AN-2267 LMH6881 Evaluation Board

1 Introduction

The LMH6881EVAL evaluation board is designed to aid in the characterization of Texas Instrument's High Speed LMH6881 Differential Amplifier. The evaluation board is designed to be easy to use and to offer high performance signal analysis. The board is illustrated in Figure 1.

In order to use the full bandwidth of the LMH6881 the LMH6881EVAL board has been built with a high performance dielectric on the top layer (ROGERS RO4350B). This high performance dielectric provides well matched impedance and low loss to frequencies beyond 1GHz. All signal paths are routed on the top layer. The remainder of the board is conventional FR4.

http://www.rogerscorp.com/documents/726/acm/RO4000-Laminates---Data-sheet.aspx

Use the evaluation board as a guide for high frequency layout and as a tool to aid in device testing and characterization. A full schematic of the board is shown in Figure 14.

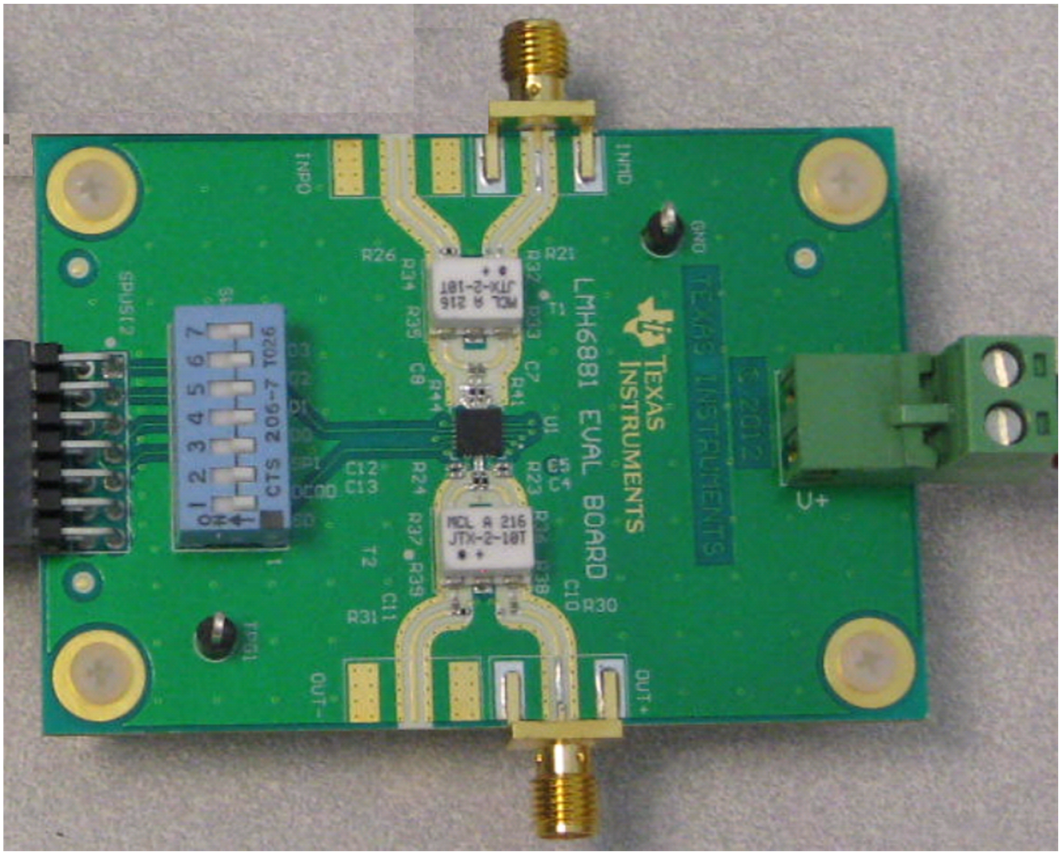

Figure 1. LMH6881 Evaluation Board

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2 Equipment

In addition to the LMH6881EVAL board, a bench supply capable of 5V and 150mA as well as SMA cables, a 50 Ohm signal source and an oscilloscope are required. Other equipment such as a vector network analyzer and a spectrum analyzer are very useful. A typical bench setup is shown in Figure 6.

The LMH6881 PDA has differential inputs and differential outputs. To aid evaluation with 50Ω single ended test equipment the LMH6881EVAL evaluation board is shipped with input and output transformers installed. The signal path uses the INPD and OUT+ marked connectors. The INMD and OUT− signal paths are grounded. The evaluation board uses edge-mounted SMA connectors. The LMH6881EVAL evaluation board is designed to be used either with transformers (as shipped) or without. Directions for modifying the board for other input/output options are described below. There are DC-blocking capacitors on both the input and output signal traces, some of these are not needed when using transformers, but are installed for maximum flexibility with other configurations. The input pins of the LMH6881 will self-bias to approximately mid supply (2.5V). The output pins need to be biased near 2.5V as well by applying the appropriate voltage to the OCM pin. This pin is biased properly on the evaluation board by resistors R17 and R18.

Transformers T1 to T2 provide both impedance matching as well as single ended to differential conversion. The board is shipped with 2:1 impedance ratio transformers that will match 50Ω equipment with the 100Ω input impedance of the LMH6881 PDA . The LMH6881 PDA has low impedance outputs, so resistors R23 and R24 provide 100 Ohm termination so that the output port is also 50 Ohms at the output port of the transformer.

The LMH6881 supports single ended inputs. To configure the evaluation board for single ended inputs remove transformer T1 and configure the input as shown in Figure 4. Where shorts are indicated it is permissible to use either 0 Ohm resistors or small pieces of wire. Wire should be 18ga and the resistors should be either 0402 or 0603 size. Check all connections with an ohm meter.

