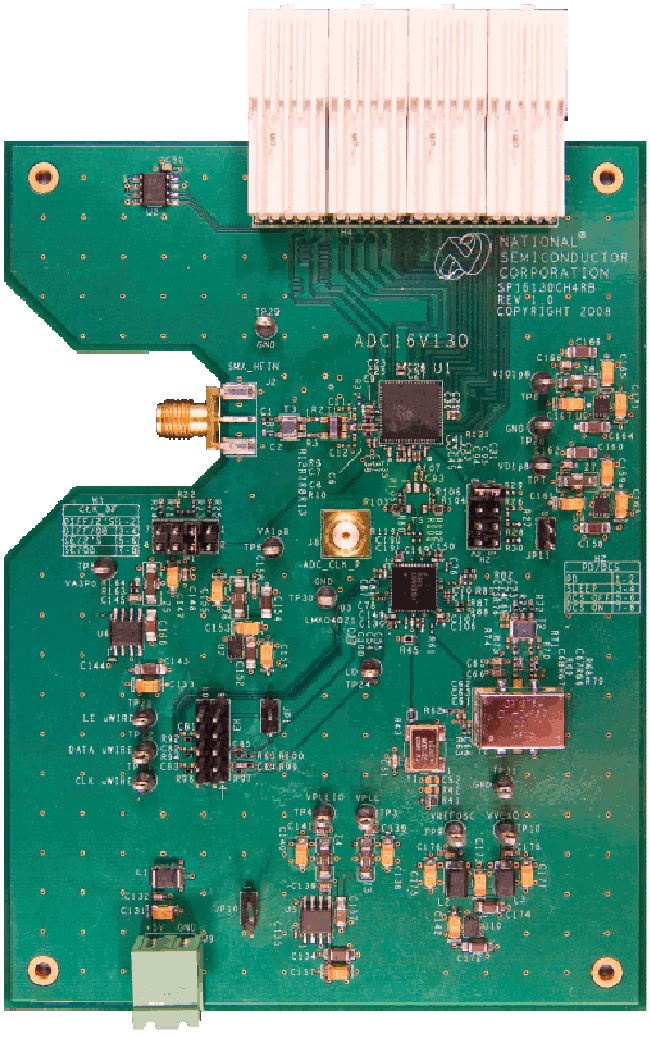
SP16130CH4RB
Low IF Receiver Reference Design Board
ADC16V130 + LMK04031B
User's Guide



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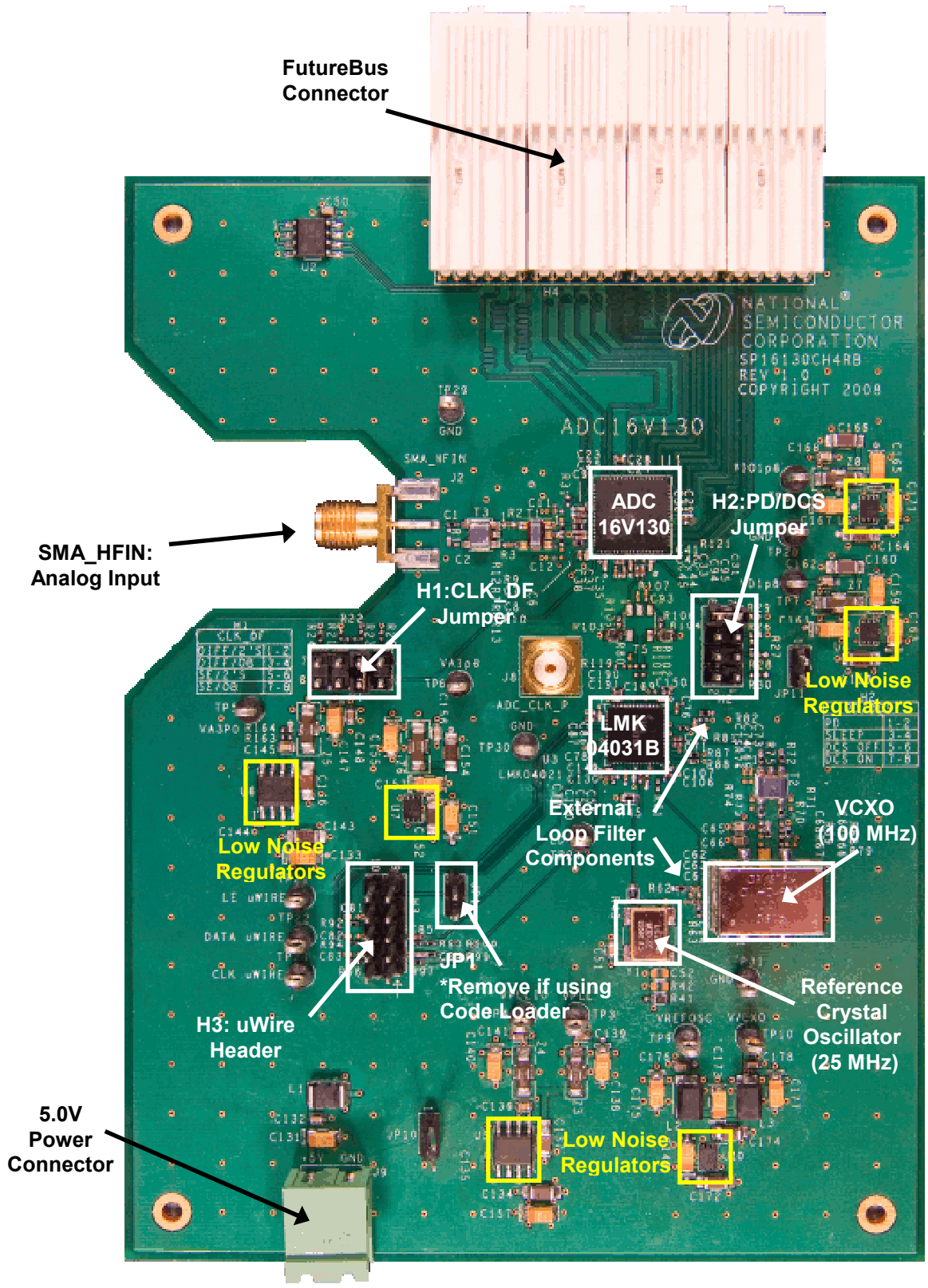

Figure 1: SP16130CH4RB Component, Connector and Jumper Locations

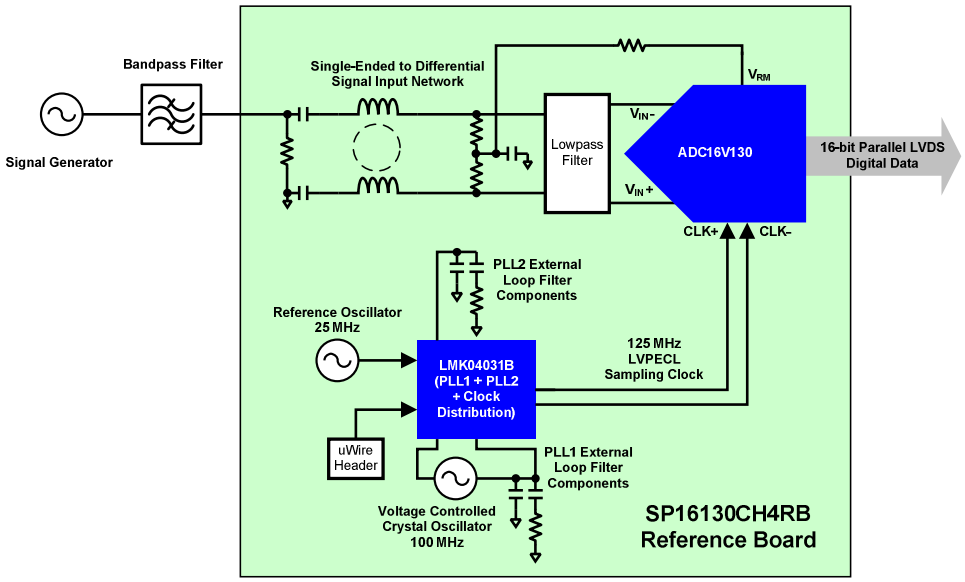

Figure 2: SP16130CH4RB Block Diagram

1.0 Introduction

The SP16130CH4RB is a low IF receiver reference design board that utilizes the following components from National Semiconductor:

- **ADC16V130** A 16-bit, 130 MSPS (Megasample per second) ADC with parallel LVDS outputs.
- **LMK04031B** A full clocking solution composed of a low-noise jitter cleaner, clock multiplier, and distribution stage in cascade.
- Several energy-efficient **power management ICs**.

As shown in block diagram of Figure 2, this subsystem reference design provides single to differential conversion and lowpass filtering of the input signal, high dynamic range digitization to parallel LVDS outputs using the ADC16V130, and a 125 MHz low-jitter, LVPECL clock signal using the LMK04031B.

The measured system performance demonstrates large signal SNR of 75.8 dBFS for a 52 MHz input signal and SFDR greater than 84 dBFS for input frequencies less than 52 MHz with a sampling frequency of 125 MSPS.

This reference design enables immediate evaluation of a high dynamic range, low-IF sampling application

2.0 Data Capture

The digital data from the SP16130CH4RB reference design board can be captured with a suitable instrument, such as a logic analyzer, or with National Semiconductor's WaveVision signal path data acquisition hardware and software platform. The SP16130CH4RB board can be connected to the data acquisition hardware through the FutureBus connector (schematic reference designator H4).

The SP16130CH4RB is compatible with National Semiconductor's WaveVision 5.1 Signal Path Digital Interface Board and associated WaveVision software. Please note that the SP16130CH4RB board is not compatible with previous versions of the WaveVision hardware (WaveVision 4.x Digital Interface Boards).

The WaveVision hardware and software package allows fast and easy data acquisition and analysis. The WaveVision hardware connects to a host PC via a USB cable and is fully configured and controlled by the latest WaveVision software. The latest version of the WaveVision 5 software and information about the WaveVision 5.1 Signal Path Digital Interface hardware (part number: WAVEVSN BRD 5.1) are available through the National Semiconductor website at http://www.national.com/analog/adc.

3.0 Evaluation Kit Contents

The SP16130CH4RB evaluation kit includes the following items:

- SP16130CH4RB reference design board
- PIC microcontroller board (ADC14PIC REV. A)

The SP16130CH4RB is factory configured for evaluation of input signals between 5 MHz and 52 MHz. Each board is populated with an analog input network which has a cascade of baluns for single-ended to differential conversion, and a filtering network optimized for these frequencies.

