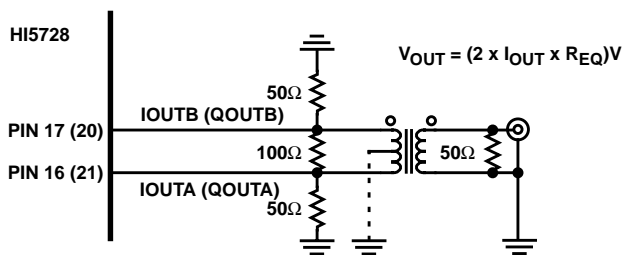


FIGURE 1.

### Sleep

The converter can be put into 'sleep' mode by connecting pin 8 to either of the converter's supply voltages. For normal operation, it is recommended that pin 8 be tied to ground. However, the sleep pin does have an active pulldown current, so the pin can be left disconnected. On the evaluation board, jumper J1 is provided for controlling the sleep pin. Remove the jumper from J1 for normal operation and replace it for sleep mode.

### Power Supply(ies) and Ground(s)

The user can operate from either a single supply or dual supplies. The DAC is designed to function with the digital and analog voltages at the same value or at different values. The DAC can be driven with a 3 or 3.3V digital supply and a 5V analog supply. In compliance with the absolute maximum ratings for the DAC listed in the datasheet, the digital input voltages should not be more than  $DV_{DD1} + 0.3V$ . A single power supply wire can be attached to either  $DV_{DD1}$  or  $AV_{DD1}$ , and then the  $DV_{DD1}$  and  $AV_{DD1}$  holes jumpered together on the board using regular wire if a single supply is desired. The board uses dual ground planes connected at a single point near the converter (this is the recommended configuration). For dual supply mode, connect a power supply wire to both  $AV_{DD1}$  and  $DV_{DD1}$  and ground wires to  $DGND1$  and  $AGND1$  independently.

### Clock Inputs

The elaborate nature of the clock input circuit (see the schematic) achieves versatility. It provides the means to drive both channels from a single clock via the VME connector, or to drive each with separate clocks via SMAs 8 and 9. Notice that the  $0\Omega$  resistors (R28, 29, 50 and 53) are used as jumpers to enable the different clock sources without degrading signal integrity, or they can be replaced by nominal value resistors if series input termination(s) are desired on the clock(s).

### Input Termination

For clock rates below 50MSPS, the method of input termination on the data and clock lines could be open,  $50\Omega$ , or nominal series, depending on the current drive available from the digital source. The performance of the converter should not vary greatly with the termination method for these update rates. For clock rates above 50MSPS, it may be necessary that  $50\Omega$  termination resistors be used on this board to achieve optimum spectral purity. If the digital pattern source cannot drive this load, it is recommended that  $200\Omega$  series resistors be used at high clock rates. The board is shipped with  $200\Omega$  series resistors on the data and clock lines. Notice that the PCB footprints are available on the board for either termination technique. For high clock rates, adjustment of the timing between the clock and the data may be necessary for optimum performance. When implementing the HI5728 onto a board that contains the digital data/clock source in close proximity to the DAC, it is unlikely that any termination resistors will be required.

Note that the board is also shipped with both input channels tied together via  $0\Omega$ , 402 package resistors on the bottom of the board. This is done so that both channels can be evaluated from a single pattern generator. If  $50\Omega$  termination is used while the channels are tied together, it should be obvious that they are only needed on one channel, not both; else you will be driving  $25\Omega$ .

### Getting Started

A summary of the external supplies, equipment, and signal sources needed to operate the board is given below:

1. +3V to +5V power supply(ies) for HI5728.
2. Data Generator capable of generating 10-bit patterns. The HSP-EVAL with the HSP45116 NCOM daughter board is an option (see 'Learning Your Way Around').
3. Clock source (usually part of the Data Generator).
4. Spectrum Analyzer or Oscilloscope for viewing the output of the converter.

Attach a +3V to +5V power supply to the evaluation board connections labeled  $DV_{DD1}$  and  $AV_{DD1}$ . Connect the 10 input bits from the data generator to the evaluation board, preferably by using a male, 64 or 96-pin VME (Versa Module Eurocard) connector that mates with the eval board. See the schematic for the correct pin connections. The middle row of the VME is not used, which is why either a 64 or 96-pin connector will work.

Connect the clock source to the eval board, also preferably through the VME connector (or using the clock SMAs; see the 'Clock Inputs' section for more information). Failure to make clean and short connections to the data input lines and clock source will result in a decrease in spectral performance.