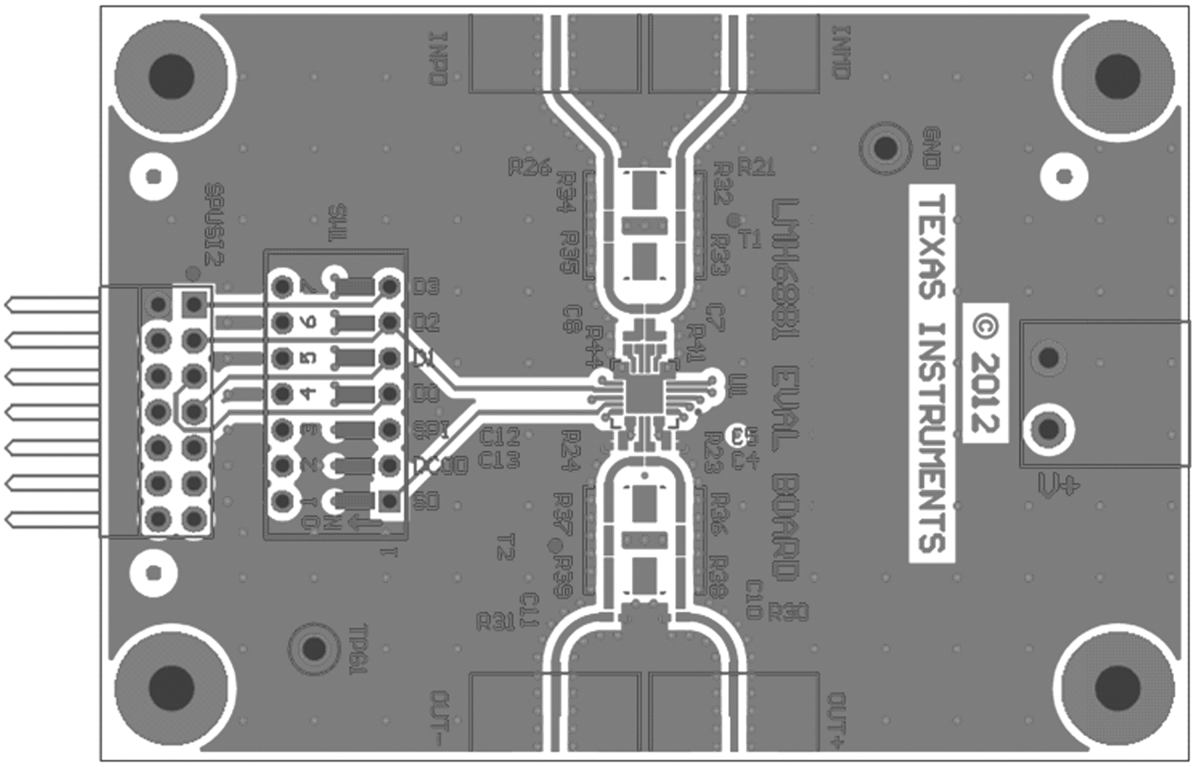

Figure 2. Top Layer Metal

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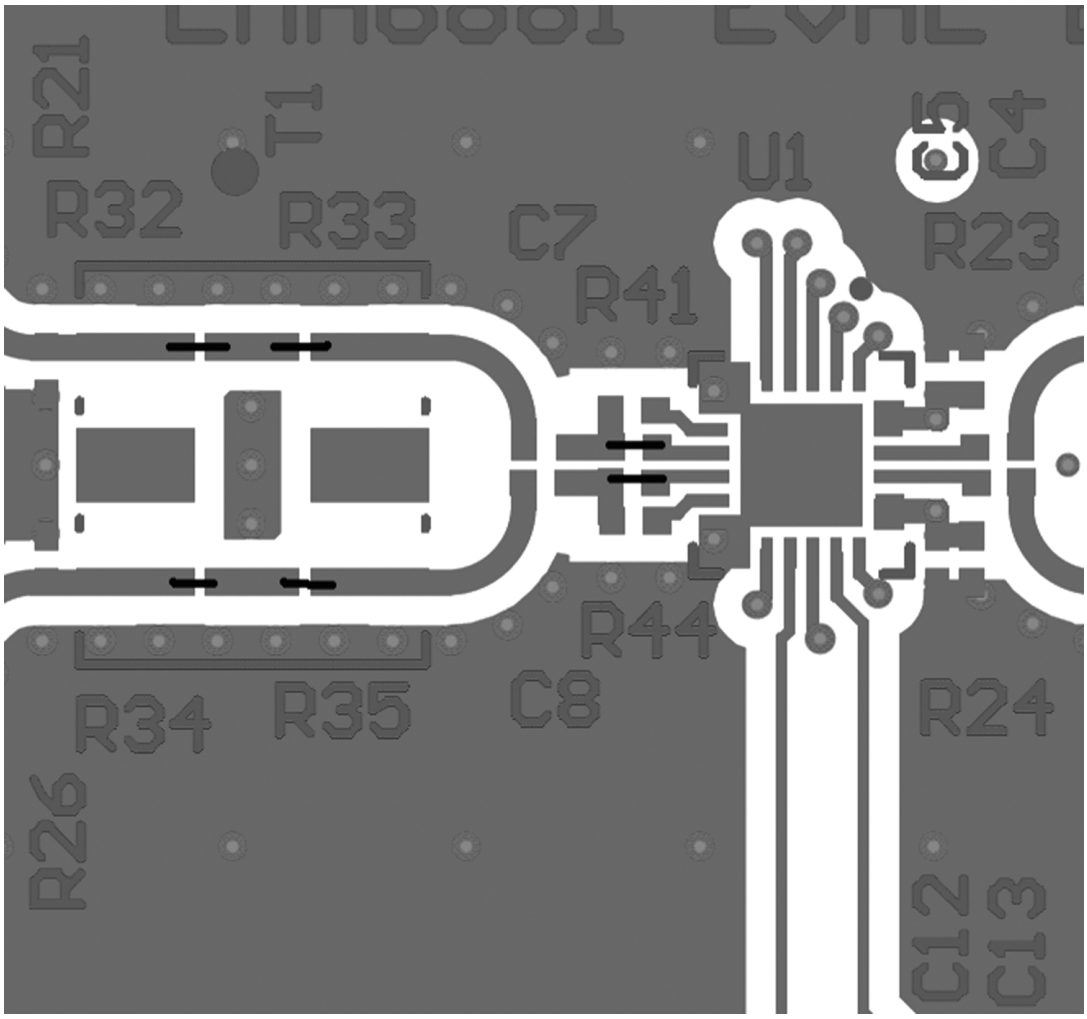

Figure 3. Input Configuration for Differential Signals. Black lines indicate shorts or 0Ω resistors.