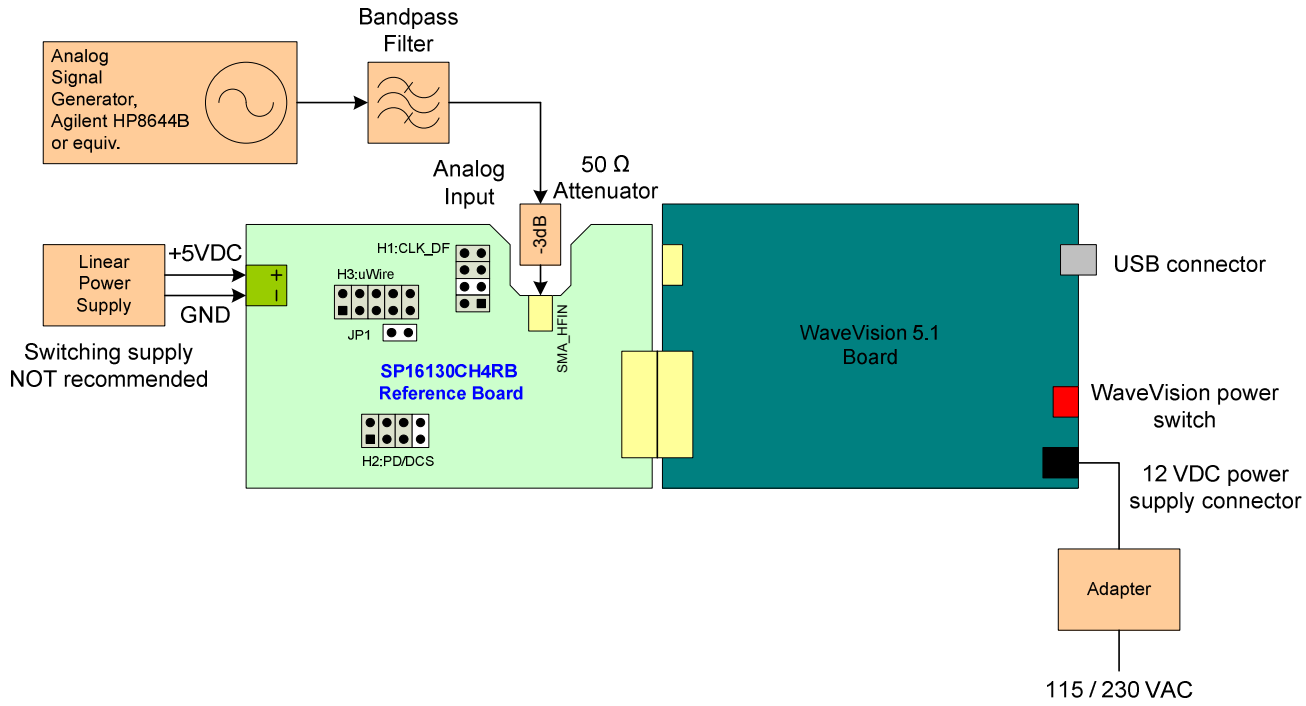

Figure 3: Connection Diagram for SP16130CH4RB and WaveVision 5.1 Data Capture Hardware

The LMK04031B, which provides the sample clock for the ADC, must be correctly programmed to output the desired operating frequency. The PIC-microcontroller board (ADC14PIC REV. A) is used to program the registers of the LMK04031B precision clock conditioner chip to output a 125 MHz LVPECL signal which is used as the sampling clock for the ADC16V130.

4.0 Quick Start

4.1 WaveVision Software and Hardware Installation

⚠ The WaveVision software must be installed before connecting the WaveVision hardware.

1. Begin by installing the latest version of the WaveVision 5 and be sure to enable the update manager to keep up to date with the most current version. Do not start the WaveVision software application at this point.
2. Connect the WaveVision 5.1 Digital Interface Board to your PC through the supplied USB cable and apply power to the WaveVision 5.1 board through the +12V AC-DC power adapter included in the WaveVision 5.1 hardware kit. The connection diagram is shown in Figure 3.
3. If this is the first time connecting a WaveVision 5.1 board to your PC, follow the on-screen instructions for installing the drivers for the hardware.

For more information on installing the WaveVision data acquisition hardware or software, please refer to the Quick Start Guide in the WaveVision User's Guide which can be found on the National Semiconductor website at http://www.national.com/appinfo/adc/evalboards_dataccapture.html.

Please note that the SP16130CH4RB is only compatible with National Semiconductor's WaveVision 5.1 Digital Interface board.

4.2 Evaluation Board Jumper Positions

The SP16130CH4RB board jumpers should be configured as follows. Please refer to Figure 1 for the exact jumper locations.

1. **JP1** should have a jumper installed to provide power to the PIC microcontroller board used for programming the LMK04031B registers.

⚠ Remove **JP1** if using Codeloader to program the LMK04031B (see Section 5.4 of this guide).

2. The **H2:PD/DCS** jumper places the ADC16V130 into either power-down or sleep mode and enables or disables the duty cycle stabilizer (DCS). Table 1 shows how to select between the power-down modes. For normal operation, a jumper should be placed on 5-6 or 7-8.

⚠ Depending on the power supply turn-on time, it may be desireable to recalibrate the ADC16V130. This can be done by moving the H2 jumper to

power-down mode and then returning it to the original position.

3. The **H1:CLK_DF** jumper selects the output data format (2's complement or offset binary) and clock mode (single-ended or differential). Table 2 below shows how to select between the clock modes and output data formats. Please note that the SP16130CH4RB reference board is delivered with the ADC16V130 configured for differential clock operation and Offset Binary output data format (Position 3-4).

H2:PD/DCS Jumper Setting	Mode
1-2	Power-down
3-4	Sleep
5-6	DCS Off
7-8	DCS On

Table 1. PD and DCS Selection Table

H1:CLK_DF Jumper Setting	Clock Mode	Output Data Format
1-2	Differential	2's Complement
3-4	Differential	Offset Binary
5-6	Single-Ended	2's Complement
7-8	Single-Ended	Offset Binary

Table 2: CLK and DF Selection Table

4.3 Connecting Power and Signal Sources

1. Connect the SP16130CH4RB reference board to the WaveVision 5.1 board through the FutureBus connector as shown in Figure 3. The SP16130CH4RB reference board should not be powered up, as the WaveVision hardware does not support hot-swapping of boards.
2. Power up the WaveVision 5.1 board and connect it to the PC with a USB cable.
3. Plug the PIC microcontroller board onto the dual-row header labeled "H3: uWIRE" as shown in Figure 4. Align the arrows on the two boards to ensure proper orientation. JP1 should have a jumper installed on the main board to provide power to the PIC microcontroller board. Lastly, flip the switches on the PIC microcontroller board to the following positions: Switch 1 = OFF, Switch 2 = ON.
4. Connect a 5.0V power supply capable of supplying up to 1A to the green, 2-terminal power connector located along the side edge of the SP16130CH4RB board. This is shown in Figure 3. Ensure that the polarity of the wires going to the green power connector match the "+5V" and "GND" labels on the evaluation board. Turn on the 5V supply.
5. Press the "RESET" button on the PIC microcontroller to load the register settings into the LMK04031B. The three LED's on the PIC microcontroller board will flash to indicate that the register bits have been sent to the LMK04031B. If the lights to not flash, ensure that **JP1** is connected to supply power to the PIC board.
6. Connect the signal source to the "INP" SMA connector as shown in Figure 1. The recommended signal generators are the HP8644B (HP/Agilent) or the SMA100A (Rohde & Schwarz). A bandpass filter between the signal generator output and the SP16130CH4RB SMA connector is required to measure the true performance of the board. See Figure 3.
7. Set the signal source frequency to 170 MHz and the starting input amplitude to 0 dBm.
8. Start the WaveVision software. The WaveVision software will automatically load the appropriate firmware to allow data capture from the SP16130CH4RB. Allow the firmware file to finish downloading before continuing. At this point, the board should be ready to capture digital data.
9. Capture the data and display the FFT of the captured data with the WaveVision software.

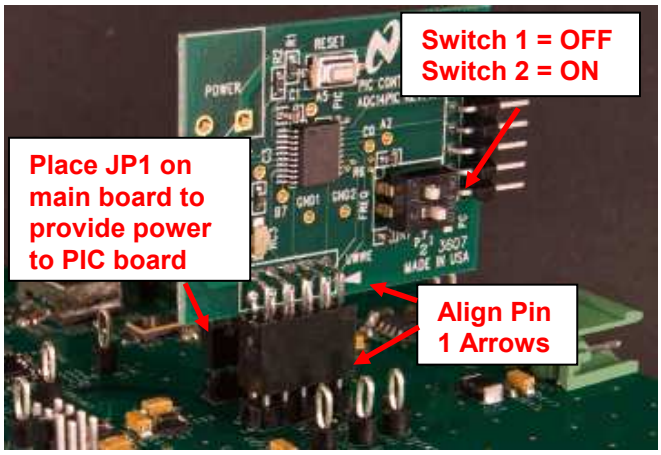

Figure 4: PIC microcontroller Board Connection and Configuration

4.4 SP16130CH4RB Reference Board Performance

The following plots show the typical frequency sweep performance of the SP16130CH4RB reference board for an -1 dBFS input signal and a sample rate of 125 MSPS.

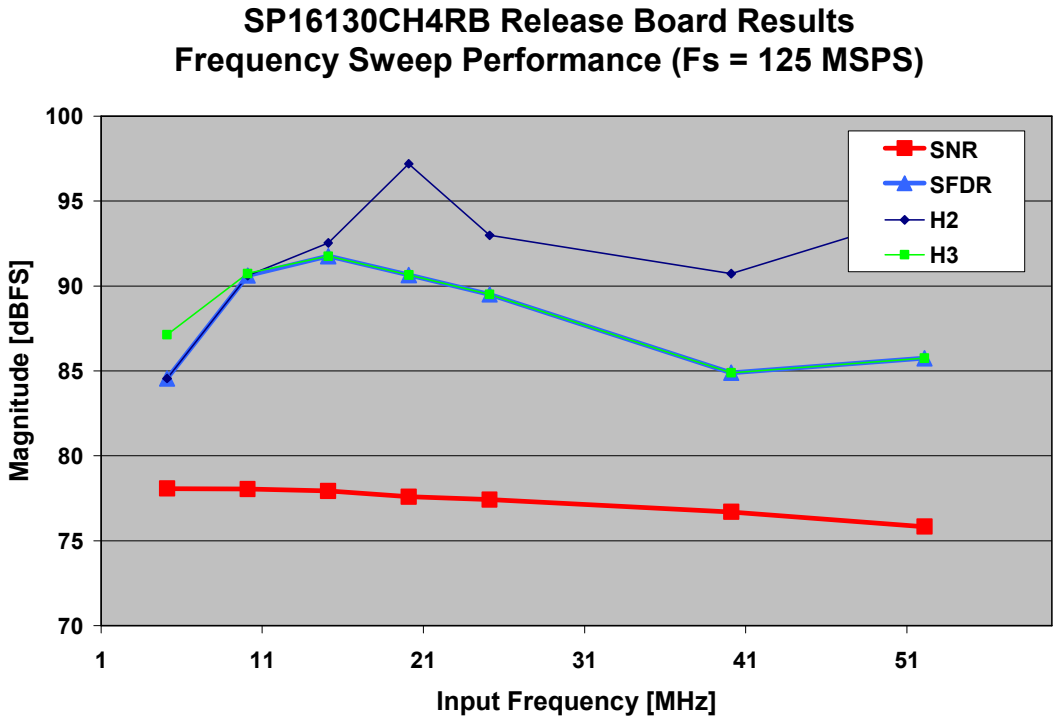

Figure 5: SP16130CH4RB Typical SFDR and SNR Performance vs. Input Amplitude input