Using a coaxial cable with the proper SMA connector, attach the output of one of the transformers, IOOUT or QOUT, to the measurement equipment that will be evaluating the converter's performance. Make sure that the jumpers are in their proper placement. Consult the 'Voltage Reference' section and the 'Sleep' section of this document for a definition of the jumpers' functionality.

### Learning Your Way Around

#### Direct Digital Synthesis

To ensure that everything on the board is configured properly and functional, it is suggested that the following DDS setup be implemented. The board test requires:

1. HI5728 Evaluation Board.
2. Spectrum Analyzer.
3. HSP-EVAL Board with the HSP45116 NCOM Daughter Board Attached and included software, NCOMCTRL (or a Data/Pattern Generator).
4. Personal Computer (IBM compatible) with a Parallel Port.
5. 50Ω SMA Cable.
6. Two +5V power supplies. One for the DAC Eval Board and one for the HSP Eval Board.

Note: If the HSP-EVAL Board is to be used, it is highly recommended that the user obtain the User's Manual, the data sheet for the HSP45116 NCOM, and the User's Manual for the HSP45116-DB. This platform is capable of testing the converter up to 25MSPS, which is the speed of the HSP-EVAL's on-board clock. The user can choose to substitute this clock with a slower one, but the DSP chip and DSP Eval Board are only designed to work at a maximum of 25MHz (a 52MHz version of this DSP chip does exist but not in this evaluation platform; see the HSP45116A). For testing of the HI5728 at higher speeds, it is recommended that the user

obtain a high speed data generator capable of generating 10 bit patterns at the clock speed needed. The HSP45116 NCOM generates two, 16-bit channels of data. HI5728EVAL1 is designed so that both of its input channels mate with both of the DSP's output channels. The zero ohm resistors that connect the I and Q channels together on the DAC eval board must be removed before using the HSP45116 evaluation board. Also, the DSP Eval Board cannot drive 50Ω.

#### HSP-EVAL Setup for DDS

Attach the HSP-EVAL and the HSP45116 Daughter Board together; see figure 2. Consult their respective user manuals for details. Connect the HI5728EVAL1 board to the P2 connector of the HSP-EVAL board. Then connect these to an IBM compatible PC via the parallel port. Provide power to both boards. To run the software (NCOMCTRL) that accompanied the HSP evaluation kit, place the diskette into the 3.5" drive of the PC and type:

**(drive letter):\NCOMCTRL,**

which will run the HSP45116 Control Panel software. Set the control panel's selections to the following and check one of the outputs of the DACs at either IOOUT or QOUT using the spectrum analyzer for a frequency equal to 1.63MHz.

The clock select of the control panel should be set to 'Osc. CLK'. The control signals should be as follows:

```
0 ENPHREG
0 CLROFR
1 LOAD
0 BINFMT
1 PMSEL
```

The amplitude of the real output (RIN0-15) should be 8000<sub>HEX</sub> for full scale output. The center frequency register can be set to 10ABCDEF<sub>HEX</sub> for a 1.63MHz tone. The Offset Frequency, Phase Offset, and Time Accumulator Registers should all be set to zeros. The spurious free dynamic range that can be expected is typically 70dBc with this setup operating at this frequency.

