Low IF Receiver Reference Design

National Semiconductor
RD-170
Strategic Signal Path Applications
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1.0 Design Description

The SP16130CH4RB Reference Board demonstrates a low IF receiver subsystem application including an ADC16V130 analog-to-digital converter (ADC) and LMK04031B clock conditioner which provides digitization and clocking as used in wireless infrastructure systems.

This subsystem reference design provides single to differential conversion and lowpass filtering of the input signal with an optimized, double-balun network and high dynamic range digitization to parallel LVDS outputs using the ADC16V130. The 125 MHz low-jitter, LVPECL clock signal for the ADC is generated by a LMK04031B clock conditioner which demonstrates less than 250 fs of total jitter over the input bandwidth of the ADC.

The measured system performance demonstrates a large signal SNR of 75.8 dBFS and SFDR greater than 84 dBFS for a -1 dBFS, 52 MHz input signal and a sampling frequency of 125 MSPS. For small signals, the performance improves to 78.0 dBFS SNR and greater than 94 dBFS SFDR.

Evaluation of this reference board is simplified with the WaveVision 5.1 Data Capture Board and WaveVision 5 software.

2.0 Features

Key Features of the SP16130CH4RB Low IF Receiver Reference Design Board

- Demonstrates a subsystem architecture used in wireless infrastructure systems and frequency domain analyzers
- Configured for input frequencies between 5 and 52 MHz
- Board comes fully assembled and tested
- Single (+5V) supply needed
- All ADC features can be exercised
- **Featured Products Include:**
  - — ADC16V130 16-bit, 130 Megasample per second (MSPS) ADC with parallel LVDS outputs
  - — LMK04031B low-jitter precision clock conditioner consisting of cascaded phase locked loops (PLLs), an internal voltage controlled oscillator (VCO) and a distribution stage
  - — Several energy-efficient power management ICs
- Large-signal (-1 dBFS) performance for a 52 MHz input signal:
  - — SNR = 75.8 dBFS
  - — SFDR > 84 dBFS
- Small-signal (-20 dBFS) performance for a 52 MHz input signal:
  - — SNR = 78.0 dBFS
  - — SFDR > 94 dBFS
- Total integrated jitter < 250 fs
- PIC Loader board included with reference board for quick and easy configuration of the LMK04031B
- Compatible with the WaveVision 5.1 Data Capture Board and WaveVision 5 software for simplified evaluation