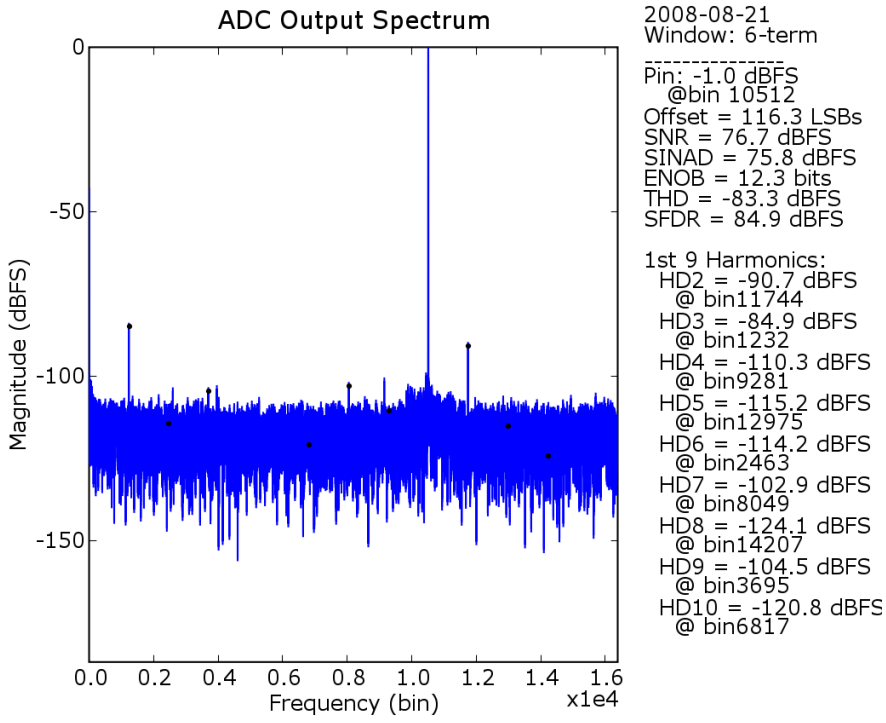

Figure 6: Typical FFT plot for the SP16130CH4RB with a 41 MHz, -1 dBFS input signal

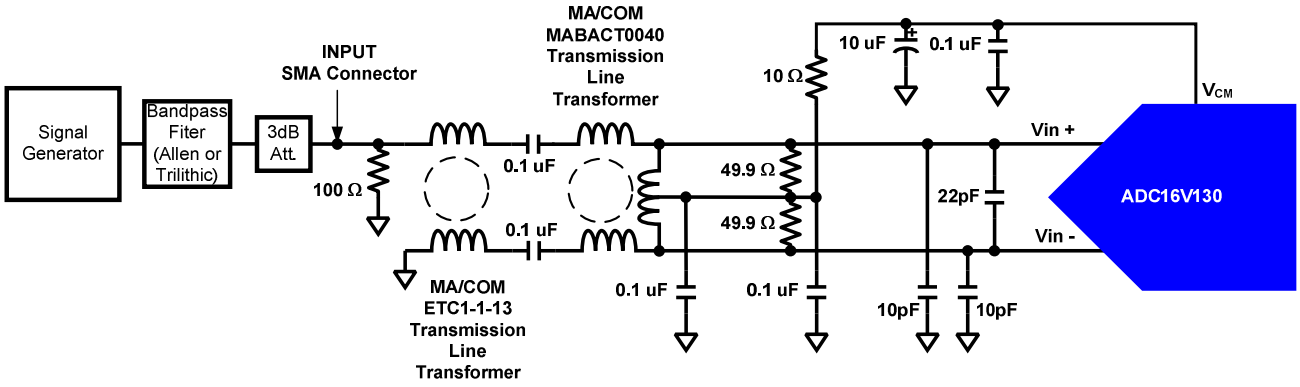

Figure 7: Analog Input Circuit for SP16130CH4RB

5.0 Functional Description

5.1 Analog Input Network

The analog input network on the SP16130CH4RB has been designed to accept input frequencies between 5 and 52 MHz. The input network consists of a cascade of transformers, common-mode bias resistors and filtering capacitors. *Figure 7* shows the input circuit on the SP16130CH4RB reference board.

The transmission-line transformers convert the single-ended output of the signal generator to a differential signal at the ADC16V130 input. Cascading two transformers improves signal balancing and reduces even-order distortion caused by the input network.

A low noise signal generator such as the HP8644B (HP/Agilent) or SMA100A (Rohde & Schwarz) is recommended to drive the signal input of the SP16130CH4RB evaluation board. The output of the signal generator must be filtered to suppress the harmonic distortion and noise produced by the signal generator and to allow accurate measurement of the ADC's distortion performance. A tunable bandpass filter made by Trilithic (Indianapolis, IN) is recommended. Using only a lowpass filter is not recommended as the SNR performance is significantly degraded by the broad-band signal generator noise in the passband. See Figure 3.

5.2 ADC Reference

The SP16130CH4RB reference board is configured to use the internal 1.2V reference on the ADC16V130. This is the recommended reference configuration for the ADC16V130.

5.3 Clock Input

The clock signal used to sample the analog input is generated using the LMK04031B. The LMK04031B is a

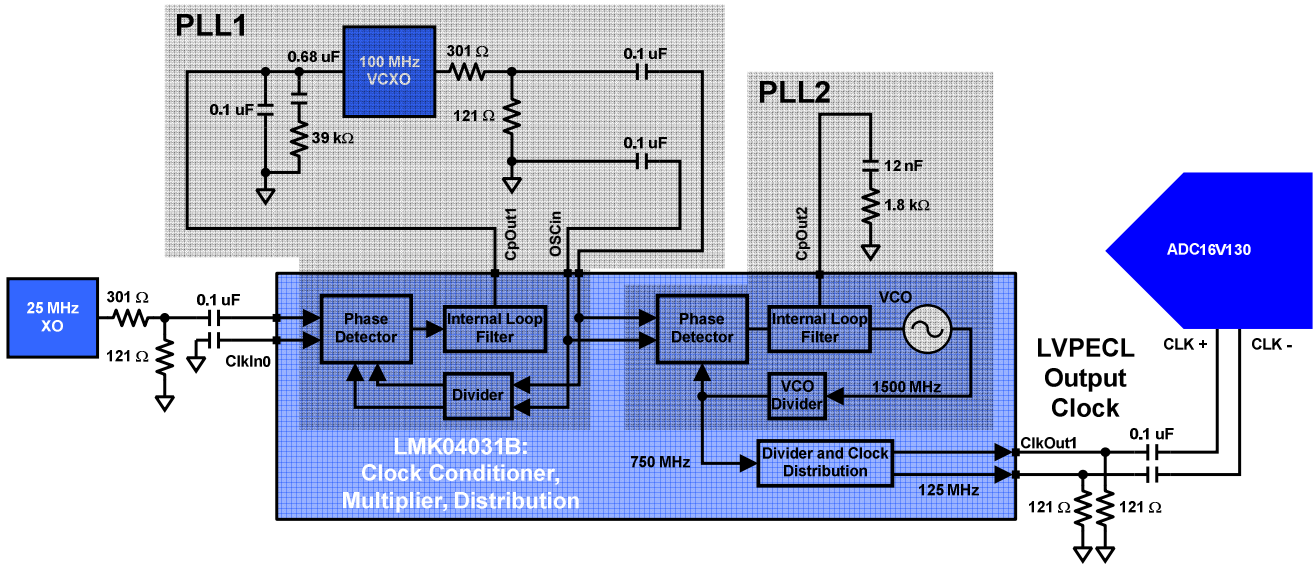

Figure 8: Clocking Circuit for SP16130CH4RB

low-jitter precision clock conditioner consisting of cascaded phase locked loops (PLLs), an internal voltage controlled oscillator (VCO) and a distribution stage. The first PLL employs a low loop bandwidth to lock an external voltage controlled crystal oscillator (VCXO) to an incoming reference clock. For a lower cost implementation, the first PLL can also be programmed to use an internal, low-noise oscillator circuit with a simple external crystal and varactor diode. The output of the first PLL becomes the reference input to the second PLL stage which uses a VCO to multiply the external VCXO frequency. The VCO output is passed to the distribution stage which provides frequency division, buffering and conversion to a number of clock output formats including CMOS, LVPECL and LVDS.

On the SP16130CH4RB board, the clock is generated with the LMK04031B by locking a 100 MHz VCXO (Crystek CVHD-950-100.000) to the 25 MHz reference oscillator, cleaning the phase noise, multiplying the VCXO to 1500 MHz and then dividing the frequency down to output a 125 MHz, differential LVPECL clock. The external loop filter components for PLL1 and PLL2 are optimized for low jitter performance. Measurements show that the total integrated jitter seen by the ADC is less than 250 fs.

The differential LVPECL clock signal from the LMK04031B is AC coupled to the CLK+ / CLK- pins on the ADC16V130.

5.4 LMK04031B Programming

The LMK04031B, which provides the sample clock for the ADC, must be programmed to correctly configure it for the desired clock frequency. The programming can be accomplished by either one of two methods.

The first method is to attach a small PIC-based module that is included in this evaluation kit. This module is plugged onto the 10-pin uWire header labeled "H3" as described in Section 4.3 of this user's guide. If this module is used, the JP1 jumper must be installed to provide power from the main boad to the PIC module. The PIC module will program the LMK04031B to output a 125 MHz LVPECL signal.

The second method for programming the LMK04031B uses the 10-pin uWire header to connect the LMK04031B's serial programming interface (DATA, CLK, LE) to a PC. To use this programming interface, a special parallel port (LPT) cable supplied by National Semiconductor allows the device to be directly programmed with a PC using National Semiconductor's Codeloader software. The serial programming interface can also be programmed over the USB port of the PC. To program the LMK04031B through the USB port, a separate interface board is available from National Semiconductor.

See http://www.national.com/appinfo/interface/clk_conditioners.html to download Codeloader, obtain a user's guide and to order any necessary hardware such as programming cables or USB interface boards.

