TI Designs: TIDA-00659 Reference Guide
Two Stage, Cascaded LMH5401 Reference Design Board

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LMH3401	Product Folder
TIDA-00522	Tools Folder
LMH5401 TINA-TI Reference Design	Tools Folder

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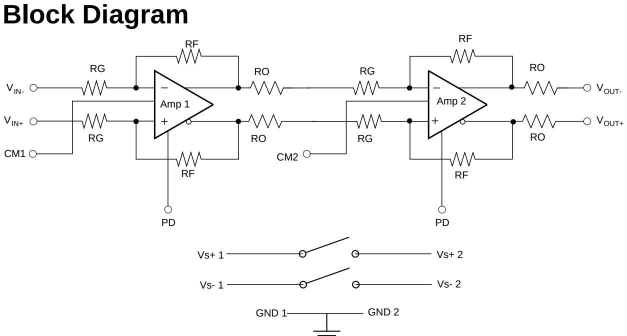
Block Diagram



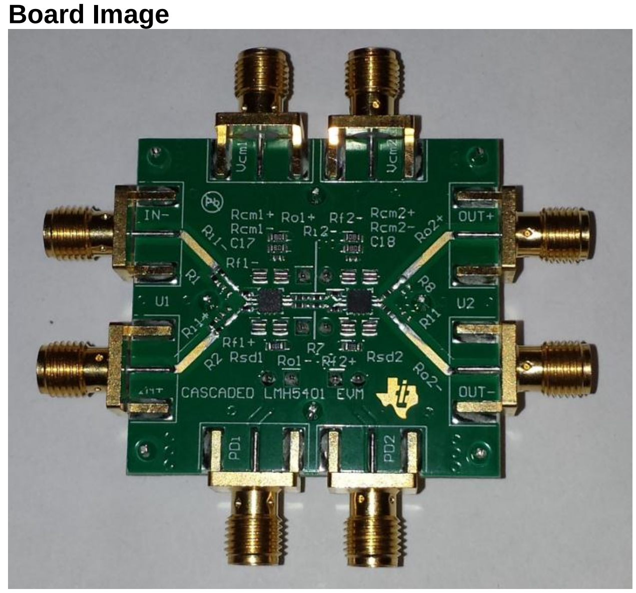
Design Features

- Two LMH5401 Amplifiers
- Compatible with LMH3401
- Separate Power Supplies for each Amp
- Power Supplies can be combined
- Compatible with single or split supplies
- Signal gains up to 20dB

Featured Applications

- Cascaded Gain
- Cascaded Common mode shift
- Radar

Board Image



1 Key System Specifications

Table 1 Key System Specifications

Parameter	Specification
Supply Voltage	4.5V to 5.25V single or split
Supply Voltage	Separate for each amp, can be combined
System Gain	Configurable with external resistors
Common Mode	(Vcc/2) +- 2V

2 System Description

The LMH5401 as implemented on the standard EVM is used as a single stage amplifier. This reference design has a dual amplifier configuration with the ability to use separate gain settings as well as separate power supplies for each stage. With feedback amplifiers both signal bandwidth and distortion performance present limits to the maximum gain that is practical to implement in a single stage. When higher gains are desired using cascaded stages is an option to preserve performance.

2.1 Differential Systems

The TIDA-00659 reference design is capable of providing a fully differential, dual stage gain path. With external resistors the gain of each stage can be set separately. In addition, the impedance of the first stage can be configured to match the signal source.