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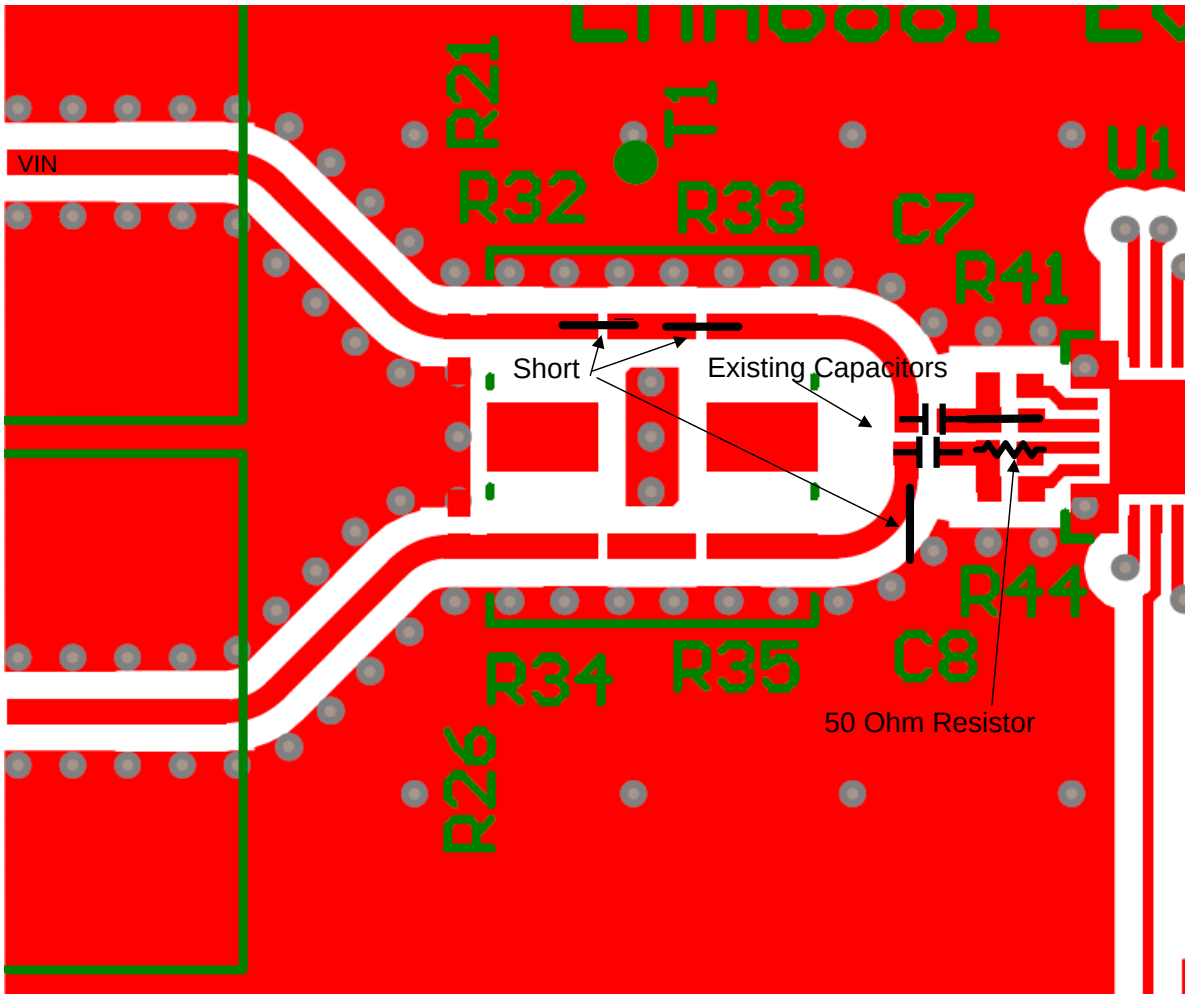

Figure 4. Input Configuration for Single Ended Signal. R44 should be 50Ω to ground. R32, 33 are 0Ω shorts. R34 and R35 are not needed.

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3 Board Setup

The LMH6881EVAL board is shipped with transformers installed so that the input and output of the evaluation board are 50Ω single ended ports. The transformers convert the signal to balanced, differential signals at the amplifier pins.

For parallel control only the evaluation board is required, for serial control the evaluation board must be connected to the USB2ANY USB to SPI controller. In addition there is an included adapter board that converts the USB2ANY pinout to match the board SPI connector. See Figure 5 for a photograph of the assembled board.