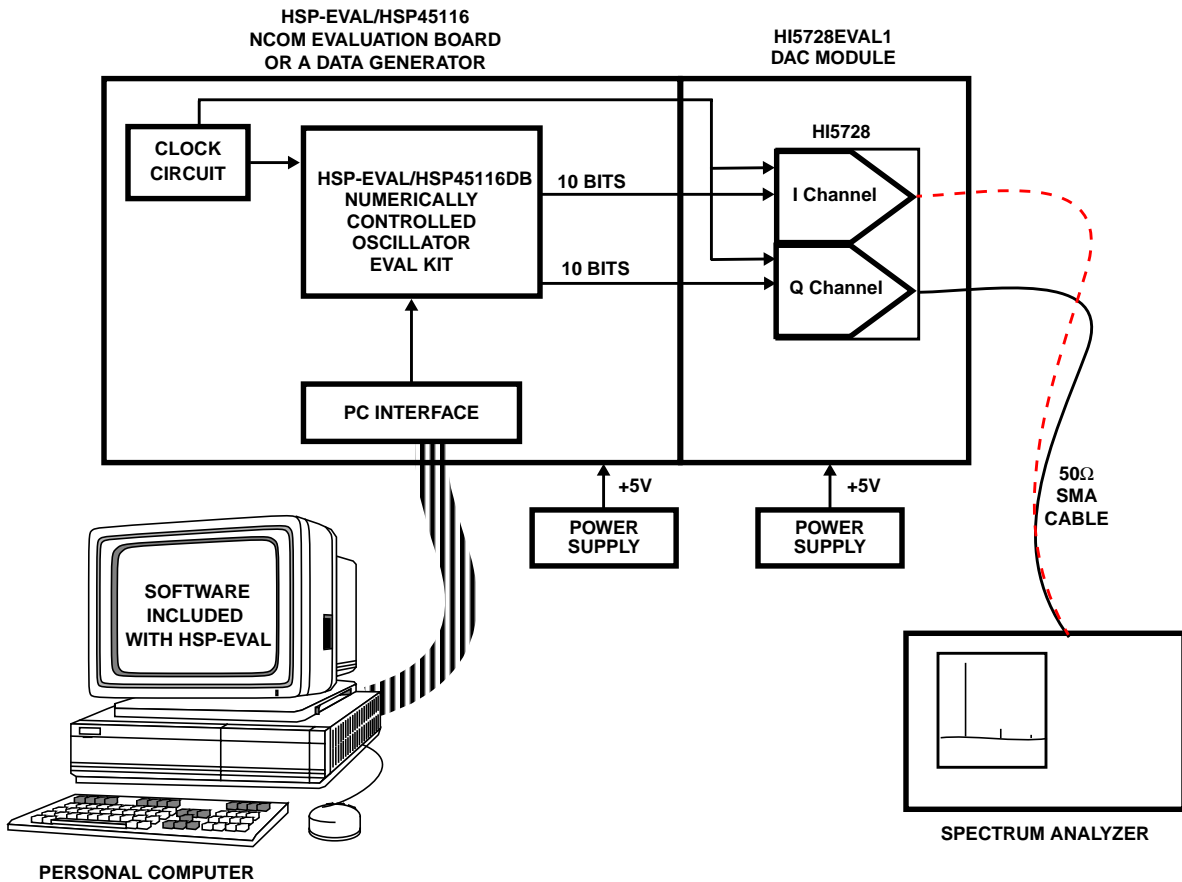


FIGURE 2. INTERSIL HI5728/DDS EVALUATION SYSTEM SETUP BLOCK DIAGRAM

### Appendix A Description of Architecture

The segmented current source architecture has the ability to improve the converter's performance by reducing the amount of current that is switching at any one time. In traditional architectures, major transition points required the converter to switch on or off large amounts of current. In a traditional 10-bit R/2R ladder design, for example, the midscale transition required approximately equal amounts of currents switching on and off. In a segmented current source arrangement, transitions such as midscale become one in which you simply have an additional intermediate current source turning on and several minor ones turning off. In the case of the HI5728, there are 31 intermediate current segments that represent the 5 MSBs and five, binary-

weighted current sources representing each of the five LSBs. See the Functional Block Diagram in the data sheet for a visual representation. To relate the midscale transition example to the HI5728, consider the following: The code 0111111111 would be represented by 15 intermediate current segments and each of the 5 LSB current sources all turned on. To transition to code 1000000000 would simply require turning off the 5 LSB current sources and turning on the next intermediate current segment, bringing the total amount of current switching at this 'major' code transition equal to the same amount switching at 30 other code transition points in the code ramp from 0 to 1023, so that the total glitch energy is distributed more evenly.