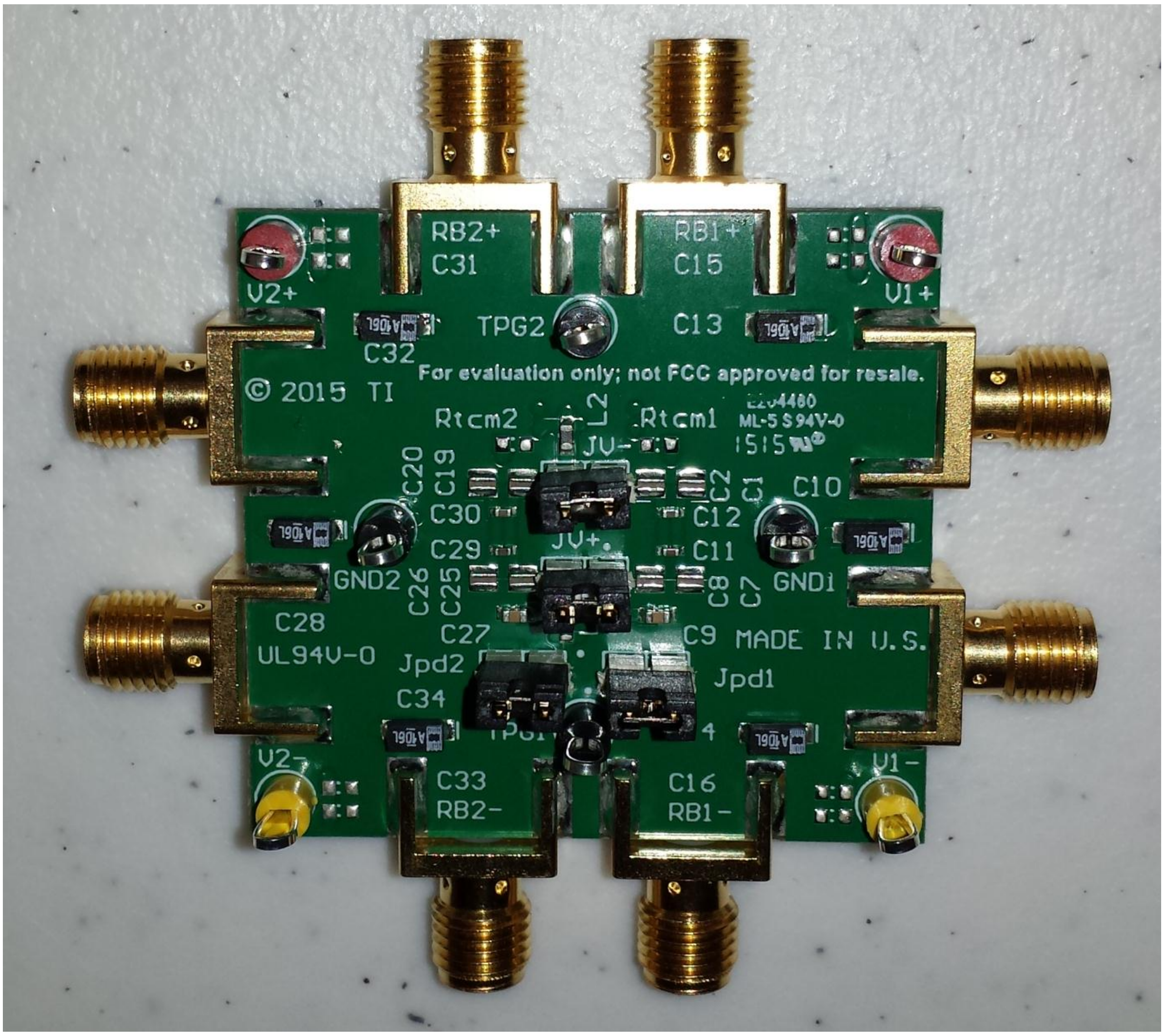


Figure 1: Rear of Board showing power connectors and jumpers

2.2 Single Ended to Differential Systems

The TIDA-00659 reference design is capable of providing a fully differential signal output, when driven from a single ended signal source. With external resistors the gain of each stage can be set separately. In addition, the impedance of the first stage can be configured to match the signal source.

When using the LMH3401 as the first stage in a single ended to differential system the need for external feedback and gain set resistors is eliminated provided the source impedance is 50 Ohms.