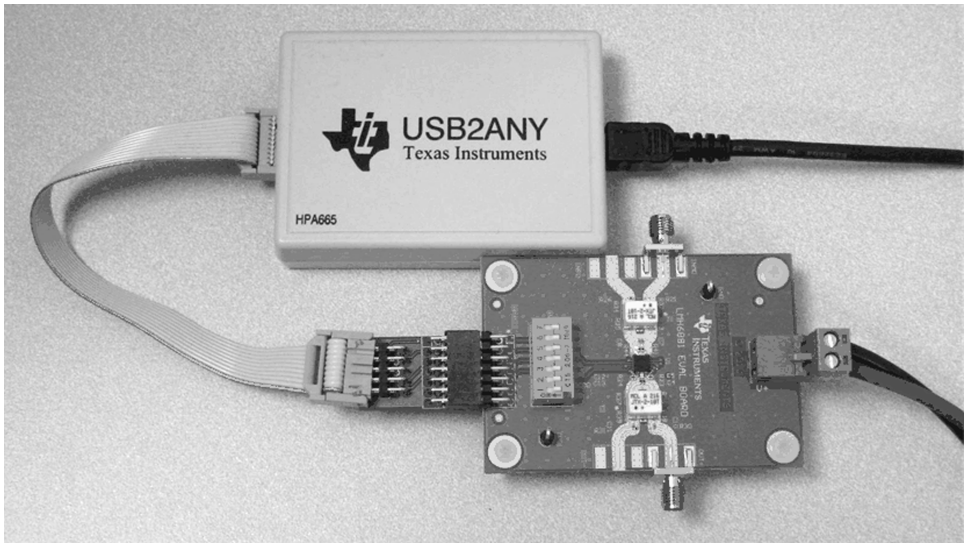

Figure 5. Evaluation Board

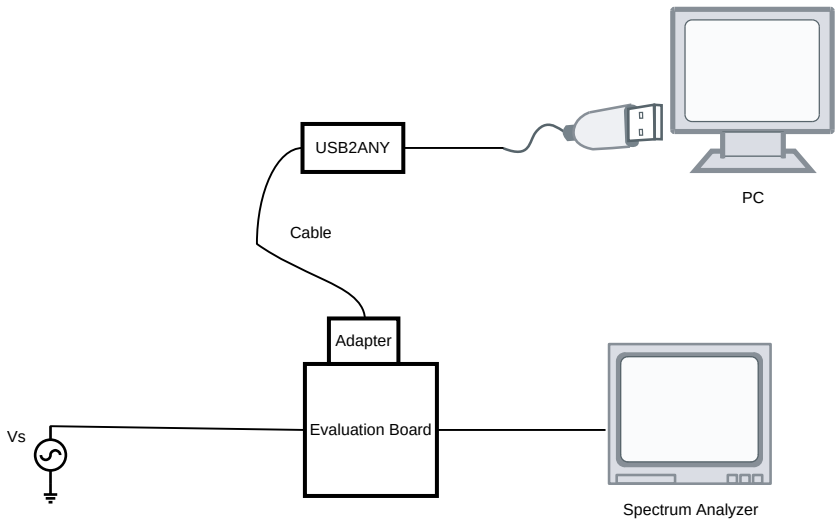

Figure 6. Typical Bench Setup

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The LMH6881EVAL has provisions for differential and singled ended input signals. The LMH6881EVAL board can be hand modified to support several test configurations.

To use the evaluation board with external differential signal sources or external differential measuring equipment make the following changes: The transformers T1 and T2 need to be removed and zeroΩ resistors can be soldered instead as shown in Figure 3. For DC-coupled operation capacitors C7 and C8 can be replaced by 0Ω resistors, otherwise these capacitors should be left intact. If DC coupled operation is desired it is important to provide for proper bias voltages on the input and output pins (see the LMH6881 datasheet for more details)

To use the LMH6881 PDA as a single ended to differential amplifier also requires manual changes to the evaluation board. The input transformer needs to be removed as well as R42 and R43. As shown in Figure 4, the zero ohm resistor from R42 should be moved to the R41 position. The resistor from position R43 can be used as a short between the unused input trace and ground. A 49.9Ω resistor should be placed in the R44 position. The input of the LMH6881 is symmetrical, so either single ended input can be used. If DC coupled operation is required C7 can be replaced with a 0Ω resistor. The capacitor at C8 should be left in place and a 2.5V DC source should be connected between C8 and R44.

4 Gain Control Parallel Mode

To set the LMH6881EVAL board in parallel mode, set switch position number 3 to the On (closed) position.

For ease of use, a bank of DIP switches is installed on the board to control gain settings in parallel mode. The DIP switches short the corresponding pins to ground. For example, to use the LMH6881 in parallel mode the SPI switch must be in the ON position which shorts the SPI pin to a logic low state. Table 1 lists the different switch positions and their functions. The Parallel functions are listed first when the pins have dual function. The DCOC and Shutdown pins have no effect in serial mode.

Table 1. Switch Functions

Switch	Function
1	Shutdown (Active ON). Only active in Parallel Mode.
2	Not used
3	SPI/Parallel (Parallel when ON)
4	D0*/ SDO
5	D1/ SDI
6	D2/ CLK
7	D3/ CS
Due to pull down resistor D0 does not function in parallel mode.	

Table 2. Setting Gain with DIP Switches

D3	D2	D1	D0	Gain
On	On	On	NA	26dB
Off	On	On	NA	10
On	Off	On	NA	18
On	On	Off	NA	22
Off	Off	Off	NA	8dB
Due to pull down resistor D0 does not function in parallel mode. Due to board losses measured gain will be 9dB lower				

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Due to component losses on the evaluation board the measured gain of the board will not be the same as the gain settings indicated in the table above. The input and output baluns each have 1.5dB of loss and the series termination resistors have 6dB of loss, for a total of 9dB of loss. When the gain of the amplifier is set to 26dB the evaluation board will measure approximately 17dB.

The D1, D2 and D3 pins are internally pulled to logic high (2.5V). The DIP switch connects them to a 50Ω resistor to ground to change the gain in parallel mode.

The D0 pin requires a 300Ω resistor to ground in SPI mode in order to enable the LMH6881 to be able to write data out of the registers. For this reason the D0 pin does not toggle in parallel mode by using the DIP switch. If SPI mode is not desired , resistor R15 can be removed, and a 1.5kΩ resistor can be placed in the resistor R14 position. This will restore operation of the D0 pin in parallel mode, but no data will clock out of the LMH6881 PDA during SPI mode.

The SD and SPI pins are internally biased to the logic low state. Specifically, the SD pin is biased to the device enabled state and the SPI pin is biased to the parallel mode state.

5 SPI™ Compatible Gain Control using the USB2ANY Card and LabView Control Software.

To set the LMH6881EVAL to serial mode set switch number 3 to the OFF position. A quick test to verify serial mode is to set switch number 1 to the ON position. If the amplifier supply current drops then the amplifier is not in serial mode. The shutdown pin is only active in parallel mode. In serial mode the amplifier is enabled or disabled through the SPI control bus. Refer to Figure 5 for SPI and power connections.

The LMH6881EVAL board can easily be controlled in the serial mode using Texas Instrument's USB2ANY USB-to-SPI controller card. This card and the required software are provided with the LMH6881EVAL board.