3.0 Schematic

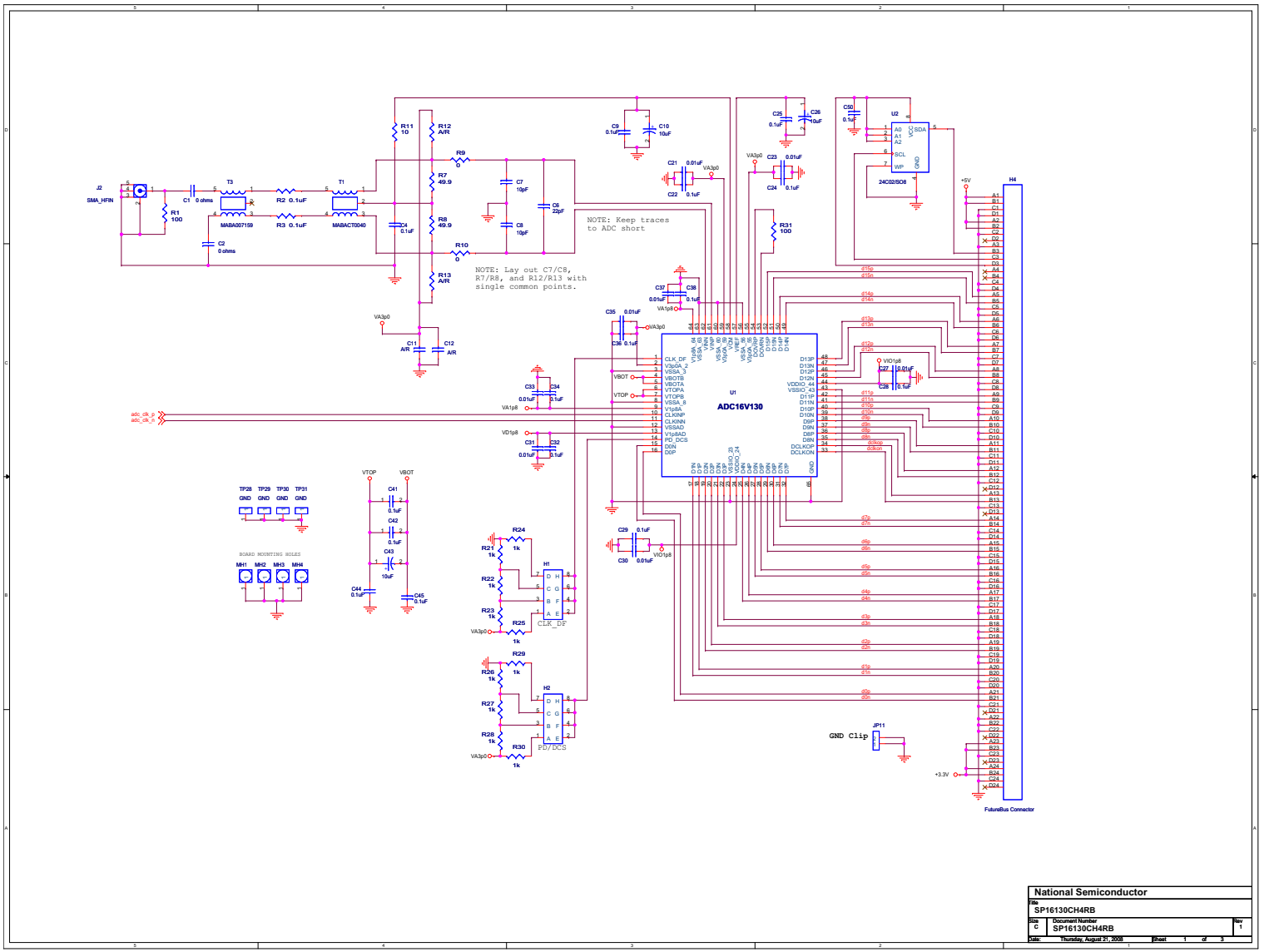