3 Block Diagram

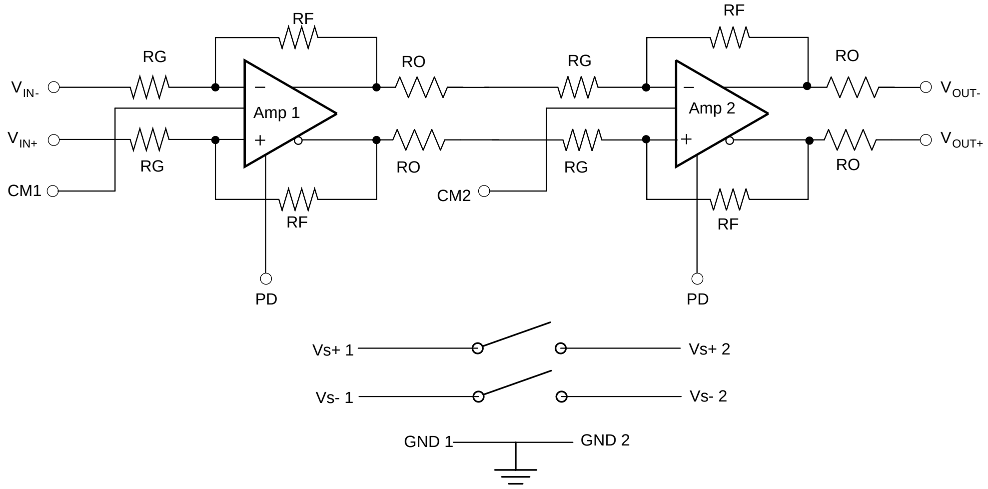


Figure 2: Block Diagram

3.1 Highlighted Products

The LMH5401 and LMH3401 are very high-performance, differential amplifiers optimized for radio frequency (RF), intermediate frequency (IF), or high-speed, time-domain applications. These devices are ideal for dc- or ac-coupled applications that require a single-ended to differential conversion when driving an analog-to-digital converter (ADC). They generate very low levels of second-order and third-order distortion when operating in single-ended-input to differential-output or differential-input to differential-output mode.

3.1.1 LMH5401

The LMH5401 features flexible design due to the use of off chip gain set and feedback resistors. This performance makes the LMH5401 ideal for applications such as test and measurement, broadband communications, and high-speed data acquisition. A common-mode reference input pin is provided to align the amplifier output common-mode with the ADC input requirements. Use this device with power supplies between 3.3 V and 5.0 V; dual-supply operation is supported when required by the application.

3.1.2 LMH3401

The on-chip resistors simplify printed circuit board (PCB) implementation and provide the highest performance over the usable bandwidth of 2 GHz. This performance makes the LMH3401 ideal for applications such as test and measurement, broadband communications, and high-speed data acquisition. A common-mode reference input pin is provided to align the amplifier output common-mode with the ADC input requirements. Use this device with power supplies between 3.3 V and 5.0 V; dual-supply operation is supported when required by the application.

3.1.3 TI Device 3

4 System Design Theory

Historically high gain systems use cascaded amplifiers to achieve the desired overall gain and performance. This reference design board shows a two stage configuration using combinations of the LMH5401 and LMH3401 differential amplifiers.

4.1 Equations

Fully differential amplifiers have a signal gain that is equal to $(\frac{RF}{RG})$. Where RF is the feedback resistance, RG is the gain set resistance. This reference design is intended for 50 Ohm single ended input or 100 Ohm differential input test equipment. Because the amplifiers are located in very close proximity terminated transmission line is not required between the two stages, so the Rg of the second stage can be combined with the output matching resistance of the first stage. For maximum flexibility the TIDA-00659 board has resistor positions for both the first stage output resistor and the second stage gain set resistor. The default configuration has one set of resistors loaded with zero Ohm shorting components. Substituting the shorting components with 0.01uF capacitors will not change the gain of the board, but will AC couple the two stages.

For the differential configuration where the source resistance is 100 Ohms the board gain is equal to $\frac{45.2}{145.2} * \frac{152}{22.6} * \frac{152}{50.2} * \frac{100}{200}$. The last term in the gain equation is the voltage divider caused by the 50 Ohm matching resistors (a portion of the matching resistance is on chip). As shipped the reference design will have a gain of 10.2 or approximately 20dB.

In the single ended input configuration the gain equation is more complex. The first stage shown in Figure 2 was designed for gain of 4. The input was designed to present a load of 50 Ohms when the other input is also terminated in 50 Ohms. The overall gain is equal to $4 * \frac{152}{50.2} * \frac{100}{200}$ = 6V/V or 15.6dB. Input termination loss would decrease this gain by ½ or 6dB for a net gain of 9.6 dB.