**Appendix B Pin Description**

PIN NO.	PIN NAME	PIN DESCRIPTION
39-30	QD9 (MSB) Through QD0 (LSB)	Digital Data Bit 9, the Most Significant Bit through Digital Data Bit 0, the Least Significant Bit, of the Q Channel.
1-6, 48-46	ID9 (MSB) Through ID0 (LSB)	Digital Data Bit 9, the Most Significant Bit through Digital Data Bit 0, the Least Significant Bit, of the I Channel.
8	SLEEP	Control Pin for Power-Down mode. Sleep Mode is active high; Connect to ground for Normal Mode. Sleep pin has internal 20 $\mu$ A active pulldown current.
15	REFLO	Connect to analog ground to enable internal 1.2V reference or connect to AV <sub>DD</sub> to disable.
23	REFIO	Reference voltage input if internal reference is disabled and reference voltage output if internal reference is enabled. Use 0.1 $\mu$ F cap to ground when internal reference is enabled.
22	FSADJ	Full Scale Current Adjust. Use a resistor to ground to adjust full scale output current. Full Scale Output Current Per Channel = 32 x I <sub>FSADJ</sub> .
14	ICOMP1	For use in reducing bandwidth/noise of I Channel. Recommended: connect 0.1 $\mu$ F to AV <sub>DD</sub> .
24	QCOMP1	For use in reducing bandwidth/noise of Q Channel. Recommended: connect 0.1 $\mu$ F to AV <sub>DD</sub> .
13, 18, 19, 25	AGND	Analog Ground Connections.
17	IOUTB	The complimentary current output of the I Channel. Bits set to all 0's gives full scale current.
16	IOUTA	Current output of the I Channel. Bits set to all 1's gives full scale current.
20	QOUTB	The complimentary current output of the Q Channel. Bits set to all 0's gives full scale current.
21	QOUTA	Current output of the Q Channel. Bits set to all 1's gives full scale current.
11, 27	NC	No Connect. Recommended: connect to ground.
12	AV <sub>DD</sub>	Analog Supply (+2.7V to +5.5V).
10, 28, 41, 44	DGND	Digital Ground.