FIGURE 1. SP16130CH4RB Schematic - ADC

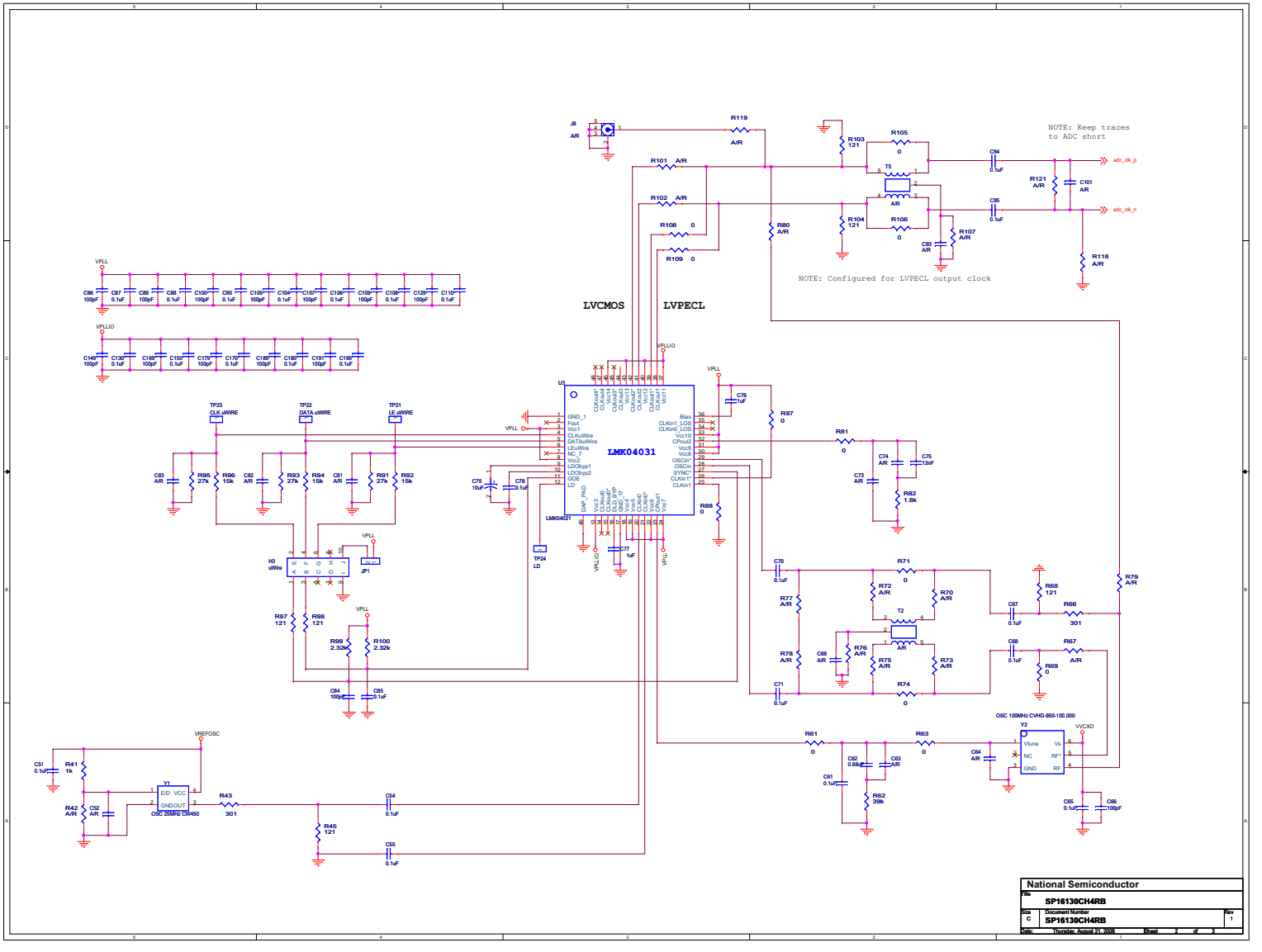