⚠ Remove JP1 if using Codeloader to program the LMK04031B.

The procedure for programming the LMK04031B through National's Codeloader software and special parallel port cable is described here if the user intends to program the SP16130CH4RB reference board for sampling rates other than 125 MSPS. Please note that the achievable sample rates will be limited by the 25 MHz reference crystal oscillator. Some output frequencies may also require loop filter changes for optimal jitter performance.

Figure 11 through Figure 15 illustrates each Codeloader configuration screen and its contents used to properly program the LMK04031B Clock Conditioner through either a parallel port or USB PC interface and appropriate cable. These configuration screens are for programming the LMK04031B to output 125 MHz at CLKout1, which is the same output produced by using the PIC-module included in this evaluation kit.

Before programming the device, it is important that the LMK04031B go through a proper reset cycle. Check and then uncheck the RESET checkbox in the *Bits/Pins* tab in Figure 12 to accomplish the reset. Then configure the Codeloader software according to the following figures and select *Load Device* from the *Keyboard Controls* file menu to program the device.

5.5 Board Outputs

The digitized 16-bit output from the SP16130CH4RB evaluation board consist of 38 lines which are arranged into 17 LVDS pairs. These 17 pairs of lines carry the 16-bit output data (16 pairs) and the DRDY output clock signal (1 pair) across the FutureBus connector on the edge of the reference board to the data capture hardware. The DRDY rising edge should be used to capture the output data.

The data is available on the reference board at pins A5/B5 (MSB +/-) through A21/B21 (LSB +/-) of the FutureBus connector (schematic reference designator H4) with the DRDY signal at pins A13/B13.

Please see the SP16130CH4RB reference board schematic in Section 6.0 of this guide and the ADC16V130 datasheet for further details.

5.6 Power requirements.

Power to the SP16130CH4RB evaluation board is supplied through the green power connector labeled "J9" located along the bottom edge of the board. The power supply should be capable of sourcing +5V up to 1A.

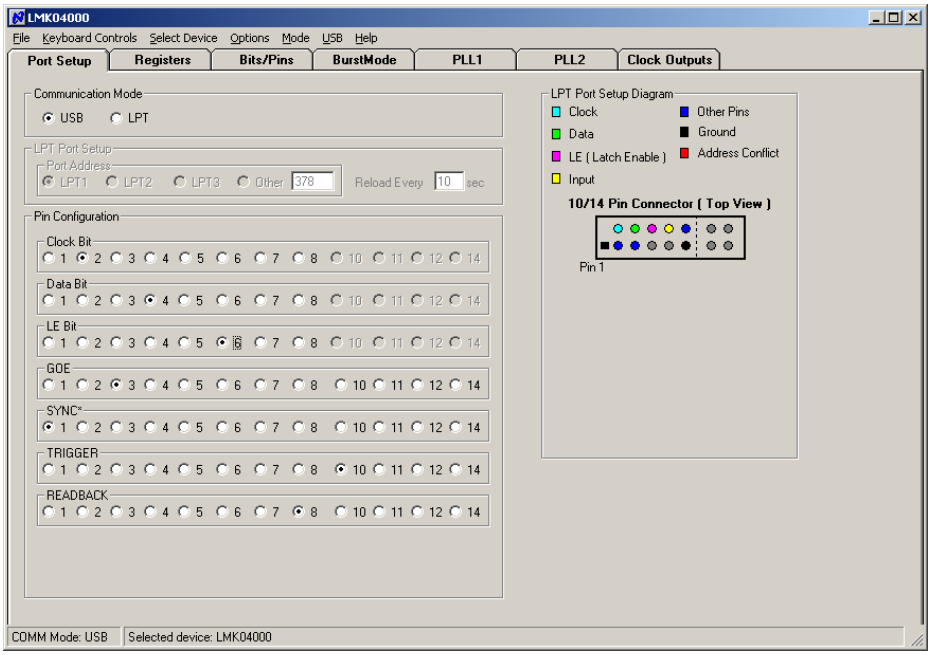

Figure 9: LMK04031B Codeloader software communication port setup for programming

The user may be required to select a different LPT port that is compatible with the capabilities of the PC being used to program the device. Using the USB port requires a separate interface board, available from National Semiconductor.

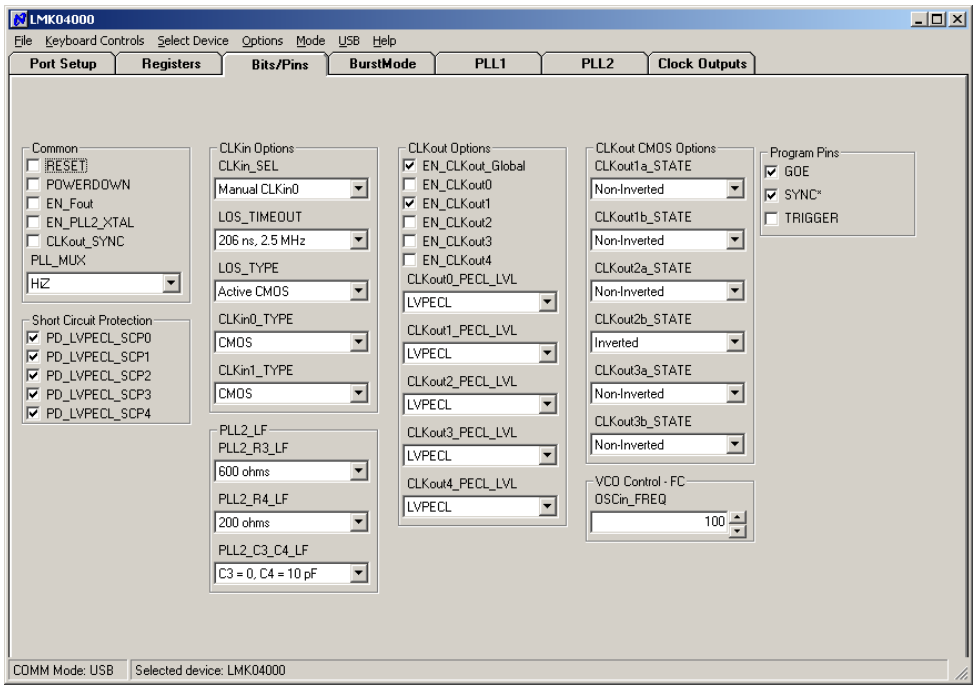

Figure 10: LMK04031 Codeloader configuration, Bits/Pins tab.

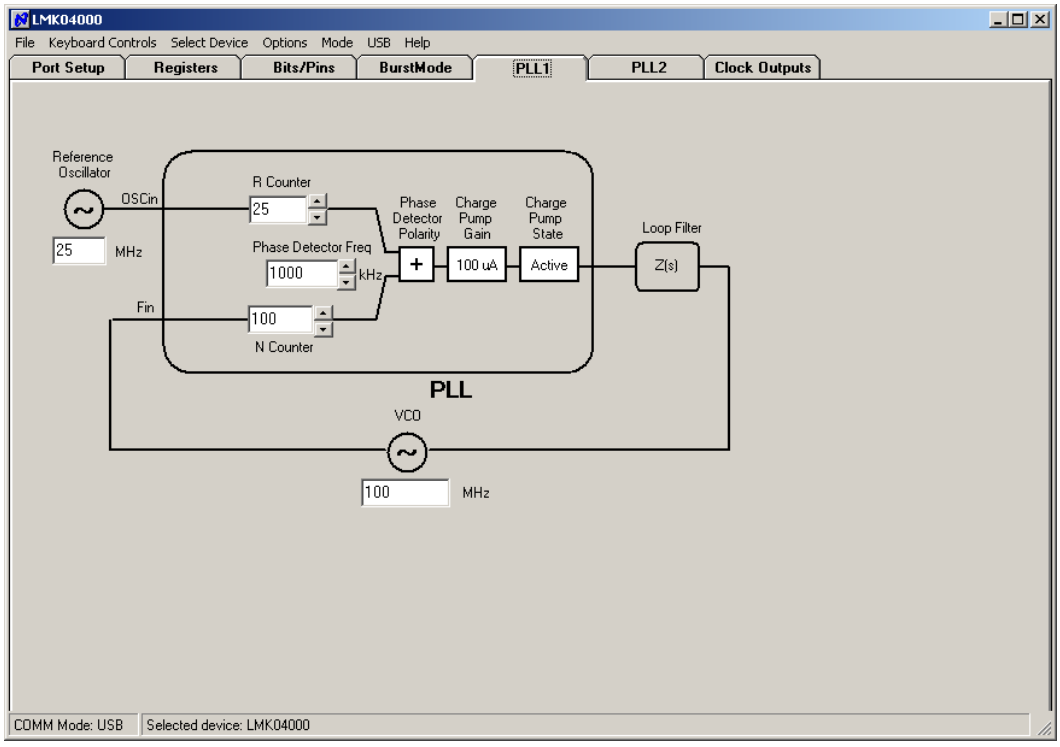

Figure 11: LMK04031B Codeloader configuration, PLL1 tab.

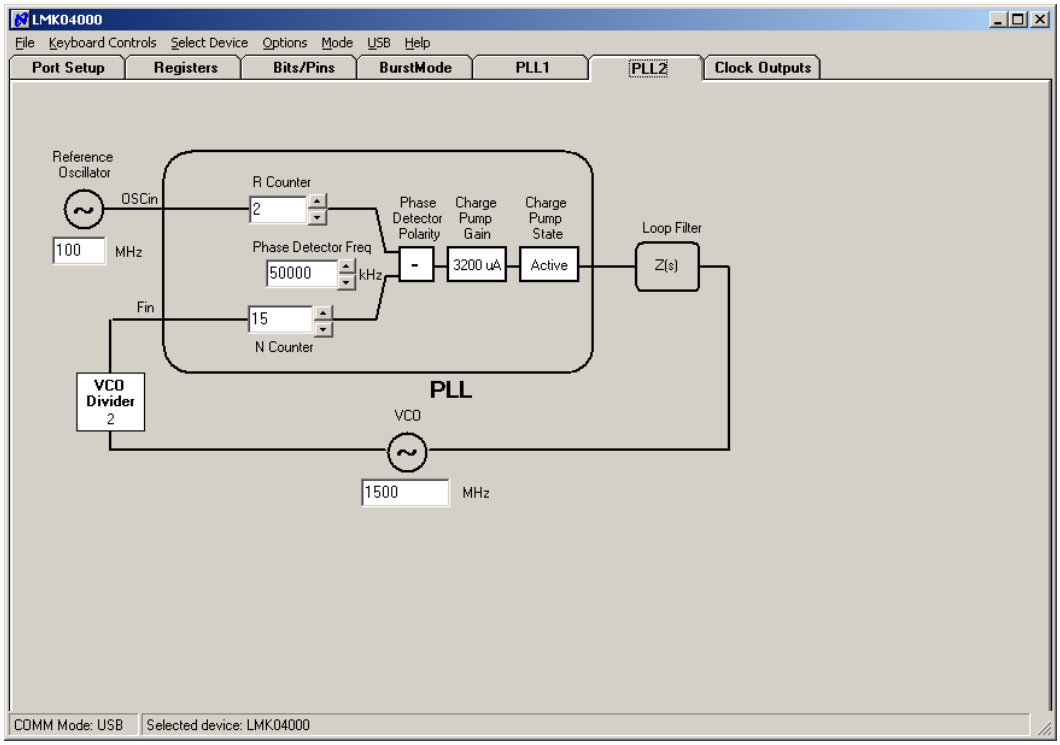

Figure 12: LMK04031B Codeloader configuration, PLL2 tab.