A table for common gain configurations is shown below. This table is for systems with a 50 Ohm Single Ended

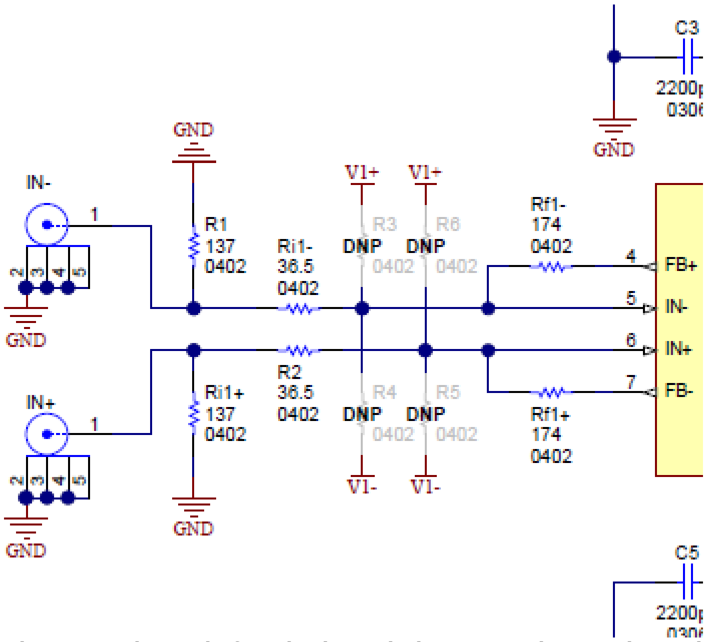


Figure 3 Schematic for Single Ended Input Resistor Value Table

Table 2 Single Ended Input Resistor Values

Gain	RF	Ri1-	R1	R2	Ri1+
4	200	36.5	137	73.2	0
5	200	24.3	226	64.9	0
6	200	15.4	698	61.9	0
8	250	12.1	N/A	60.4	0
10	300	9.76	N/A	57.6	0

4.2 Common Mode

For any differential signal there is a voltage that defines the center or operating point of the signal. This is called the common mode voltage. Many times the common mode voltage is fixed. The common mode voltage is calculated by the following equation: $Vcm = \frac{(Va+ + Va-)}{2}$. In general the input of the amplifier and the output of the amplifier can have different common mode voltages. With the TIDA-00659 there are four possible common mode voltages, one for each amplifier input and one for each amplifier output. One benefit of a cascaded amplifier configuration is that each amplifier can be configured with a separate common mode operating point. This can help when a common mode shift is required, specifically, when the input signal and the output signal have differing common mode voltages.

4.3 Subsection

5 Getting Started Hardware

To use the Cascade Amplifier reference design board you will require the following hardware:

1. TIDA-00659 Reference Design Board
2. Dual voltage bench power supply 0v to 5V; 500mA

3. (optional) Dual voltage bench power supply 0V to 5V 500mA (for second supply voltage)
4. (optional) 2, single voltage bench supply 0V to 5V 100mA (for common mode)
5. Mini grabber test leads (3 to 5 each)
6. SMA cables (2 minimum, 4 maximum)
7. Signal generator
8. Oscilloscope
9. (optional) network analyzer
10. SMA, 50 Ohm termination

The TIDA-00659 reference design board comes configured for a single power supply and there are resistors installed that set the common mode voltage to ½ of the applied supply voltage. For example, for a single 5V supply the common mode will be set to 2.5V. See section 5.3 below for common mode settings.

5.1 Power Supplies

The reference design board is shipped with jumpers installed. There are four jumpers total. Two of the jumpers are used to connect or disconnect the amplifier power supplies. (The other two jumpers are for power down, see section 5.2 for details.) Jumper JV+ connects stage one V+ to stage two V+. The Jumper JV- connects stage one V- to stage two V-. When using one power supply for both amplifiers these jumpers are left in place and either set of power connectors can be used to supply power to the entire board. For example, a split supply configuration would be to connect V1+ to +2.5V and V1- to -2.5V. This is only one example; Either of the two V+ connectors can be connected to +2.5V and either of the two V- connectors can be connected to -2.5V.

If the JV+ and JV- shorting blocks are removed then each amplifier needs to have a power supply connected to the appropriate connectors. For example: Connect +5V to V1+ and 0V to V1- additionally, connect +2.5V to V2+ and connect -2.5V to V2-. The supply voltages of the two amplifiers can be set independently, however, the voltage difference between V1+ and V2+ should not exceed 3V and the difference between V1- and V2- should not exceed 3V, **NOTE: be careful to not exceed 5.25V supply voltage for each stage. This is especially important when adjusting power supply voltages. It is best to disconnect the board from the power supplies until they are set to the desired voltage.**

Table 3 Suggested Configurations (Row 1 is default)

JV+	JV-	V1+	V1-	V2+	V2-	Application
Short	Short	+2.5V	-2.5V	N/A	N/A	Data Acquisition
Short	Short	+5V	0V	N/A	N/A	AC coupled
Open	Open	+5V	0V	+3.3V	-1.7V	ADC Driver
Open	Open	+2.5V	-2.5V	+3.3V	-1.7V	ADC Driver