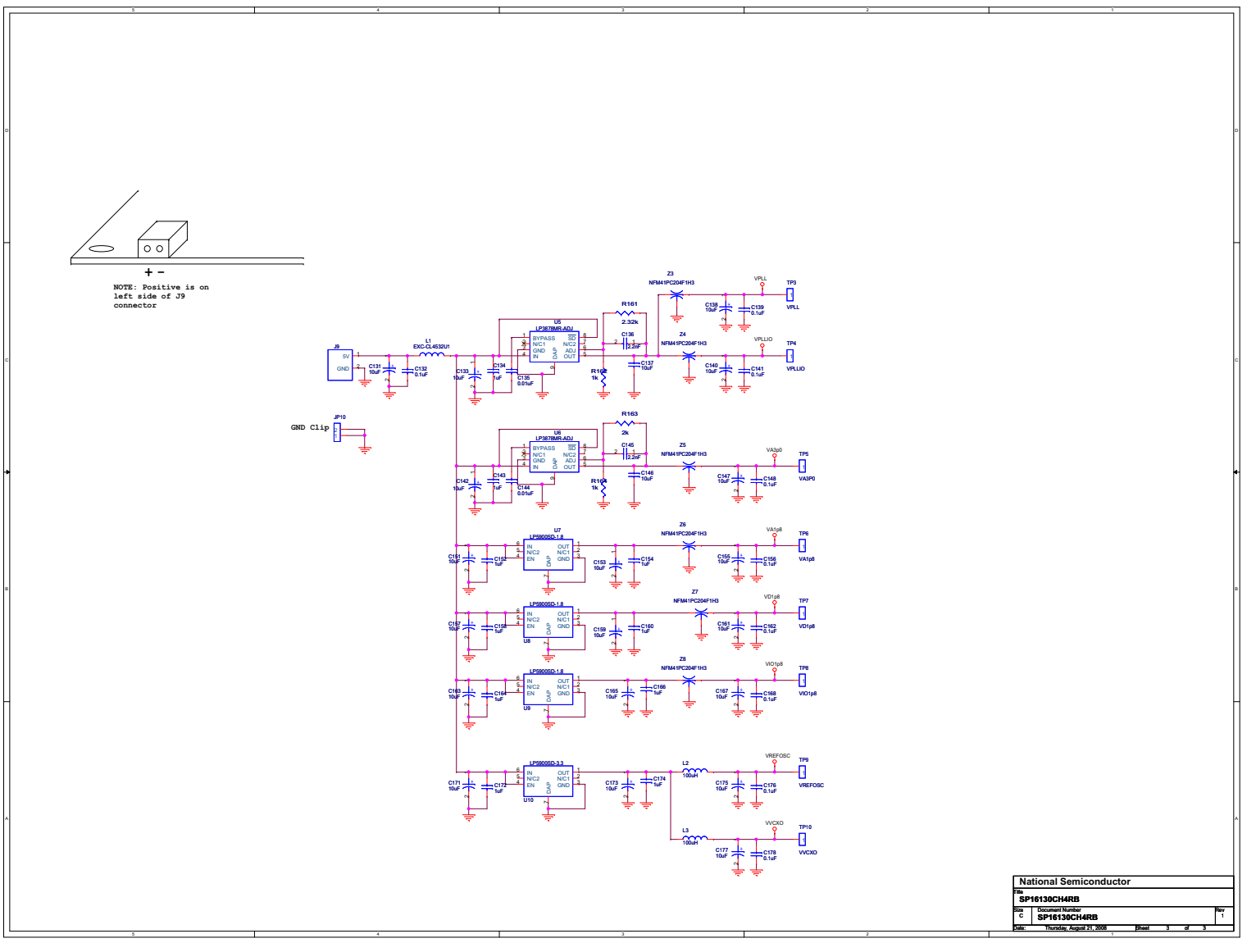