Using PLL parameter values different from the values shown in *Figure 11* and Figure 12 may result in degraded performance of the reference board.

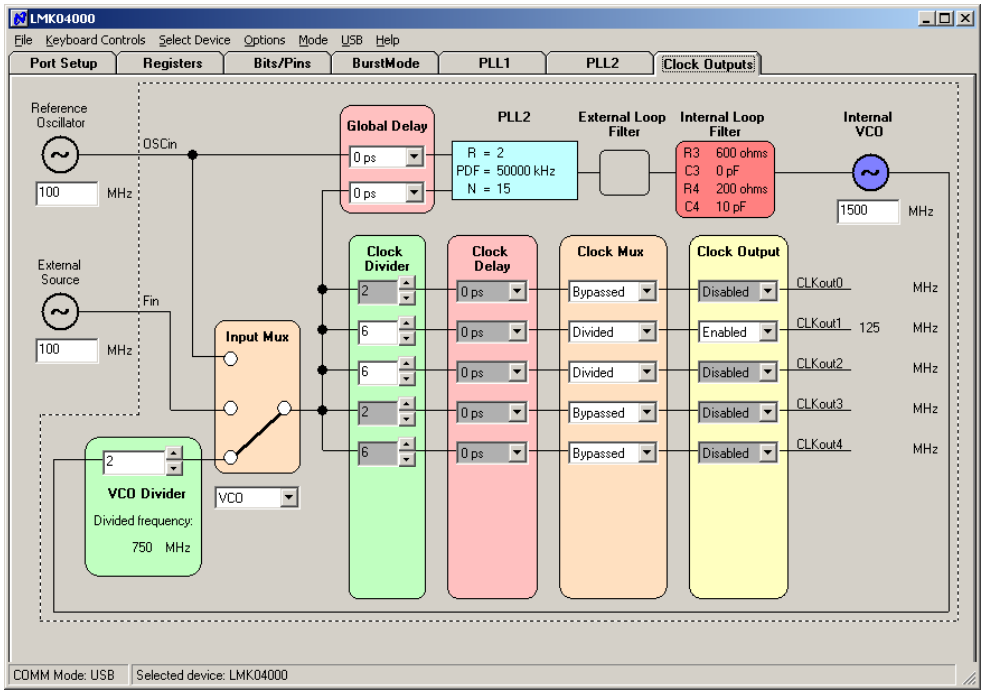

Figure 13: LMK04031B Codeloader configuration, Clock Outputs tab.

The LMK04031B clock outputs are not accessible on the SP16130CH4RB evaluation board. See http://www.national.com/appinfo/interface/clk_conditioners.html for information on acquiring the LMK04031B Evaluation board, which provides full access to all clock outputs on the LMK04031B.