Appendix C Circuit Board Layout

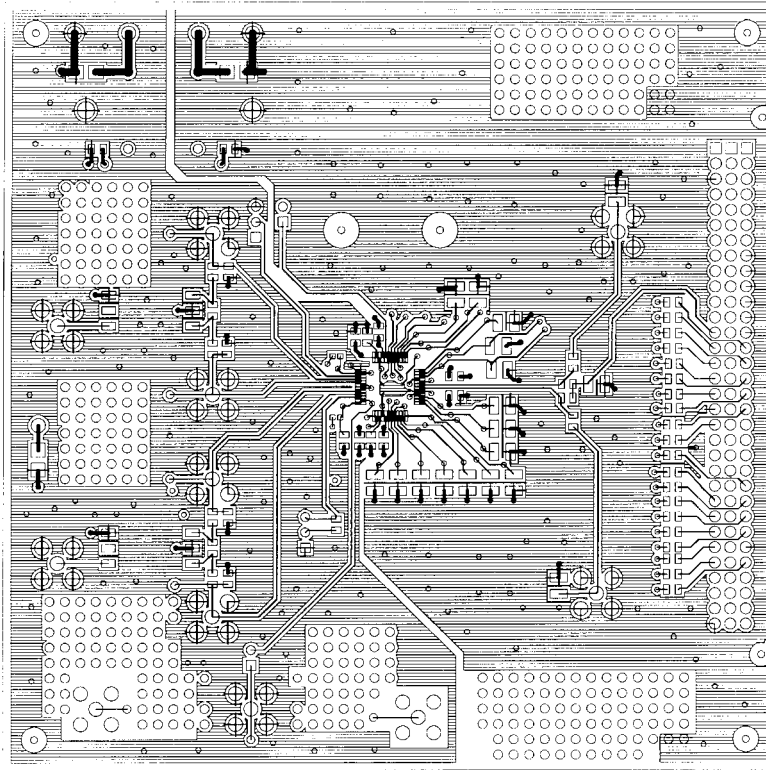


FIGURE 3. PRIMARY SIDE

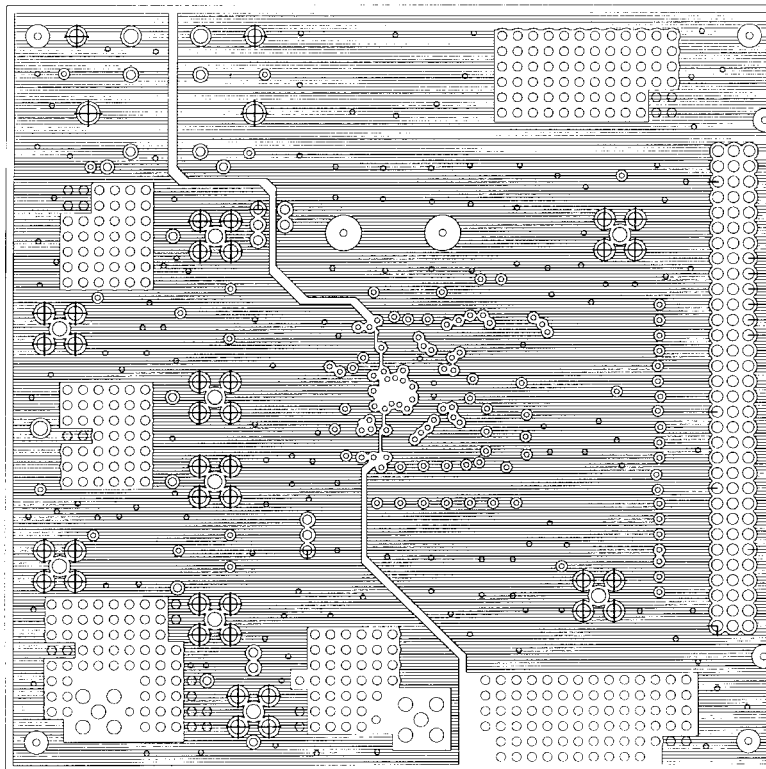


FIGURE 4. GROUND LAYER (2)

Appendix C Circuit Board Layout (Continued)

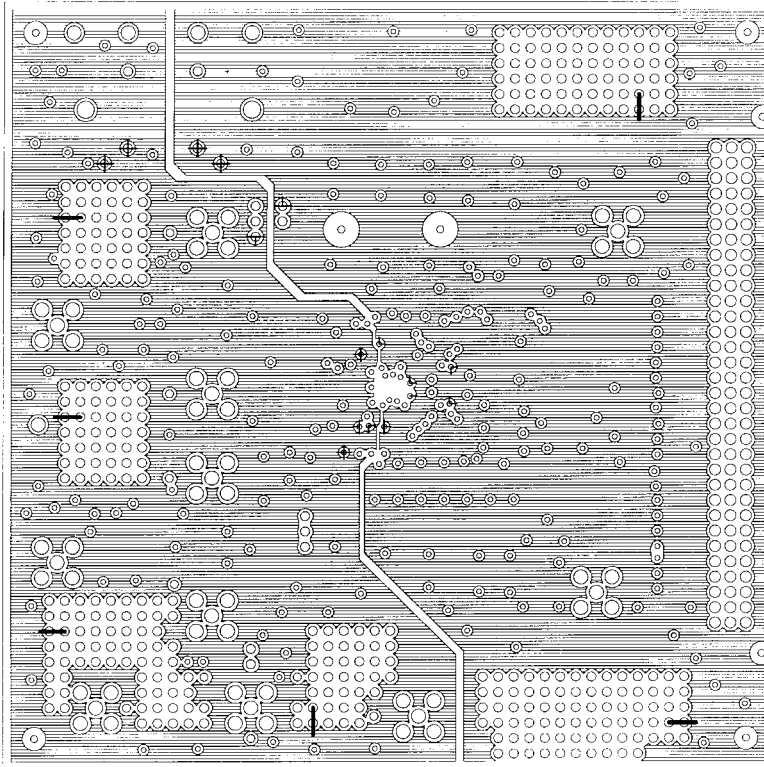


FIGURE 5. POWER LAYER (3)

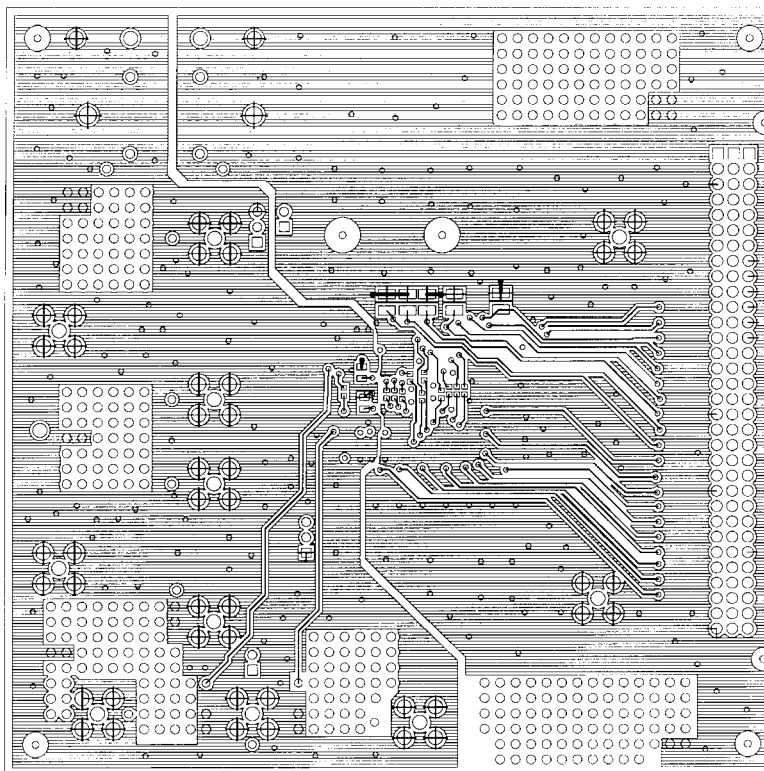
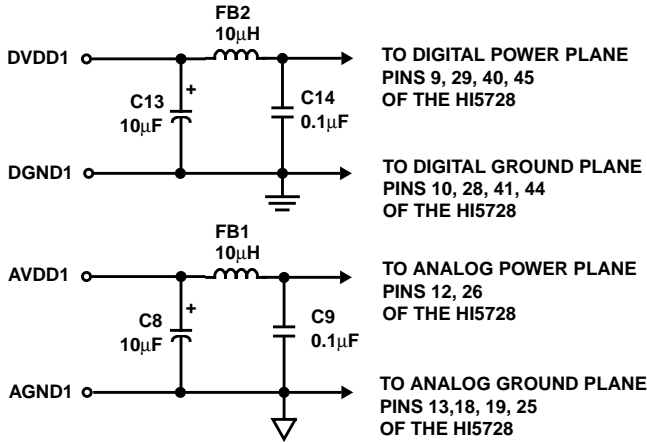