FIGURE 2. SP16130CH4RB Schematic - LMK



schematic3

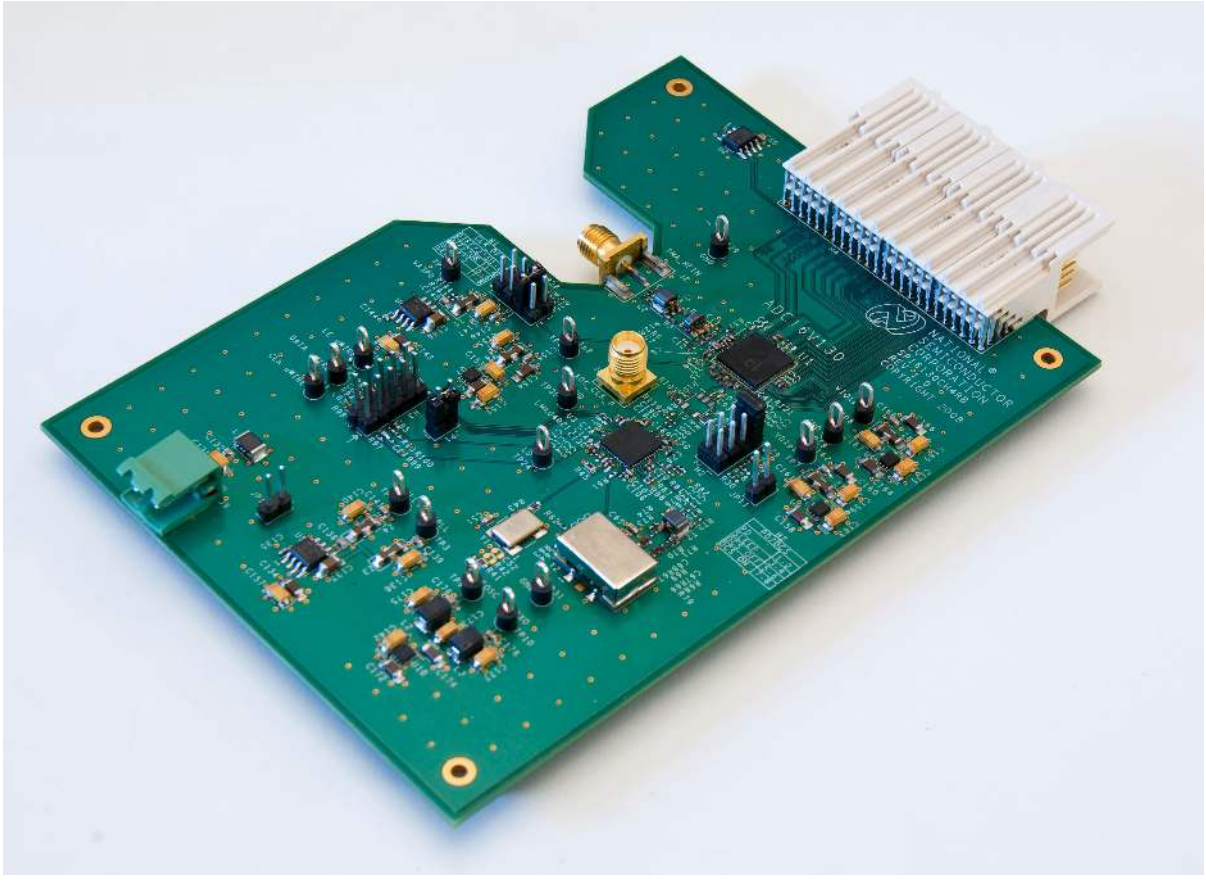
FIGURE 3. SP16130CH4RB Schematic - Power