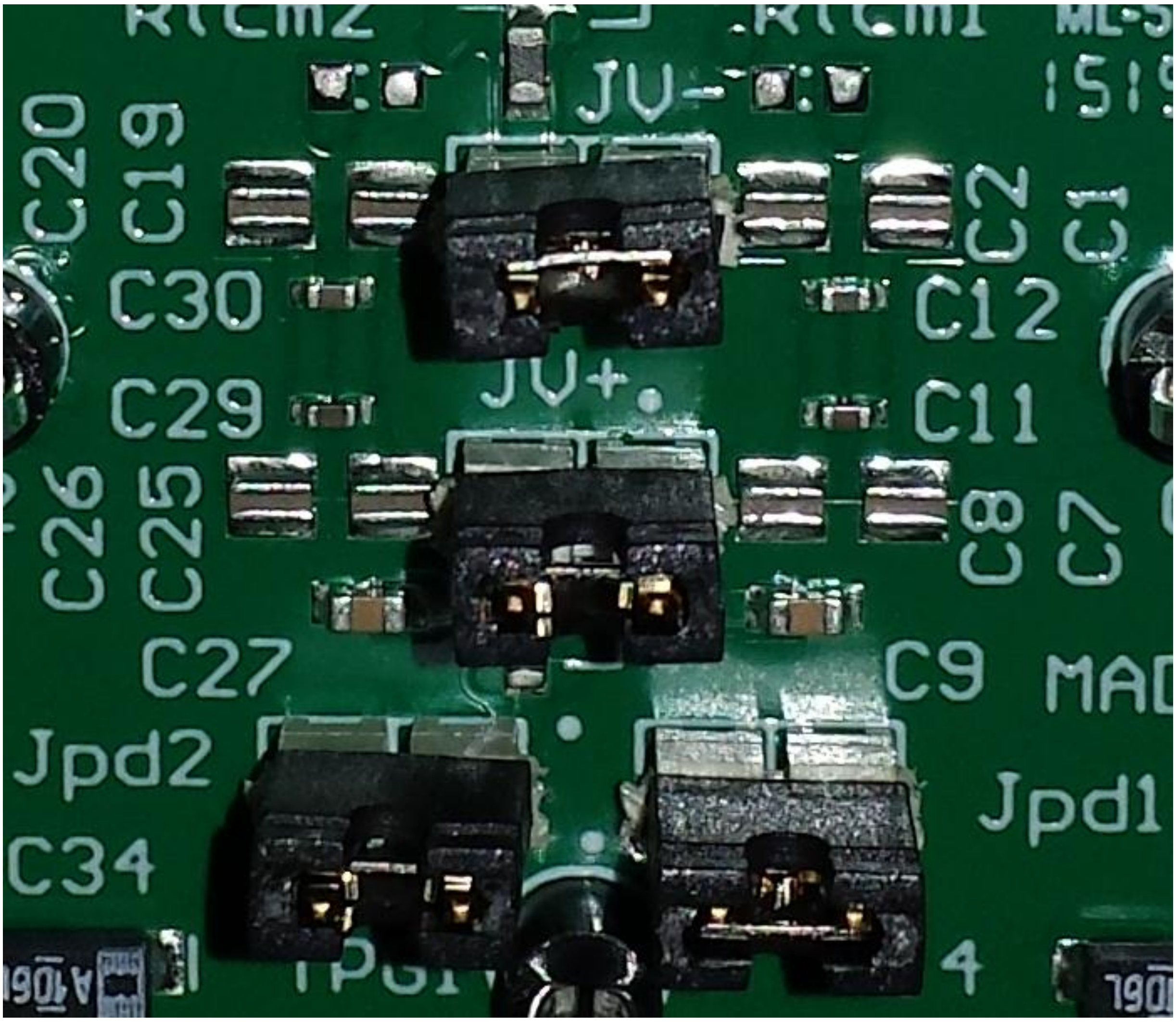


Figure 4 Jumpers

5.2 Power Down Pins

Both the LMH3401 and LMH5401 have power down pins. The TIDA-006659 has two jumpers, one for each amplifier power down pin. The board is shipped with these jumpers installed as shown in Figure 4 above. These should be either removed and set aside or removed and replaced as shown below. The Power Down pins are referenced to the board ground with a threshold of 1V.