6.0 Evaluation Board Schematic

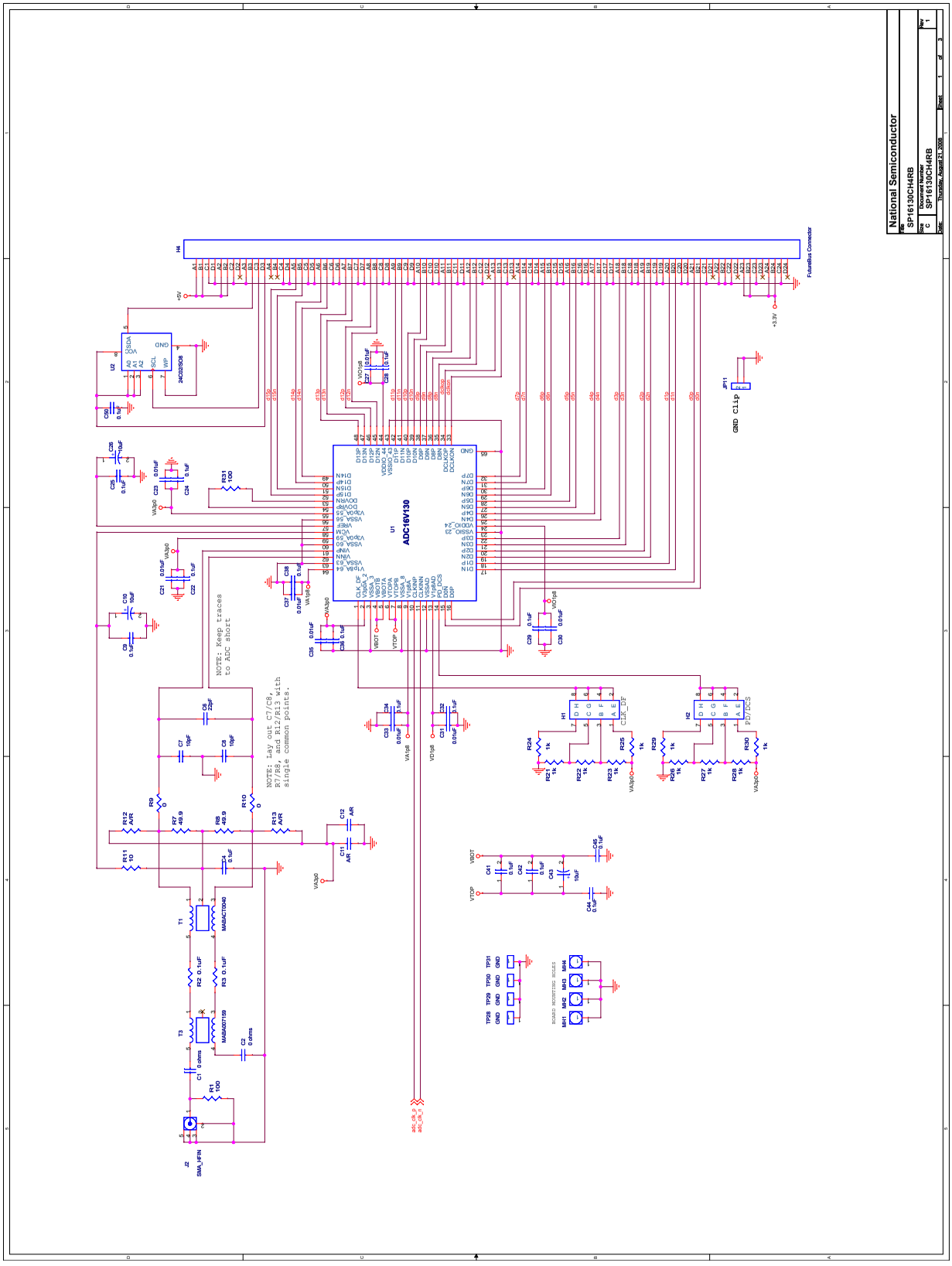

Figure 14: Analog input and ADC16V130 Circuit

6.0 Schematic (cont.)

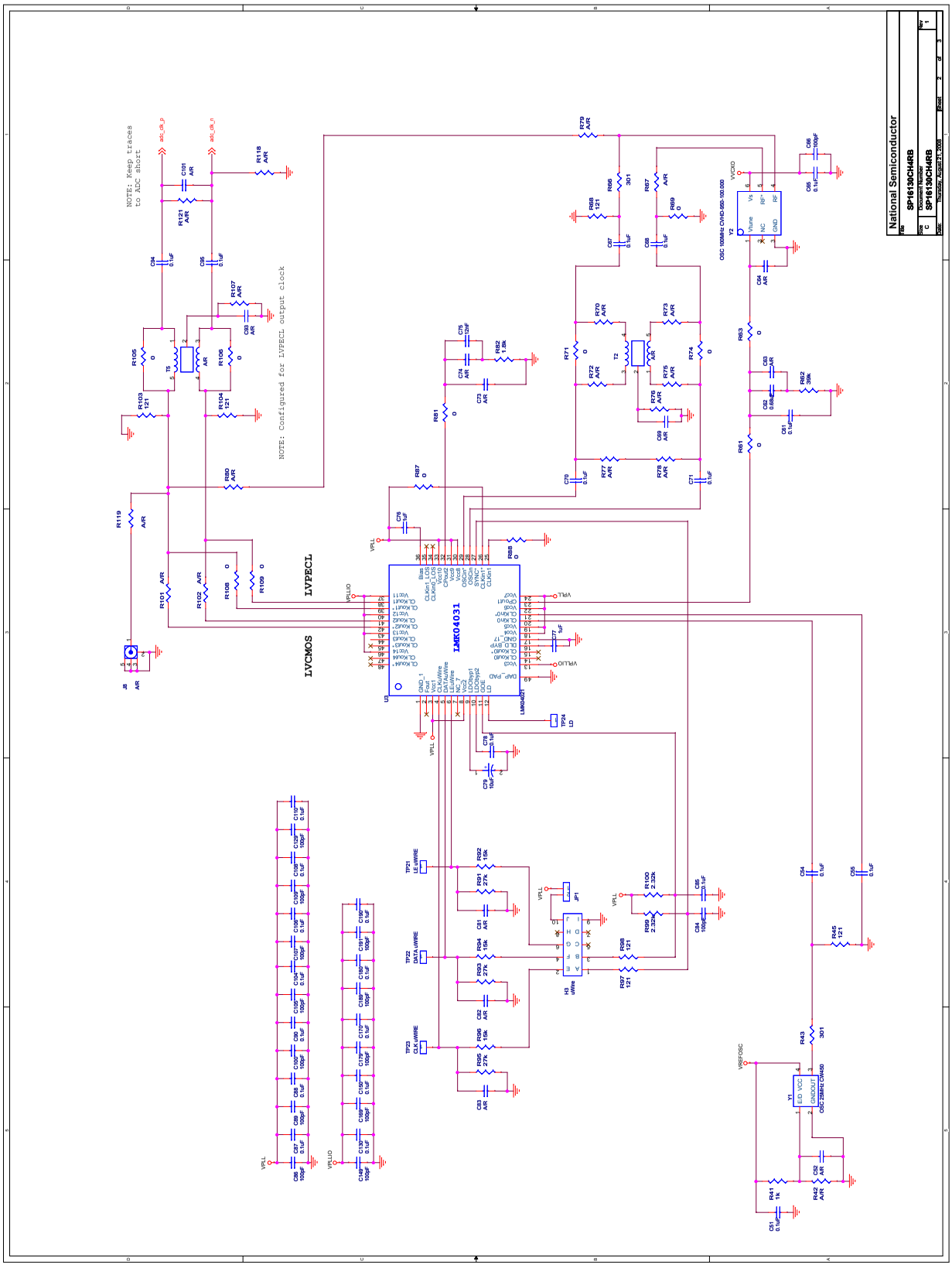

Figure 15: LMK04031B Clock Circuit

6.0 Schematic (cont.)

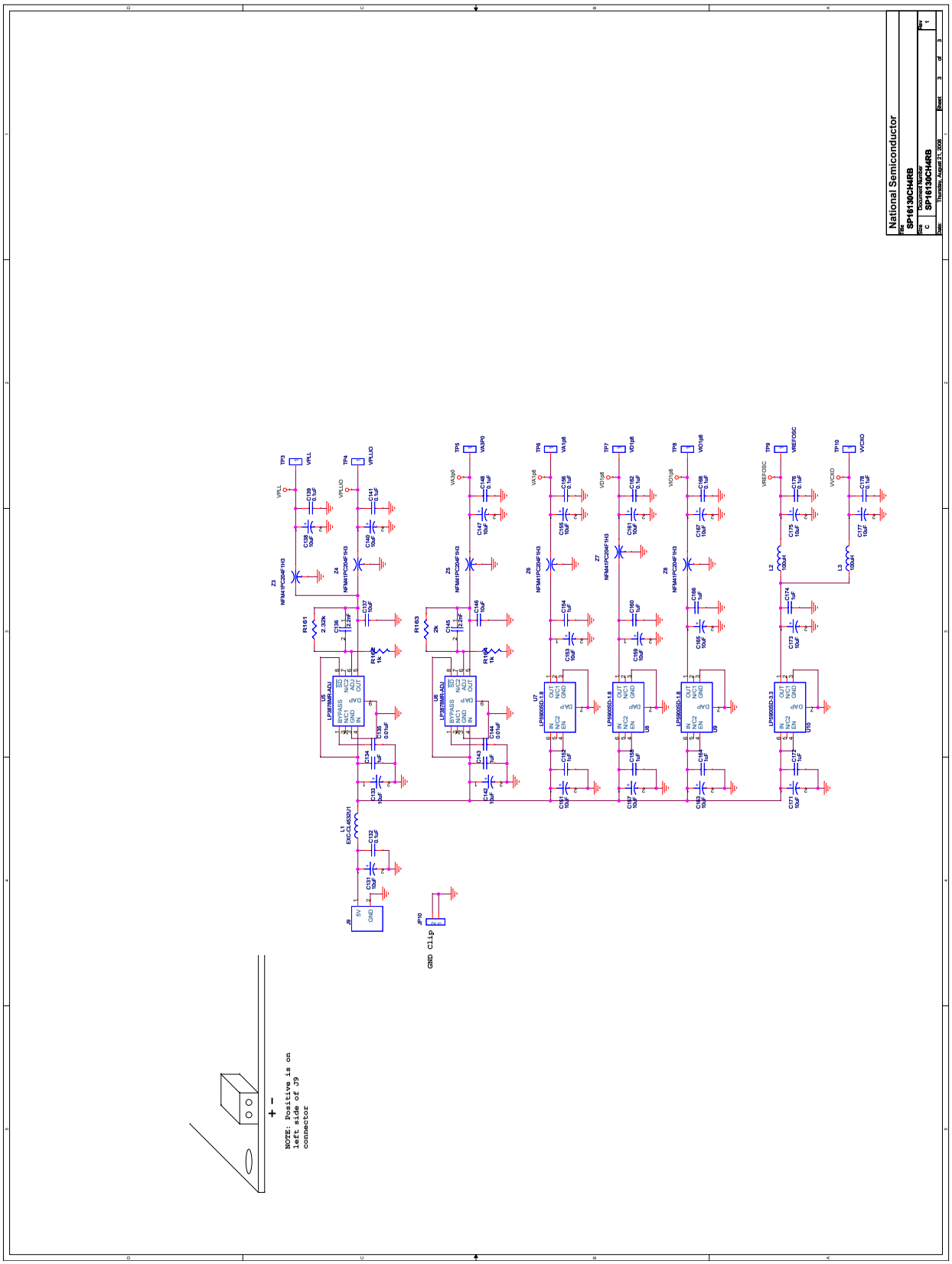

Figure 16: Power Distribution

7.0 Evaluation Board Layout

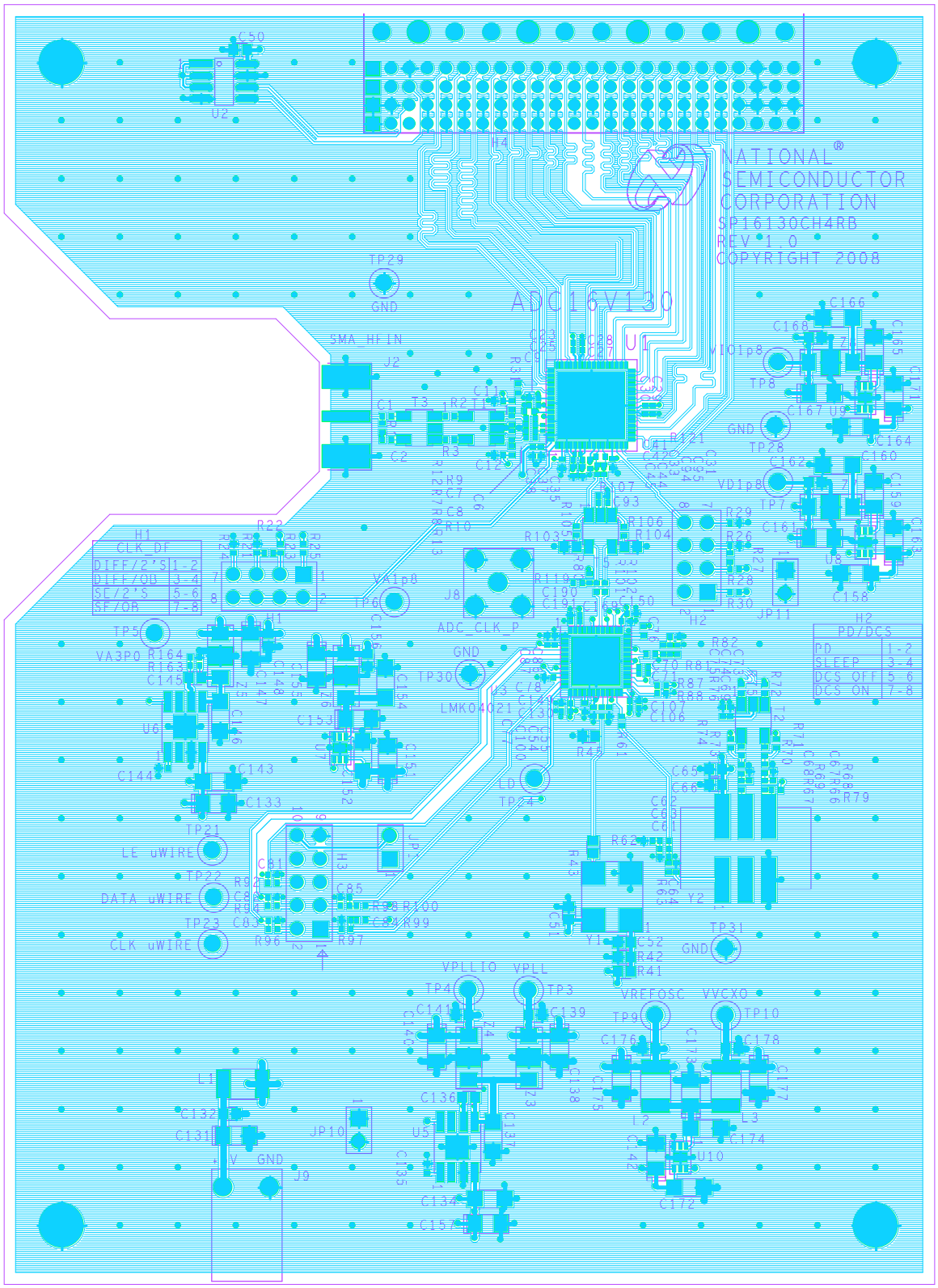

Figure 17: Layer 1 - Signal

7.0 Evaluation Board Layout (cont.)

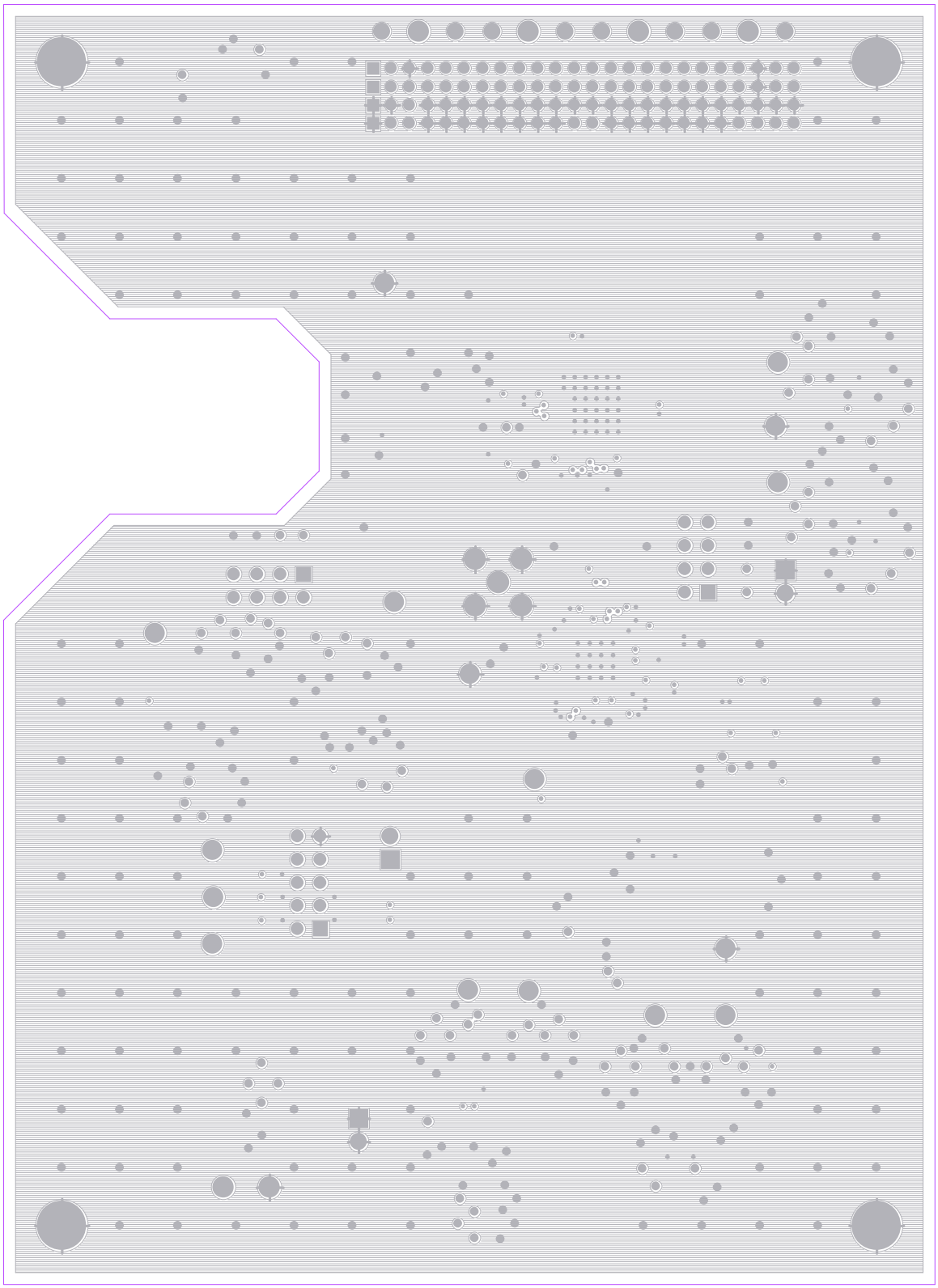

Figure 18: Layer 2 - Ground

7.0 Evaluation Board Layout (cont.)

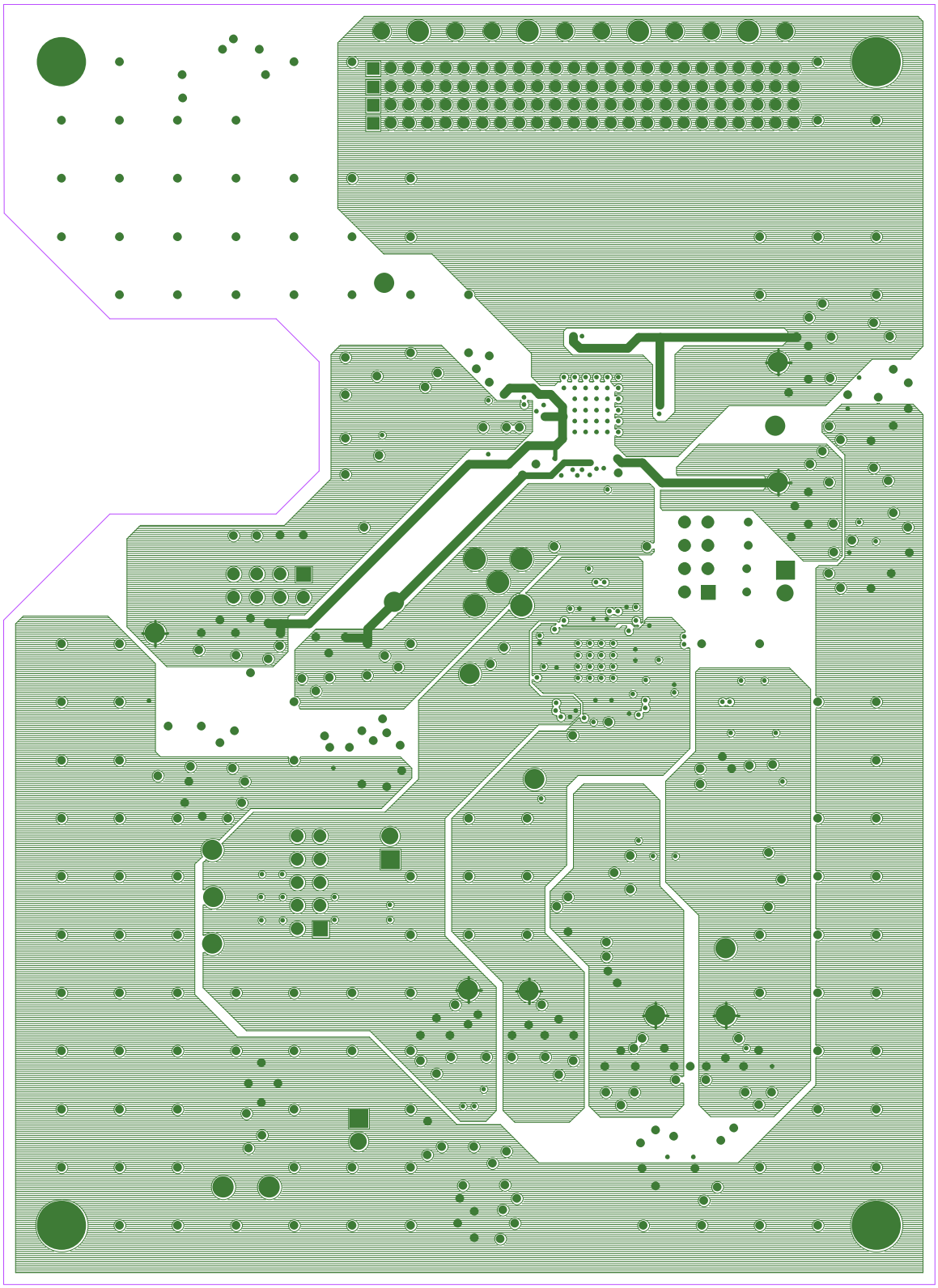

Figure 19: Layer 3 - Power

7.0 Evaluation Board Layout (cont.)

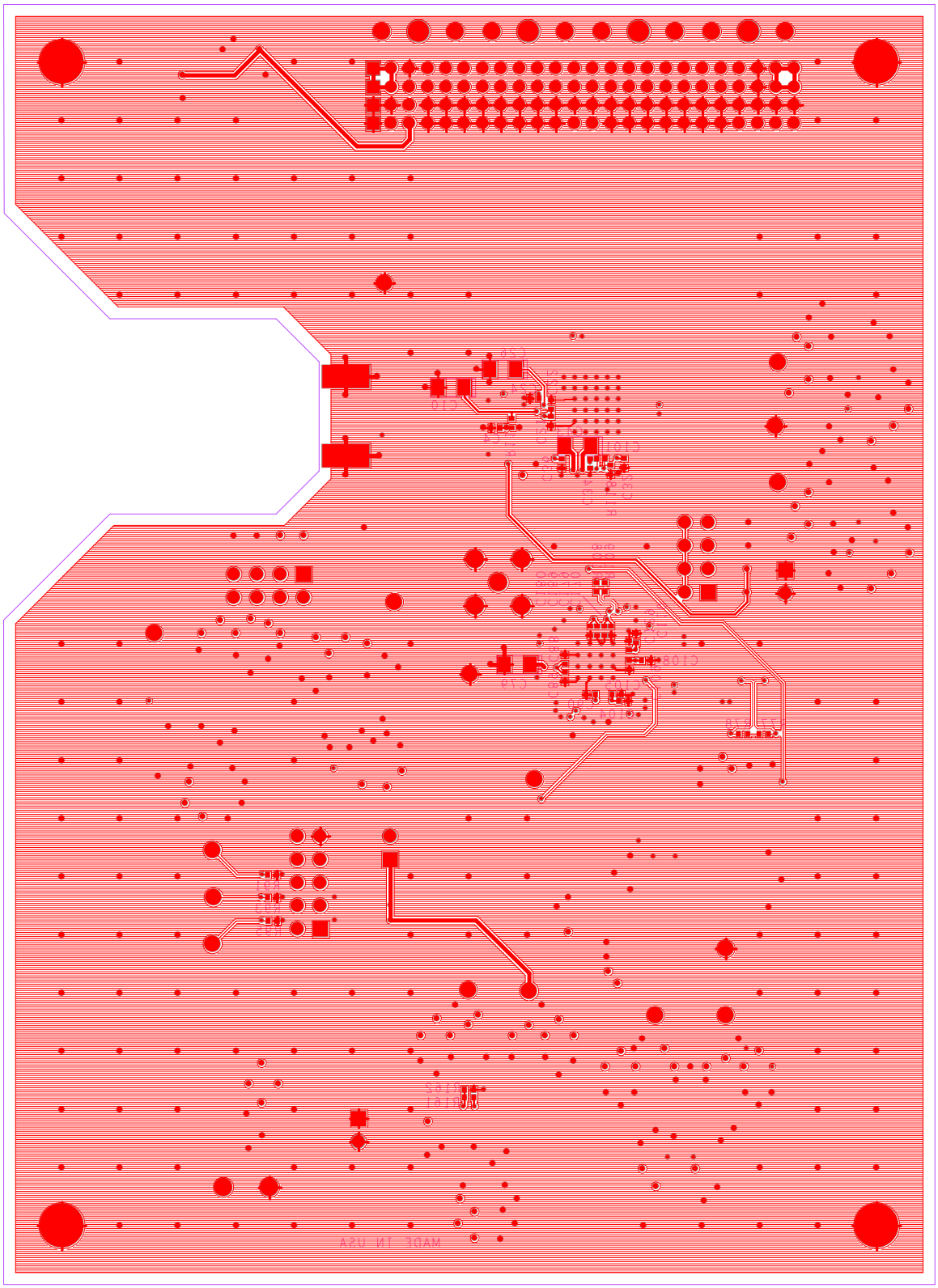

Figure 20: Layer 4 - Power

8.0 Evaluation Board Bill of Materials

Item	Quantity	Schematic Reference	Part Name	Description	PCB Footprint	Manufacturer	Supplier	Supplier Part Number	Unit Cost	Price Break (# Units)	Total Cost	Notes
	2	C7, C8	10pF	CAP 10PF 50V CERAMIC 0402 SMD	sm0402	Panasonic - ECG	Digi-Key	PCC100CQCT-ND	$0.0260	10	$0.05	
	1	C6	22pF	CAP 22PF 50V CERAMIC 0402 SMD	sm0402	Panasonic - ECG	Digi-Key	PCC220CQCT-ND	$0.0730	10	$0.07	SOLDER ACROSS PADS OF C7 AND C8, NOT ON C6 PADS
	14	C66, C84, C86, C89, C100, C105, C107, C109, C129, C149, C169, C179, C189, C191	100pF	CAP 100PF 50V CERAMIC X7R 0402	sm0402	Panasonic - ECG	Digi-Key	PCC1709CT-ND	$0.0260	10	$0.36	PLACE 0402 ON C66 PAD
	2	C136, C145	2.2nF	CAP CERM 2200PF 5% 100V X7R 0603	sm0603	AVX Corporation	Digi-Key	478-3705-1-ND	$0.2970	10		
	1	C75	12nF	CAP .012UF 16V CERAMIC X7R 0402	sm0402	Panasonic - ECG	Digi-Key	PCC1700CT-ND	$0.0260	10	$0.03	
	10	C21, C23, C27, C30, C31, C33, C35, C37, C135, C144	0.01uF	CAP .01UF 25V CERAMIC X7R 0402	sm0402	Panasonic - ECG	Digi-Key	PCC2270CT-ND	$0.0260	10	$0.26	
	1	C41	0.1uF	CAP CERAMIC .1UF 6.3V X5R 0201	sm0201	Panasonic - ECG	Digi-Key	PCC2366CT-ND	$0.0430	10	$0.04	
	39	R2, R3, C4, C9, C22, C24, C25, C28, C29, C32, C34, C36, C38, C42, C44, C45, C54, C55, C61, C67, C68, C70, C71, C78, C85, C87, C88, C90, C94, C95, C104, C106, C108, C110, C130, C150,	0.1uF	CAP .1UF 10V CERAMIC X5R 0402	sm0402	Panasonic - ECG	Digi-Key	PCC2146CT-ND	$0.0380	10	$1.48	
	12	C50, C51, C65, C132, C139, C141, C148, C156, C162, C168, C176,	0.1uF	CAP .1UF 16V CERAMIC X7R 0603	sm0603	Panasonic - ECG	Digi-Key	PCC1762CT-ND	$0.0360	10	$0.43	
	1	C62	0.68uF	CAP CER .68UF 6.3V Y5V 0402	sm0402	Murata Electronics	Digi-Key	490-3278-1-ND	$0.0780	10	$0.08	
	2	C76,C77	1uF	CAP 1UF 6.3V CERAMIC Y5V 0402	sm0402	Panasonic - ECG	Digi-Key	PCC2268CT-ND	$0.1040	10	$0.21	