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	

bom

FIGURE 4. SP16130Ch4RB BOM

5.0 Board Photos



boardphoto

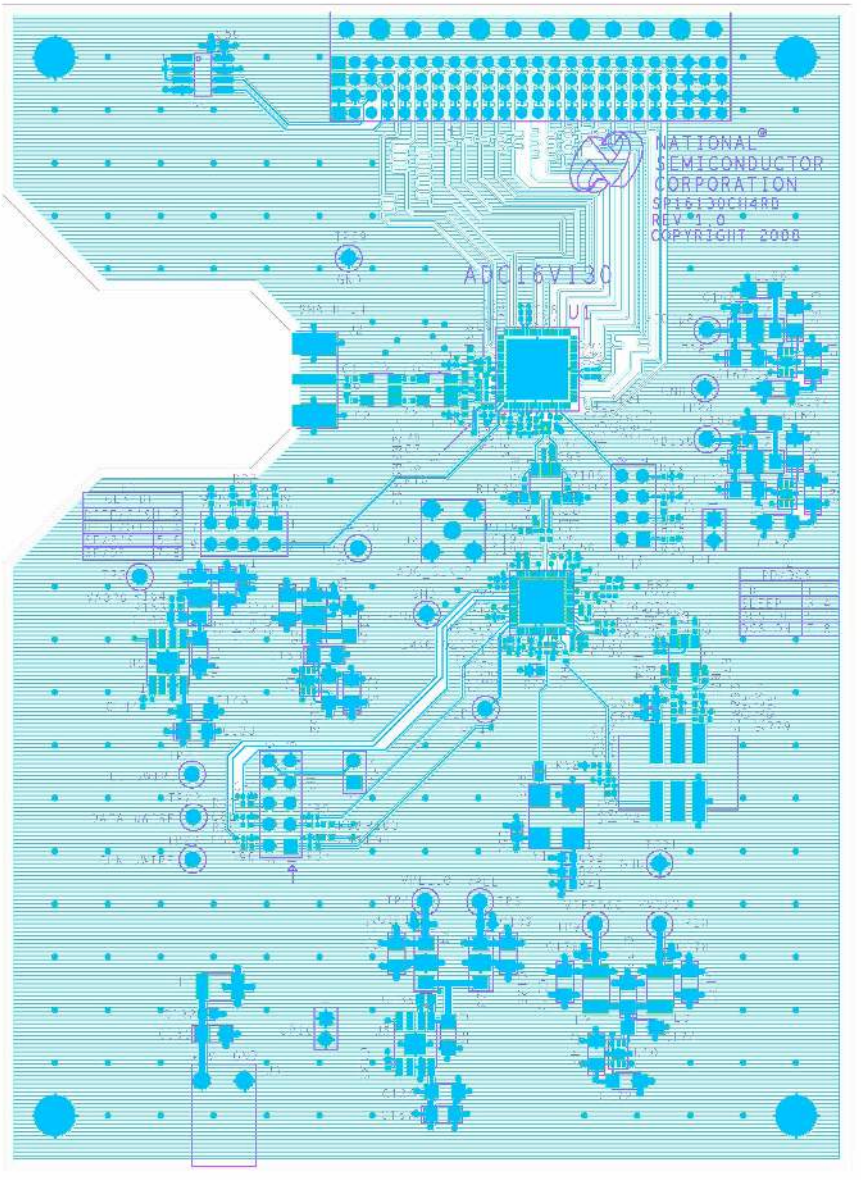
FIGURE 5. SP16130CH4RB Board Photo

6.0 Hardware Description

A comprehensive discussion of this design is within in the **SP16130CH4RB Low IF Receiver Reference Design Board ADC16V130 + LMK04031B User's Guide.** The user guide can be found in the **Design Resources** section on the RD-170 reference design folder:

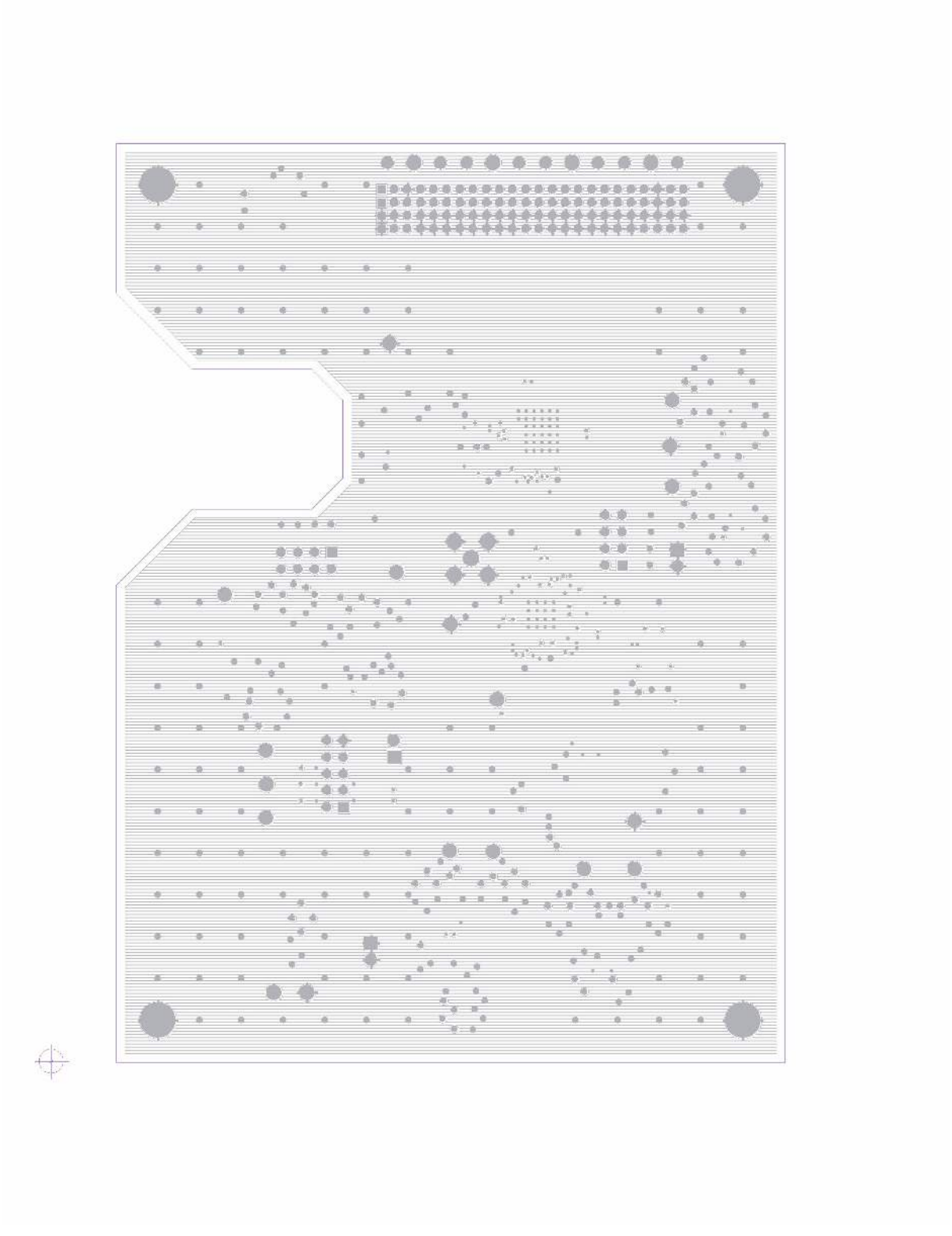
http://www.national.com/rd/RDhtml/RD-170.html