In addition to the on board jumpers the Power Down pins are routed to SMA connectors labeled PD1 and PD2. With these connectors high speed pulse signals can be used to enable and disable the amplifiers. These signals should be referenced to the board ground and should not exceed the positive supply or negative supply voltage.

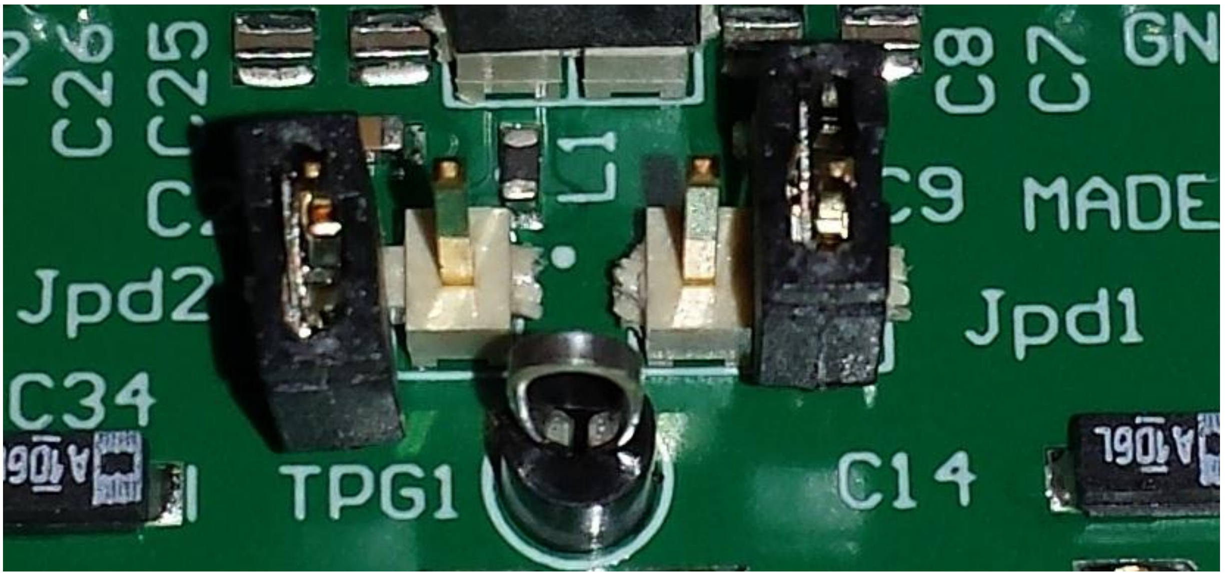


Figure 5 PD Jumpers, Device enabled

5.3 Common Mode

LMH5401 is a high speed amplifier with common mode control. For ease of use the TIDA-00659 reference design board has resistors installed which set the amplifier common mode voltages to the optimum voltage. This voltage is calculated as $Vcm = \frac{(V+ - V-)}{2}$. For example, when using a +5V and 0V single supply the common mode voltage is automatically set to 2.5V. Another example would be a +3.3V and – 1.7V split supply configuration. In this case the common mode would be 0.8V. There is an SMA connector for each amplifier such that the common mode for that amplifier can be driven by an external supply to any desired voltage. Note that for best performance the common mode voltage should not be driven more than 0.5V from its default value. Refer to the product datasheet for more details on performance with respect to output common mode voltage.

For small values of DC level shifting a single amplifier will suffice. When the common mode shift is more than 1 V, however, it is best to use multiple stages to reduce the amount of voltage drop across any given stage. Figure 5 below shows an example where an input common mode of 2.5V is shifted down to a common mode of 0V. Figure 6 shows the expected waveforms of the circuit in Figure 5. The circuit in Figure 5 has the Vocm pins set to the optimal voltage of ½ of the total supply voltage. This is done to provide the best possible linearity and output voltage swing. If even more common mode range is required each output can be shifted by up to 0.5V from the mid-scale voltage. Referring to the LMH5401 datasheet, the optimal range for the Vocm pin is only +- 0.5V from this mid supply voltage. The input range is much larger at +- 1V, so we make use of this and put the largest common mode voltage offsets at the amplifier input pins. Also of note is the fact that there is a significant Vocm shift across the gain set resistors. This shift is essentially “free” in that it does not impact amplifier performance. There is some penalty in power consumption, however as the extra current places additional demands on the power supply circuit and, possibly, the input signal generator. If the signal generator cannot tolerate any DC current there are places on the PC board for bias resistors. Bias resistors may be used to reduce or eliminate the necessary DC current for the voltage shift by using the power supplies instead of the signal source. The drawback to using bias resistors is that they increase system noise and if not carefully implemented could pull the amplifier input pin voltages outside the valid operating voltage range. The bias resistors in Figure 8 (R3, R4, R5, R6) are shown greyed out with a DNP symbol. This indicates that they are not initially populated on the reference design board. If desired they can be added by hand.