When using the LMH6881EVAL board in serial mode the SW1 DIP switches should all be in the OFF position (move slider towards center of board). This will ensure that the serial control signals are not grounded.

The LMH688x GUI software was written using LabVIEW 2011. In order to run the executable file the National Instruments LabVIEW Run-Time Engine 2011 needs to be downloaded and installed. It can be found at the NI website or at the link below. http://joule.ni.com/nidu/cds/view/p/id/2534/lang/en

To use the LMH688x GUI software, extract the files from the ZIP file into a directory. Double click the exe file and the GUI will launch as shown in. The Product ID should indicate 32 for the LMH6881. If there is an LMH6882 evaluation board connected it will show a Product ID of 33. If it does not show any ID there is a problem with the controller board or the evaluation board, recheck all connections and start the exe file again. To use the LMH6881 board click on the LMH6881 tab as shown in Figure 7. The disable switch turns the amplifier on and off. The Attenuation windows set the attenuation in 1/4 dB steps. The Maximum attenuation is 80 steps or 20dB. Zero attenuation is equal to 26dB of gain and 80dB attenuation is equal to 6dB of gain. The attenuation selected will not become effective if the Load A or Load B switch is in the OFF position. The screen shot shows the switches in the ON position, so the attenuation settings will be effective immediately. The CHA/B synchronous switch will force channel A and channel B to have the same value of attenuation if set to the ON position, it is shown in the OFF position in the screen shot so that both channels can have separate gains. The SPI Read Back window shows the contents of registers 2,3,4,5. Register 2 is the control register. Register 3 and 4 are the A and B attenuation registers. Register 5 is the gain set control register.

The default SPI settings for the LMH688x control software are shown in Figure 8. These settings should be left unchanged. If there is a problem with the SPI connection the first thing to check is the position of the DIP switches. The switch settings should be all in the OFF position (switch sliders moved towards the DUT side of the board) this is the most common problem when communicating with the evaluation board. If the switches are correct and there is power to the evaluation board it may be useful to try setting the “Divider Low” box to 8 or higher. This will slow the SPI clock speed. Sometimes merely selecting the SPI cluster tab will be sufficient to restore communication with the evaluation board. If board communication is successful the board “Product ID” field will show the proper device ID (32 for LMH6881).

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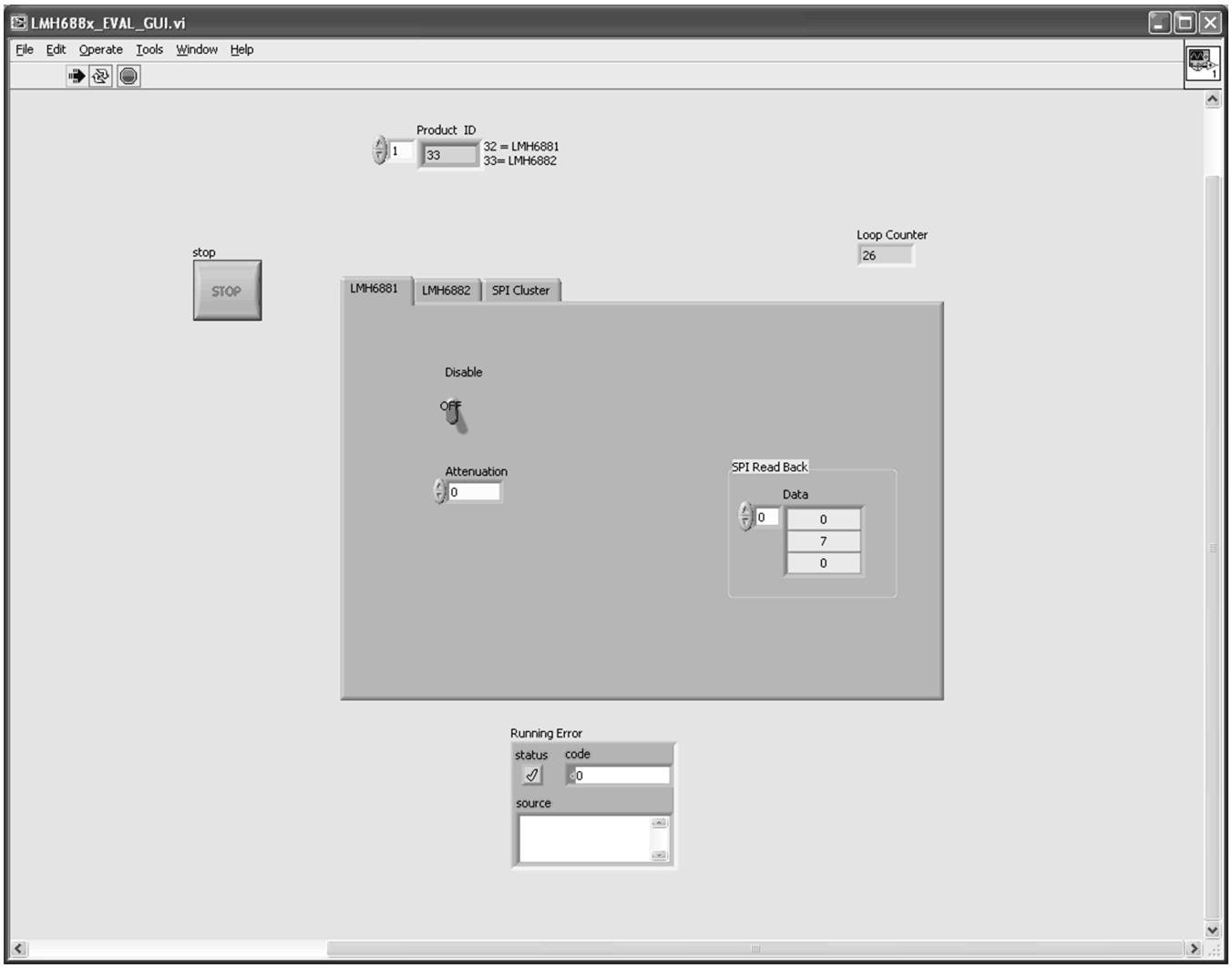