	10	C134, C143, C152, C154, C158, C160, C164, C166, C172, C174	1uF	CAP 1UF 16V CERAMIC Y5V 1206	sm1206	Panasonic - ECG	Digi-Key	PCC1896CT-ND	$0.1220	10	$1.22	
	2	C137,C146	10uF	CAP 10UF 10V CERAMIC Y5V 1206	sm1206	Panasonic - ECG	Digi-Key	PCC1894CT-ND	$0.2890	10	$0.58	
	23	C10, C26, C43, C79, C131, C133, C138, C140, C142, C147, C151, C153, C155, C157, C159, C161, C163, C165, C167, C171, C173,	10uF	CAP TANTALUM 10UF 6.3V 20% SMD	sm3126	Kemet	Digi-Key	495-2181-1-ND	$0.0160	10	$0.37	
	14	C1, C2, R9, R10, R61, R63, R69, R71, R74, R81, R87, R88, R105, R106, R108, R109	0	RES ZERO OHM 1/16W 5% 0402 SMD	sm0402	Panasonic - ECG	Digi-Key	P0.0JCT-ND	$0.0810	10	$1.13	
	1	R11	10	RES 10 OHM 1/16W 5% 0402 SMD	sm0402	Panasonic - ECG	Digi-Key	P10JCT-ND	$0.0810	10	$0.08	
	2	R7, R8	49.9	RES 49.9 OHM 1/16W 1% 0402 SMD	sm0402	Vishay/Dale	Digi-Key	541-49.9LCT-ND				
	2	R1, R31	100	RES 100 OHM 1/16W 1% 0402 SMD	sm0402	Panasonic - ECG	Digi-Key	P100LCT-ND	$0.0980	10	$0.20	
	6	R45, R68, R97, R98, R103, R04	121	RES 121 OHM 1/16W 1% 0402 SMD	sm0402	Panasonic - ECG	Digi-Key	P121LCT-ND	$0.0980	10	$0.59	PLACE 0402 ON R103 AND R104 PAD
	2	R43, R66	301	RES 301 OHM 1/16W 1% 0402 SMD	sm0402	Vishay/Dale	Digi-Key	541-301LCT-ND	$0.0830	10	$0.17	PLACE 0402 ON R43 PAD
	13	R21, R22, R23, R24, R25, R26, R27, R28, R29, R30, R41, R162,	1k	RES 1.00K OHM 1/16W 1% 0402 SMD	sm0402	Panasonic - ECG	Digi-Key	P1.00KLCT-ND	$0.0980	10	$1.27	PLACE 0402 ON R41 PAD
	1	R82	1.8k	RES 1.80K OHM 1/16W 1% 0402 SMD	sm0402	Panasonic - ECG	Digi-Key	P1.8KLCT-ND	$0.0980	10	$0.10	
	1	R163	2k	RES 2.00K OHM 1/16W 1% 0402 SMD	sm0402	Vishay/Dale	Digi-Key	541-2.00KLCT-ND	$0.0830	10	$0.08	
	3	R99, R100, R161	2.32k	RES 2.32K OHM 1/16W 1% 0402 SMD	sm0402	Panasonic - ECG	Digi-Key	P2.32KLCT-ND	$0.0980	10	$0.29	
	3	R92, R94, R96	15k	RES 15.0K OHM 1/16W 1% 0402 SMD	sm0402	Panasonic - ECG	Digi-Key	P15.0KLCT-ND	$0.0980	10	$0.29	
	3	R91, R93, R95	27k	RES 27.0K OHM 1/16W 1% 0402 SMD	sm0402	Panasonic - ECG	Digi-Key	P27.0KLCT-ND	$0.0980	10	$0.29	
	1	R62	39k	RES 39.0K OHM 1/16W 1% 0402 SMD	sm0402	Panasonic - ECG	Digi-Key	P39.0KLCT-ND	$0.0980	10	$0.10	
	2	L2, L3	100uH	INDUCTOR UNSHIELDED 100UH SMD	sm1812	API Delevan	Digi-Key	DN42113JCT-ND	$1.2200	10	$0.61	
	1	L1	Ferrite Bead Core	BEAD CORE 4.5X3.2X1.8 SMD	-	Panasonic - ECG	Digi-Key	P9812CT-ND	$0.6140	10	$0.61	
	6	Z3-8	Noise Suppression Filter	FILTER LC HIGH FREQ .2UF 1806	sm1806	Murata Electronics	Digi-Key	490-2550-1-ND	$0.7250	10	$4.35	