FIGURE 6. SECONDARY SIDE

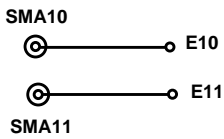


### Power Supply Input Circuit

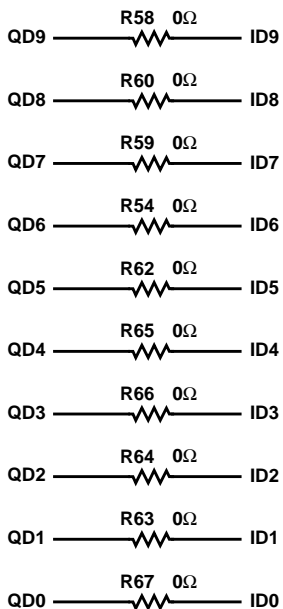


NOTE: DV<sub>DD</sub> and AV<sub>DD</sub> can be tied together for single supply operation. AGND1 and DGND1 are tied together at a single point. See text for further explanation.

**Extra SMAs** (See 'Voltage Reference' text for explanation.)



### Digital Input Additional Connections

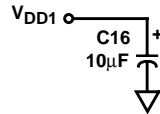


### Ground Symbol Definition

▽ = ANALOG GROUND (AGND1)  
≡ = DIGITAL GROUND (DGND1)

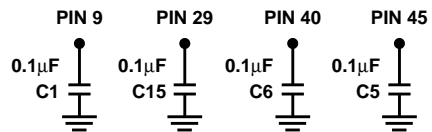
### Extra Power Supply Input Located near Output Proto Area

(Used if additional circuitry is added in the proto area)

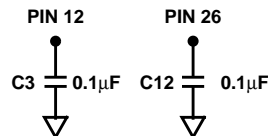


### Power Supply Decoupling

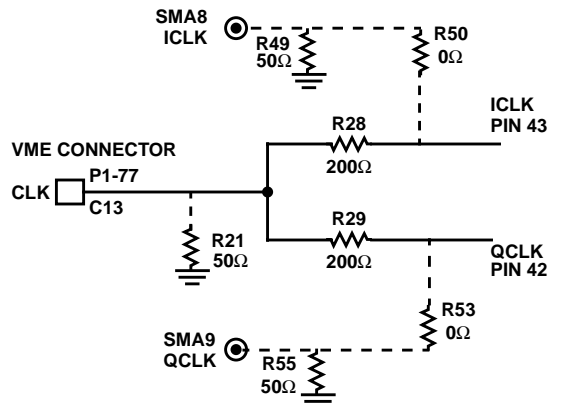
#### DV<sub>DD</sub> Power Decoupling Capacitors