Figure 7. LabView Control Software Screen Shot

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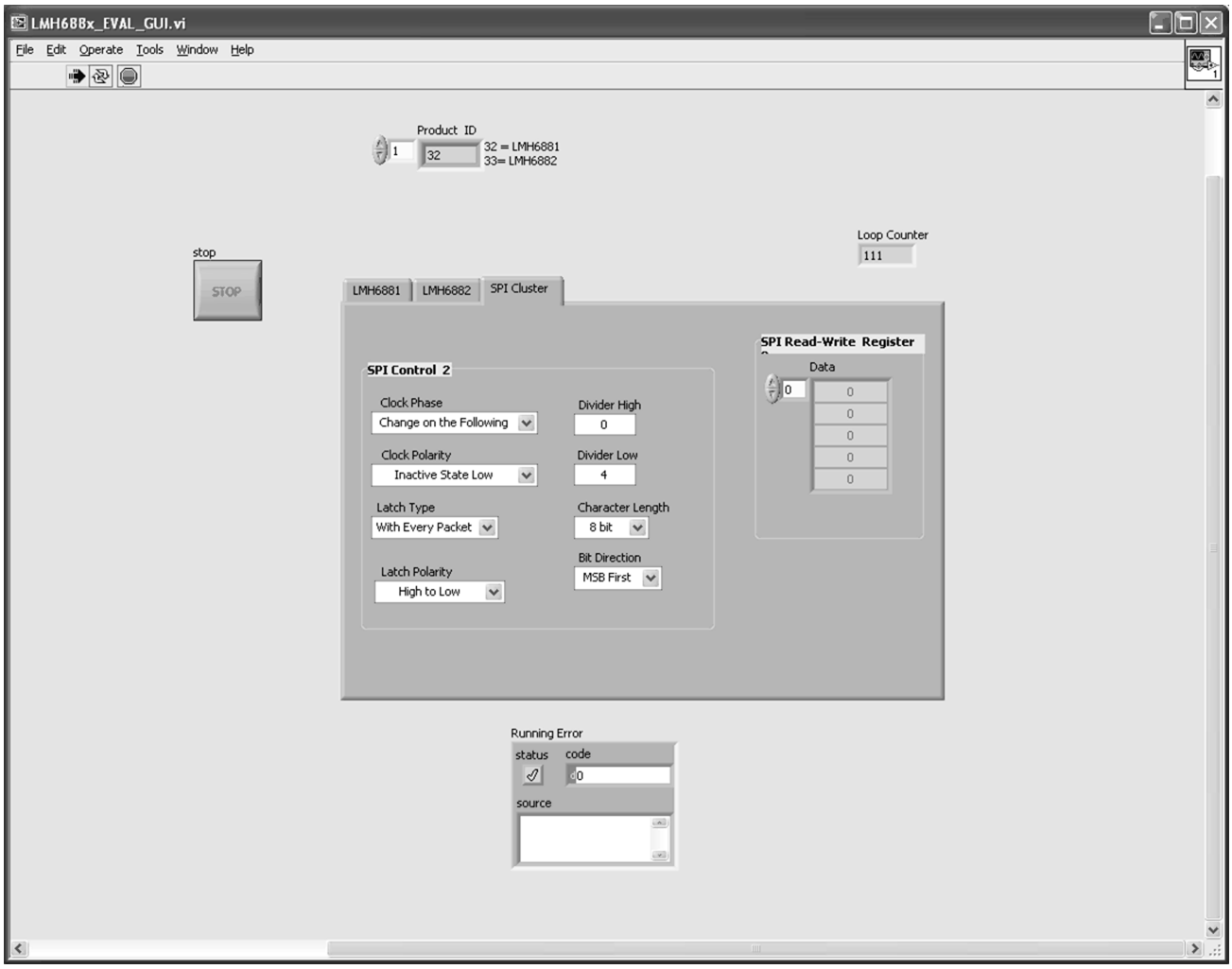

Figure 8. Default SPI Settings

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6 Functional Description

The LMH6881 evaluation board is an 8 layer board composed of FR4 for the bulk of the board and Rogers dielectric for the signal paths. The Rogers dielectric provides signal integrity and low loss for the full small signal bandwidth of the LMH6881 PDA. The evaluation board is comprised of 5 ground layers, one power layer in addition to the top layer (signal) and bottom layer (ground and power supply decoupling capacitors)

The LMH6881EVAL has all the traces and pad locations required for fully differential, fully differential with transformer and single ended input configurations.

The header on the LMH6881 supports SPI interface signals as shown in Table 3.

Table 3. Header Pins Serial Function

Pin	Function
1	Chip Select
2	Ground
3	Clock
4	N/A
5	Serial Data Out (MISO)
6	N/A
7	Serial Data IN (MOSI)
8–14	N/A

7 Troubleshooting

To resolve common problems see Table 4.

Table 4. Troubleshooting

Symptoms	Possible Problem	Solution
Low Supply Current	Device disabled.	Check Switch #1.
No Supply Current	Power not connected.	Check power supply cable connections.
Supply Current too high.	Reverse supply protection diode is conducting.	Make sure positive supply is connected to proper pin.
Disable switch does not work.	Device in SPI mode.	Check Switch #3. Should be ON for Parallel mode.
Gain does not change.	Device in SPI mode.	Check Switch #3. Should be ON for Parallel mode.
Serial control does not work.	Dip switches grounding SPI signals.	Set switches to OFF position.
Serial control does not work	SPI settings changed	See Figure 8 for correct SPI settings.