7.0 Layouts



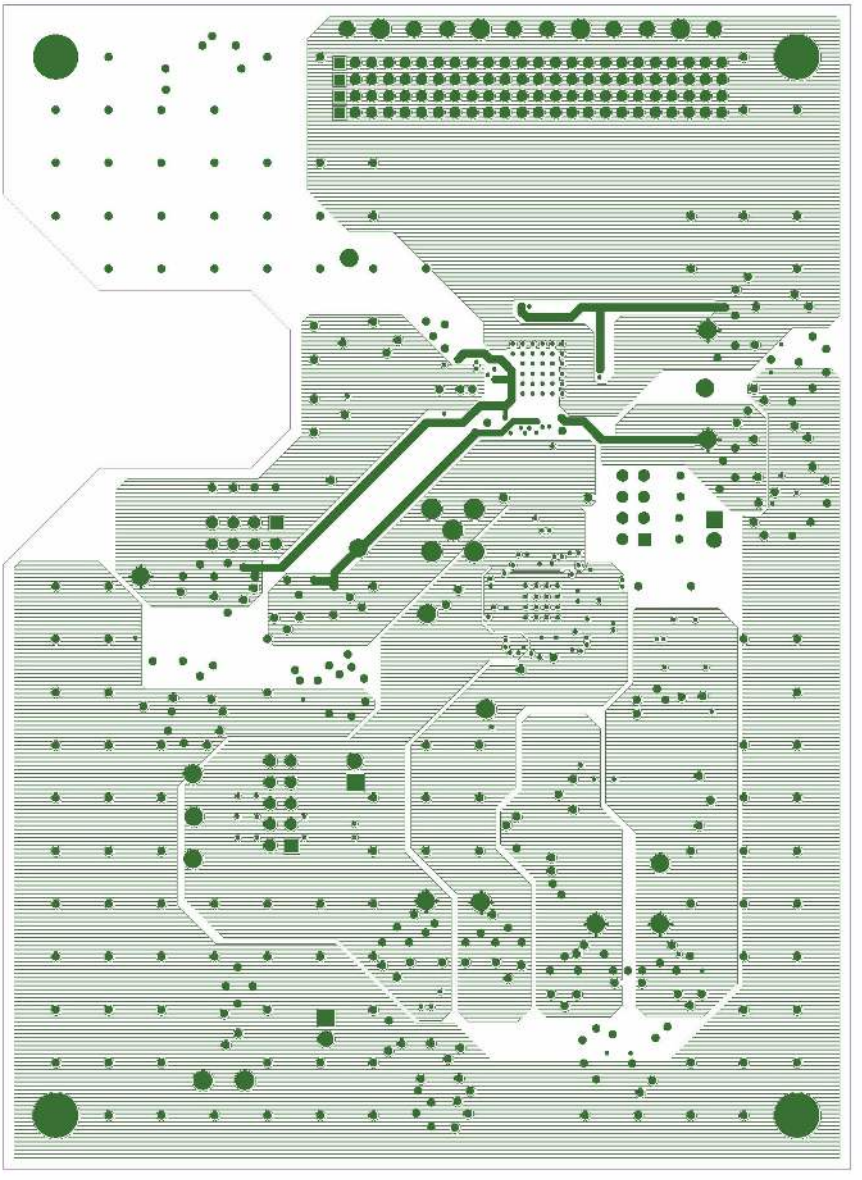
layout

FIGURE 6. SP16130CH4RB Layout - Top Signal Layer



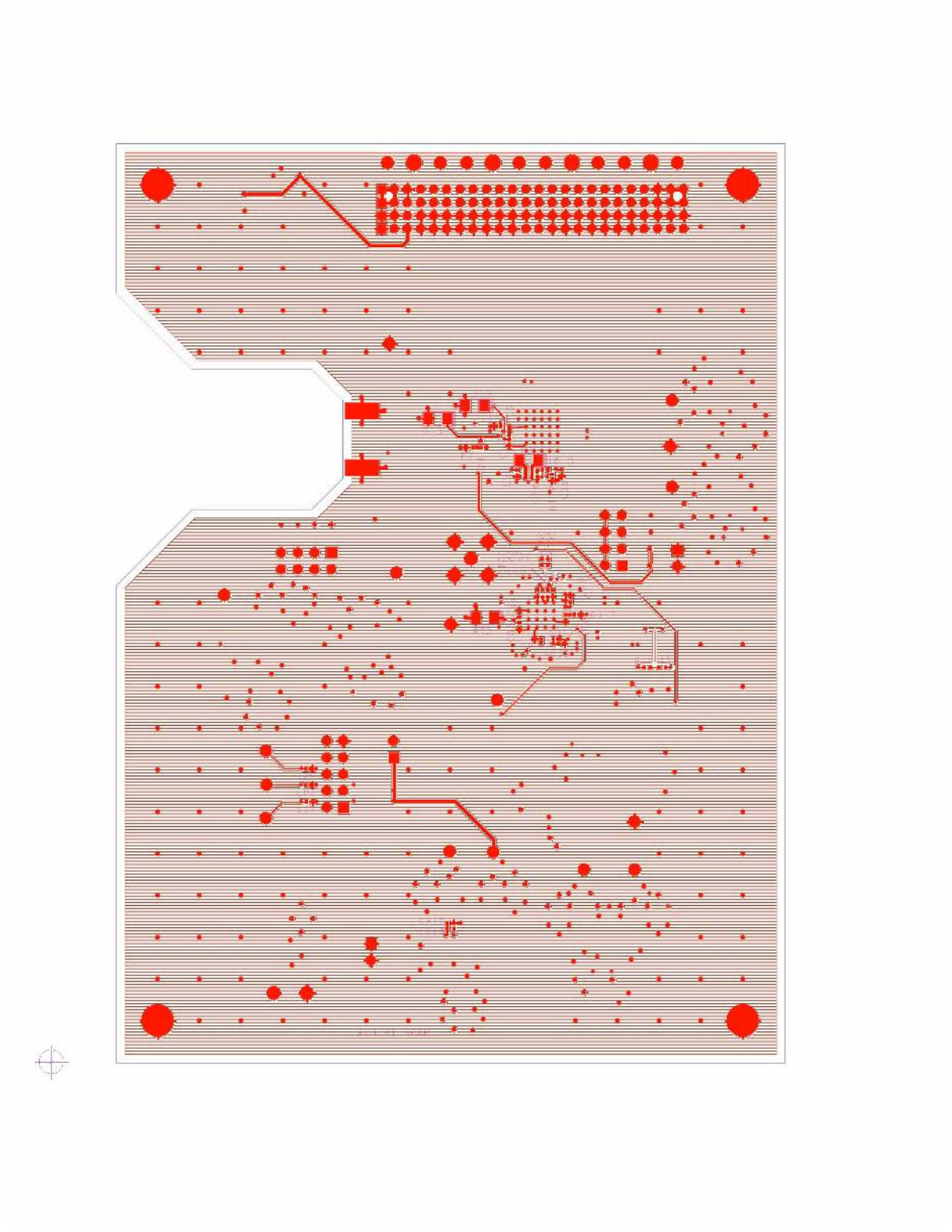
layout1

FIGURE 7. SP16130CH4RB Layout - Second GND Layer



layout2

FIGURE 8. SP16130CH4RB Layout - Third Power Layer



layout3

FIGURE 9. SP16130CH4RB Layout - Bottom Signal Layer

Notes

Notes

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