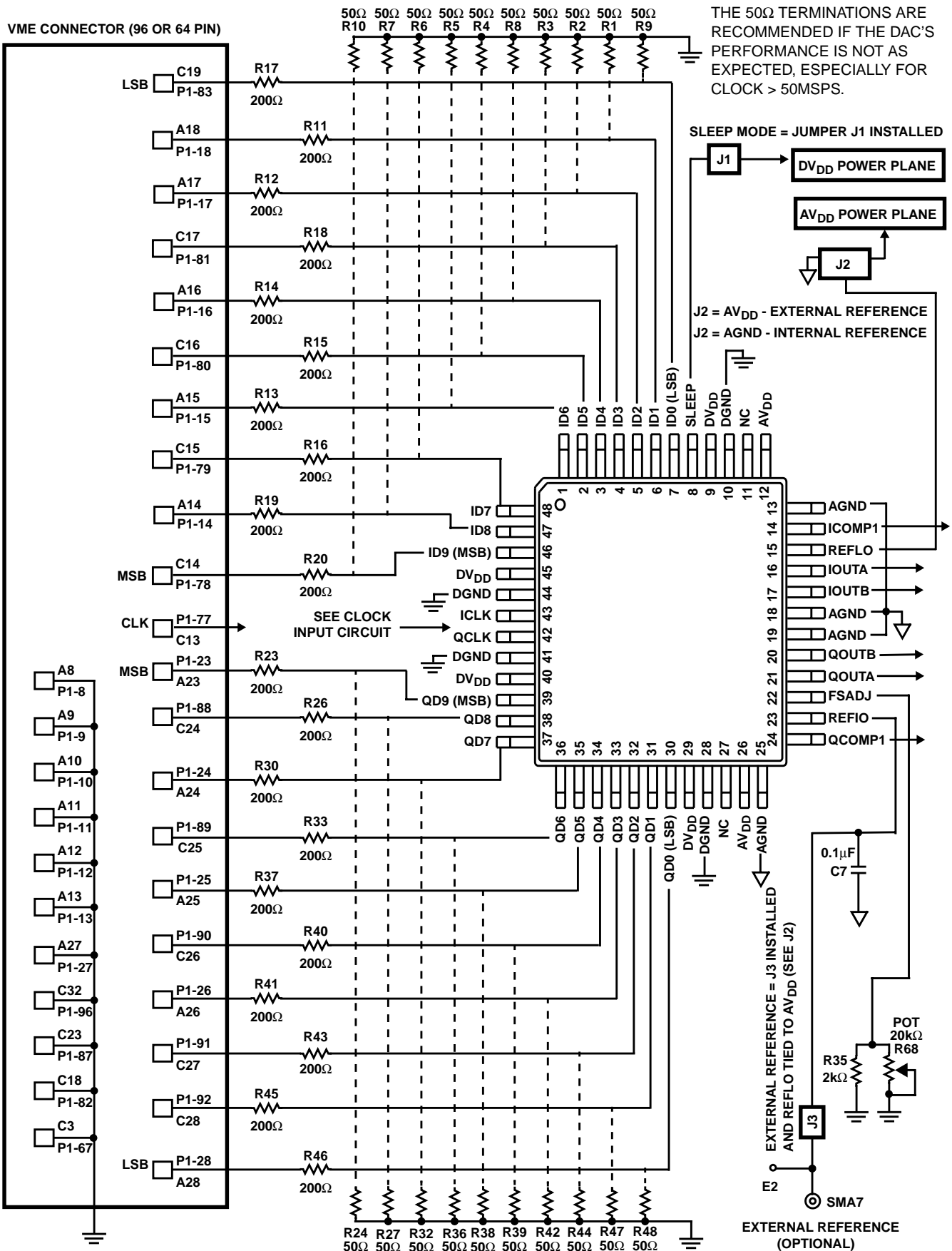
#### AV<sub>DD</sub> Power Decoupling Capacitors