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8 Layout

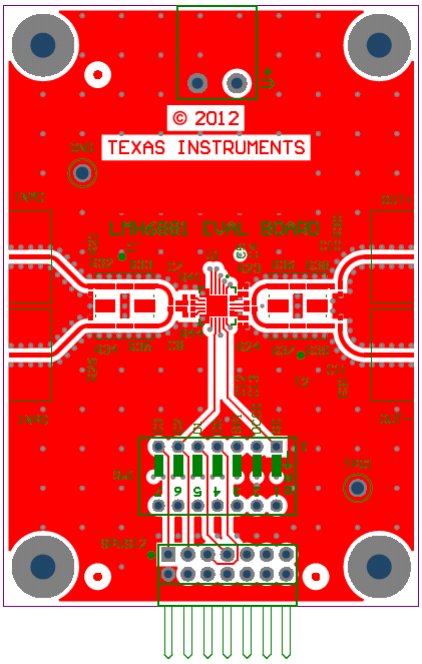

Figure 9. Top Layer

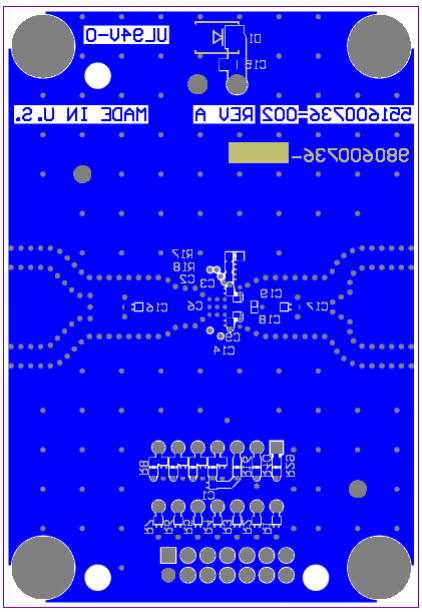

Figure 10. Bottom Layer

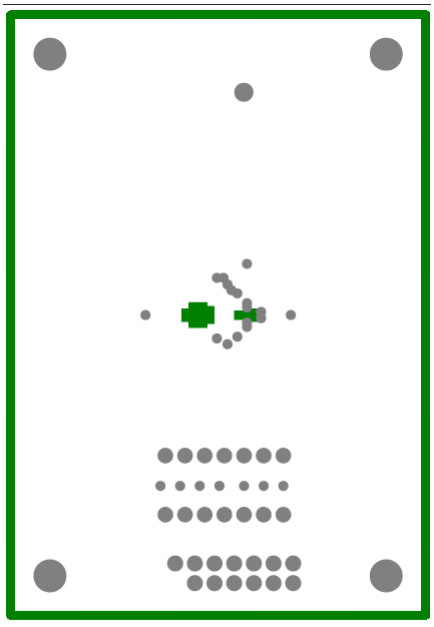

Figure 11. Layer 2, Ground

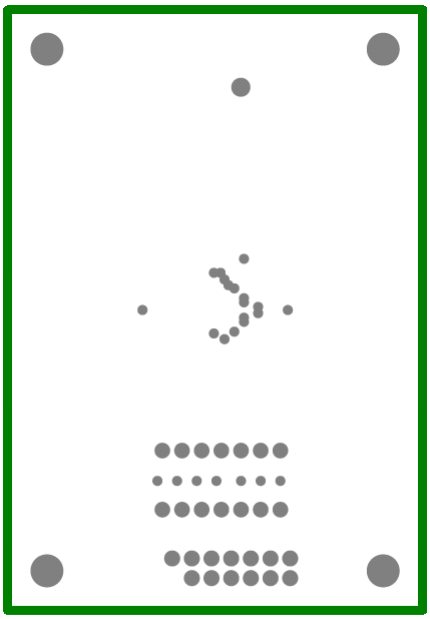

Figure 12. Layer 7, Ground

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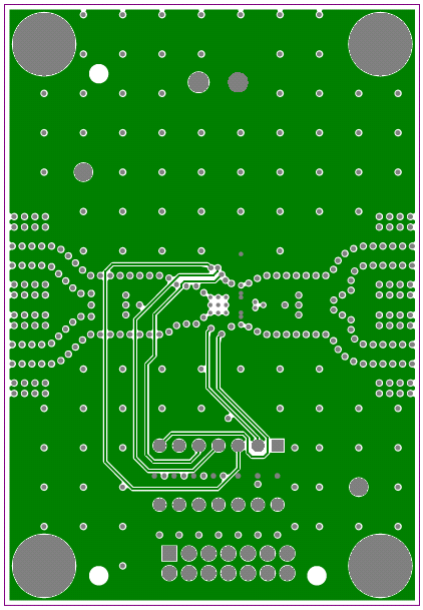