	1	Y1	Crystal Oscillator	OSC 25.0000MHZ 3.3V +-50PPM SMD	SMD 7mm x 5mm	Connor-Winfield	Digi-Key	CW450CT-ND	$2.1300	1	$2.13	
	1	Y2	VCXO	VCXO CMOS 100.0 MHZ 3.3V SMD CVHD-950-100.000	SMD 14mm x 9mm	Crystek Corporation	Digi-Key	744-1213-ND	$27.7000	1	$27.70	
	1	U1	ADC	16-BIT, 160 MSPS, 2 GHz BANDWIDTH A/D CONVERTERWITH LVDS OUTPU	LLP-48	NATIONAL SEMICONDUCTOR	NATIONAL SEMI	ADC16V130	$70.0000	1000	$70.00	
	1	U3	PLL	PRECISION CLOCK CONDITIONER/MULTIPLIER	LLP-48	NATIONAL SEMICONDUCTOR	NATIONAL SEMI	LMK04031	$14.2500	1000	$14.25	
	2	U5, U6	Voltage Regulator	IC VREG 800MA ADJ 8-PSOP	PSOP-8	NATIONAL SEMICONDUCTOR	Digi-Key	LP3878MR-ADJ-ND	$2.5000	1	$5.00	
	1	U10	Voltage Regulator	IC REG 3.3V LDO 100MA RF/ANLG 6-LLP	LLP-6	NATIONAL SEMICONDUCTOR	Digi-Key	LP5900SD-3.3CT-ND	$1.6200	1	$1.62	
	3	U7, U8, U9	Voltage Regulator	IC REG 1.8V LDO 100MA RF/ANLG 6-LLP	LLP-6	NATIONAL SEMICONDUCTOR	Digi-Key	LP5900SD-1.8CT-ND	$1.6200	1	$4.86	
	1	U2	EEPROM	2K SERIAL EEPROM	8 PIN SOIC	ATMEL	Digi-Key	AT24C02BN-SH-B-ND	$0.3200	25	$0.32	
	1	JP1	Jumper 1X2	1X2 JUMPER BLOCK HEADER	-	Samtec	Samtec	MTSW-101-07-T-D-240	???	10		
	3	JP1, H1:CLK_DF, H2:PD/DCS	Shunt	1X2 LOW PROFILE JUMPER	-	FCI Electronic	Arrow Electronics	68786-302LF	$0.0630	-	$0.19	PLACE SHUNT ON JP1
												PLACE SHUNT BETWEEN PINS 3-4 ON H1:CLK_DF
												PLACE SHUNT BETWEEN PINS 7-8 ON H2:PD/DCS
	3	H1:CLK_DF, H2:PD/DCS, H3:UWIRE	Jumper 2X5	2X5 JUMPER BLOCK HEADER	-	Samtec	Samtec	MTSW-105-07-T-D-240	???	-		Cut MTSW-105-07-T-D-240 To Size To Fit H2:PD/DCS and H1:CLK_DF
	1	J9	Power Connector Terminal Block	CONN HEADER RT ANG 2POS 5.08MM	-	Phoenix Contact	Digi-Key	277-1095-ND	$0.5000	1	$0.50	
	1	-	Power Connector Plug	CONN TERM BLOCK PLUG 2POS 5.08MM	-	Phoenix Contact	Digi-Key	277-1011-ND	$1.5300	1	$1.53	
	4	H4	FUTURE BUS CONNECTOR	Z-PACK 2mm FB (Futurebus+) RIGHT ANGLE HEADER CONNECTOR	-	AMP	Tyco Electronics	5223514-1	$6.9000	-	$27.60	
	1	J2	SMA Input	CONN JACK SMA 50 OHM EDGE MOUNT	-	Molex/Waldom Electronics	Digi-Key	WM5536-ND	$4.9000	1	$4.90	
	1	T3	Transformer	SM RF 1:1 T-LINE TRANSFORMER 4.5 TO 3000 MHz	SM-22	MA/COM	Tyco Electronics	MABA007159	???			
	1	T1	Transformer	SM RF 1:1 T-LINE HYBRID TRANSFORMER 5 TO 1000 MHz	SM-164	MA/COM	Tyco Electronics	MABACT0040	???			
	4	MT1-4	Bump-on Rubber Feet	PLACE BUMP ONS AT THE 4 CORNERS, ON BOTTOM OF BOARD	-	3M	Digi Key	SJ5003-0-ND	$0.0911	56	$0.36	PLACE BUMP ONS AT THE 4 CORNERS, ON BOTTOM OF BOARD
									PCB		$66.40	
									Assembly		$175.00	
									Total Cost		$417.73	

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