### Clock Input Circuit (See 'Clock Inputs' Text.)



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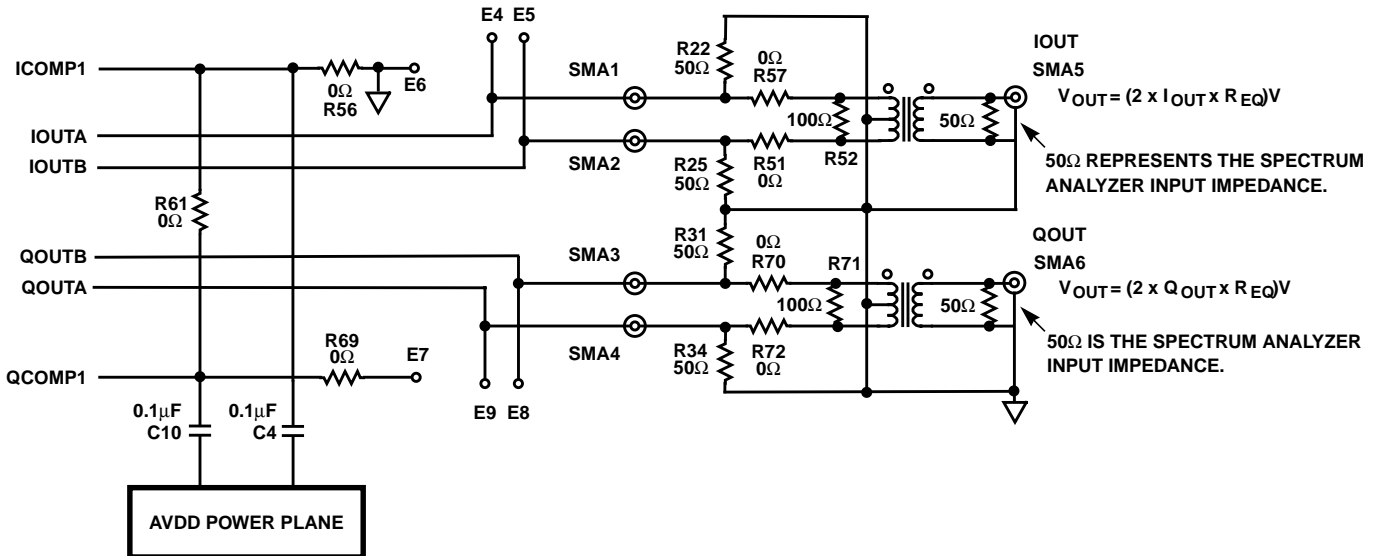
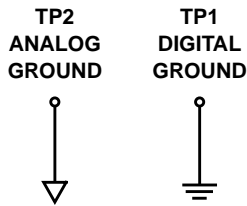


THE 50Ω TERMINATIONS ARE RECOMMENDED IF THE DAC'S PERFORMANCE IS NOT AS EXPECTED, ESPECIALLY FOR CLOCK > 50MSPS.

### Ground Connection



NOTE: AGND1 and DGND1 are tied together at a single point near the DAC. Optimum placement for Rgnd was found by iteration while observing the spectral noise floor.



NOTE: E6 was mistakenly grounded so R56 should not be populated! E7, however, is correct and can be used to overdrive the internal reference op amp for increasing the multiplying bandwidth.

## Application Note 9827

### Appendix D Evaluation Board Bill Of Materials

REFERENCE DESIGNATOR	QTY	DESCRIPTION
U1	1	HI5728IN, Intersil Dual 10-bit D/A Converter
C8, 13, 16	3	10 $\mu$ F, Tantalum Chip Capacitor, EIA Case B, 10%, 10V
C1-7, 9-12, 14, 15	13	0.1 $\mu$ F, Ceramic Chip Capacitor, 0805, 10%, 10V
R1-10, 21, 24, 27, 32, 36, 38, 39, 42, 44, 47-49, 55	23	Included, not populated 51 $\Omega$ , Chip Resistor, 1210, 5%, 1/4W
R11-20, 23, 26, 28, 29, 30, 33, 37, 40, 41, 43, 45, 46, 51, 57, 70	25	200 $\Omega$ , Chip Resistor, 0805, 1/8W
R52, 71	2	100 $\Omega$ , Chip Resistor, 0805, 1/8W
R22, 25, 31, 34	4	51 $\Omega$ , Chip Resistor, 0805, 1/8W
R54, 58, 59, 60-67, 69	12	0 $\Omega$ , Chip Resistor, 0402, 1/10W
R68	1	20k $\Omega$ , Potentiometer Resistor, 3296W, 1/8W (Shipped set to ~2k $\Omega$ )
R35	1	(2k $\Omega$ , Chip Resistor, 0805, 1/8W) (Not Populated)
J1, J2	2	1x2 Header
J3	1	1x3 Header
T1, 2	2	Mini-Circuits, T1-1T KK81, Z1:Z2 ratio of 1:1
P1	1	96-Pin Eurocard, Right Angle
SMA1-11	11	SMA Straight Jack, PCB Mount
FB1, 2	2	10 $\mu$ H, Ferrite Bead
TP1, 2	2	Test Point
-	3	1x2 Header Jumper
-	-	DUT Clamp
-	4	Plastic Legs, 1/2"
R50, 53, Rgnd	3	(0 $\Omega$ , Chip Resistor, 0805, 1/8W) (R50, 53 Not Populated)
R56	1	(0 $\Omega$ , Chip Resistor, 0402, 1/10W) (Not Populated )

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