Figure 13. Layer 6, 5V Power

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9 Schematic

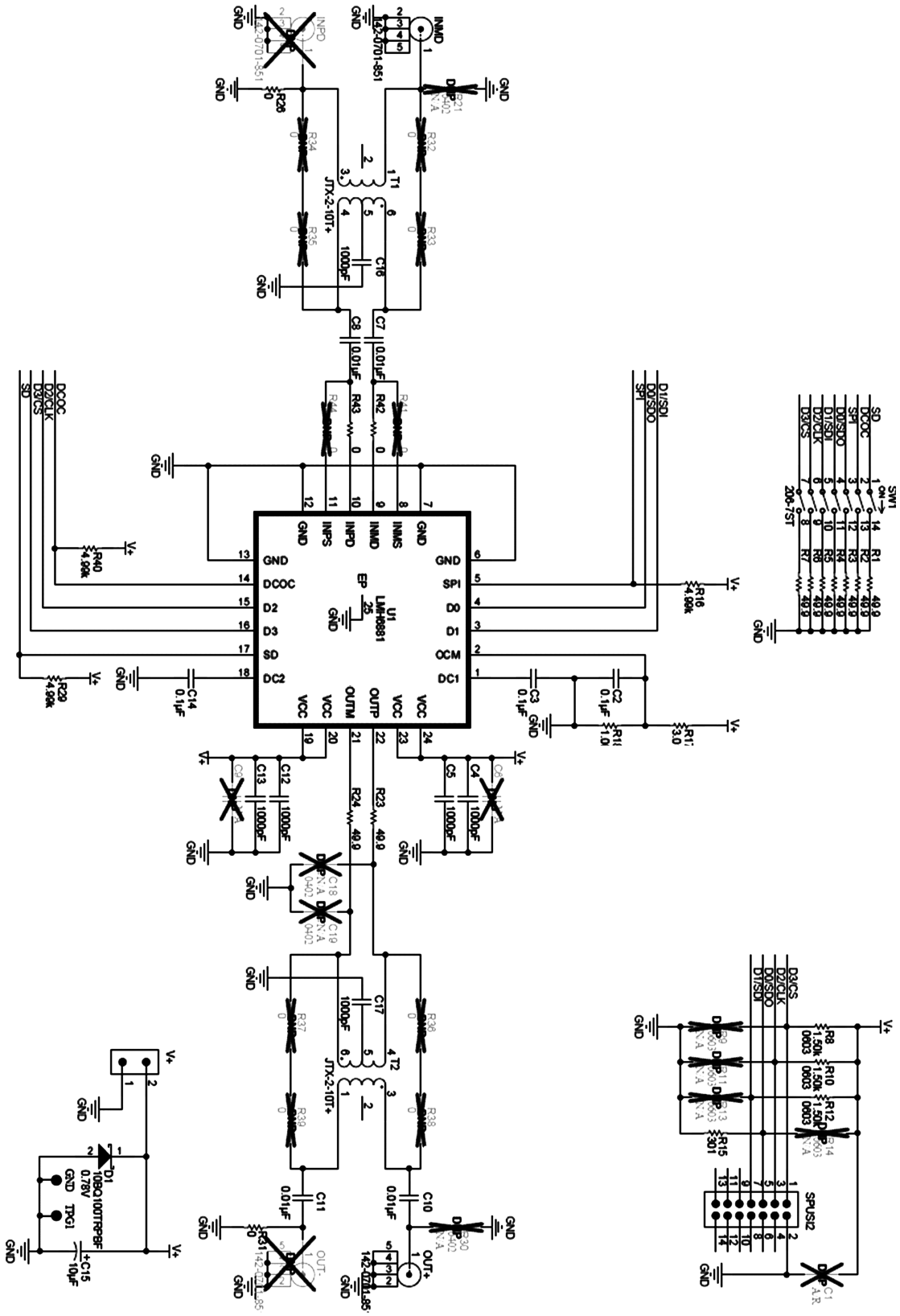

Figure 14. Schematic

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10 Bill of Materials

Designator	Description	Manufacturer	Part Number
AA1	Printed Circuit Board	TBD	Used in BOM Report
C2, C3, C14	CAP, CERM, 0.1 µF, 25V, ±10%, X7R, 0603	AVX	06033C104KAT2A
C4, C5, C12, C13	CAP, CERM, 1000 pF, 25V, ±5%, C0G/NP0, 0402	TDK	C1005C0G1E102J
C7, C8, C10, C11	CAP, CERM, 0.01 µF, 25V, ±10%, X7R, 0402	TDK	C1005X7R1E103K
C15	CAP, TANT, 10 µF, 10V, ±10%, 0.9Ω, 3216-18 SMD	AVX	TPSA106K010R0900
C16, C17	CAP, CERM, 1000 pF, 50V, ±10%, X7R, 0603	Kemet	C0603C102K5RACTU
D1	Diode, Schottky, 100V, 1A, SMB	International Rectifier	10BQ100TRPBF
FID1, FID2, FID3	Fiducial mark. There is nothing to buy or mount.	N/A	N/A
GND, TPG1	Test Point, TH, Multipurpose, Black	Keystone Electronics	5011
H1, H2, H3, H4	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	B&F Fastener Supply	NY PMS 440 0025 PH
H5, H6, H7, H8	Standoff, Hex, 0.5"L #4-40 Nylon	Keystone	1902C
INMD, OUT+	Connector, SMT, End launch SMA 50Ω	Emerson Network Power	142-0701-851
R1, R2, R3, R4, R5, R6, R7	RES, 49.9Ω, 1%, 0.1W, 0603	Vishay-Dale	CRCW060349R9FKEA
R8, R10, R12	RES, 1.50kΩ, 1%, 0.1W, 0603	Vishay-Dale	CRCW06031K50FKEA
R15	RES, 301Ω, 1%, 0.1W, 0603	Vishay-Dale	CRCW0603301RFKEA
R16, R29, R40	RES, 4.99kΩ, 1%, 0.1W, 0603	Vishay-Dale	CRCW06034K99FKEA
R17	RES, 3.01kΩ, 1%, 0.1W, 0603	Vishay-Dale	CRCW06033K01FKEA
R18	RES, 1.00kΩ, 1%, 0.1W, 0603	Vishay-Dale	CRCW06031K00FKEA
R23, R24	RES, 49.9Ω, 1%, 0.063W, 0402	Vishay-Dale	CRCW040249R9FKED
R26, R31, R42, R43	RES, 0Ω, 5%, 0.063W, 0402	Vishay-Dale	CRCW04020000Z0ED
SPUSI2	SPUSI2 MALE CONN 2x7 RT ANG HEADER 100 mil pitch	Molex	90122-0140
SW1	SWITCH GOLD SEALED 7 SEC	CTS Electrocomponents	206-7ST
T1, T2	Mini-Circuits Surface Mount RF Transfromer 75Ω 50 to 1000 MHz	Mini-Circuits	JTX-2-10T+
U1	LMH6881	TI	LMH6881
V+	CONN HEADER RT ANG 2POS 5.08 MM	Phoenix Contact	1759017
V+ PLUG	CONN TERM BLOCK PLUG 2POS 5.08 MM, MATING PLUG FOR V+	Phoenix Contact	1757019
C1, C6, C9, C18, C19, R9, R11, R13, R14, R21, R30	generic symbol for 0402 cap placeholder, Generic symbol for 0402 Res placeholder, generic symbol for 0603 cap placeholder, Generic symbol for 0603 Res placeholder		
INPD, OUT-	Connector, SMT, End launch SMA 50Ω	Emerson Network Power	142-0701-851
R32, R33, R34, R35, R36, R37, R38, R39, R41, R44	RES, 0Ω, 5%, 0.063W, 0402	Vishay-Dale	CRCW04020000Z0ED

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