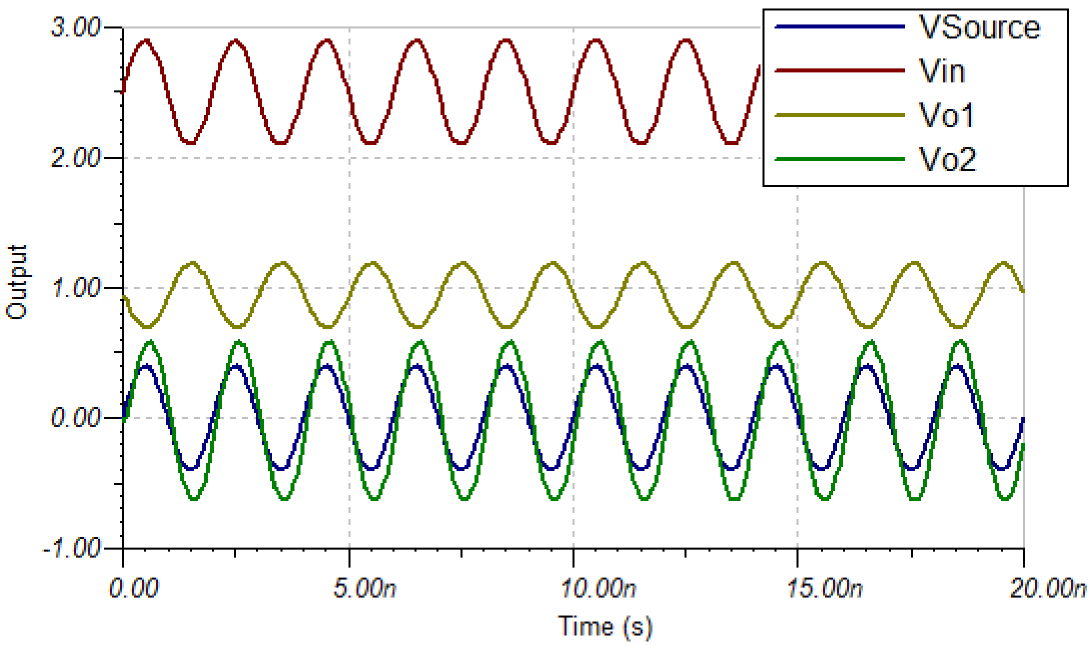


Figure 6 Transient Response Vicm1 = 2.5V, Vocm2 = 0V

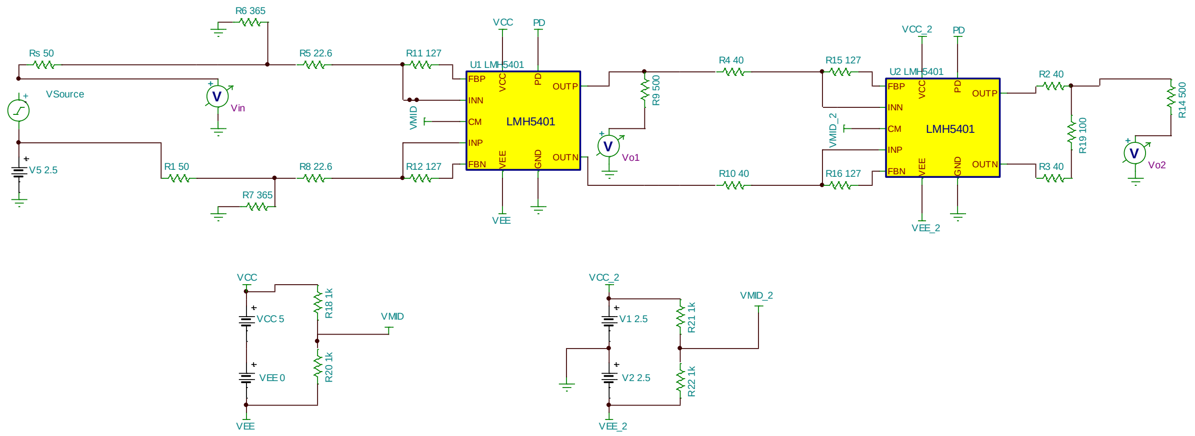


Figure 7 Schematic for Common Mode Shift

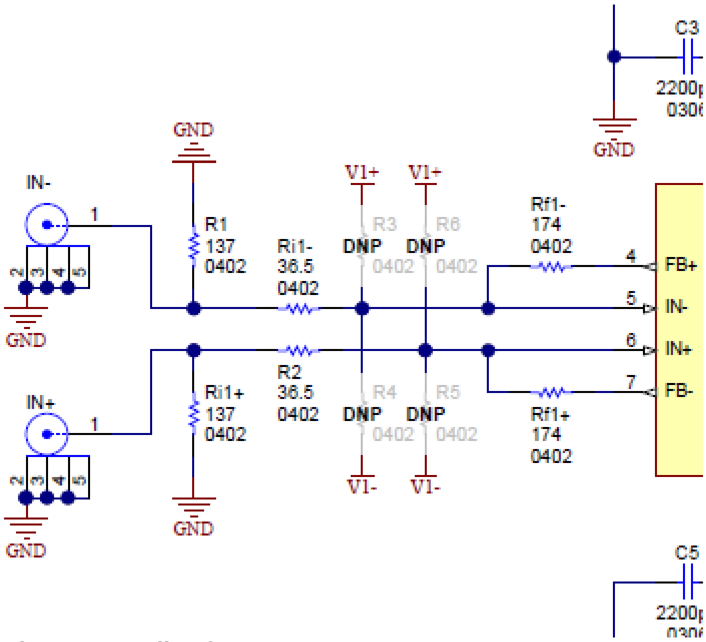


Figure 8 Details of TIDA-00659 Input Components

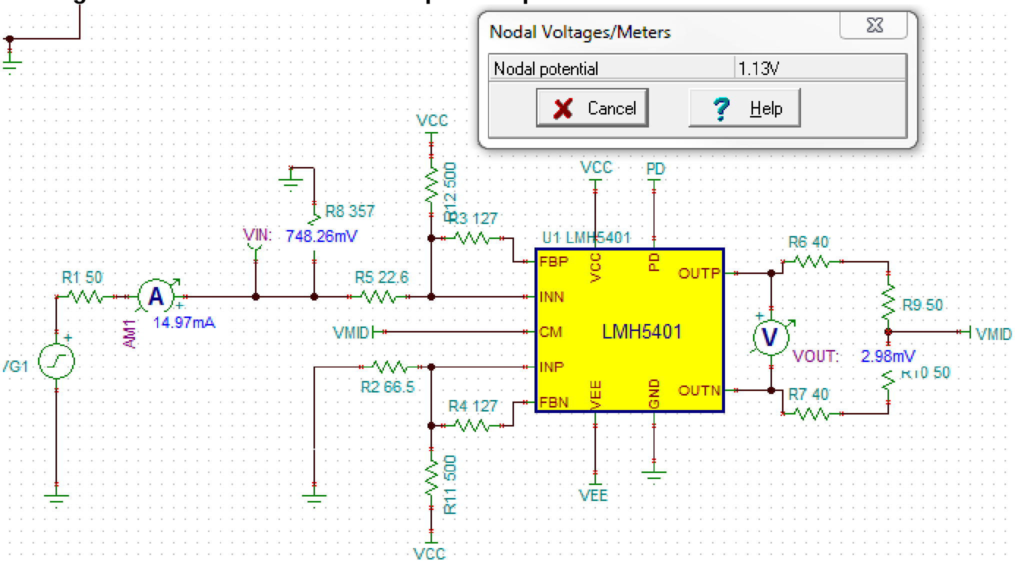


Figure 9 Bias Resistors Pull Up (Vs = 5V Single Supply)

As illustrated in Figure 9 , the bias resistors are connected to the positive supply to bias the amplifier input pins to a higher voltage. With no pull up resistors the amplifier input pin voltage would be 780mV while the input bias resistors pull this up to 1.13V. This will improve amplifier performance, but at the expense of additional DC current demanded from the signal source. In this example the current is nearly 15mA while the default case is 10.3mA.

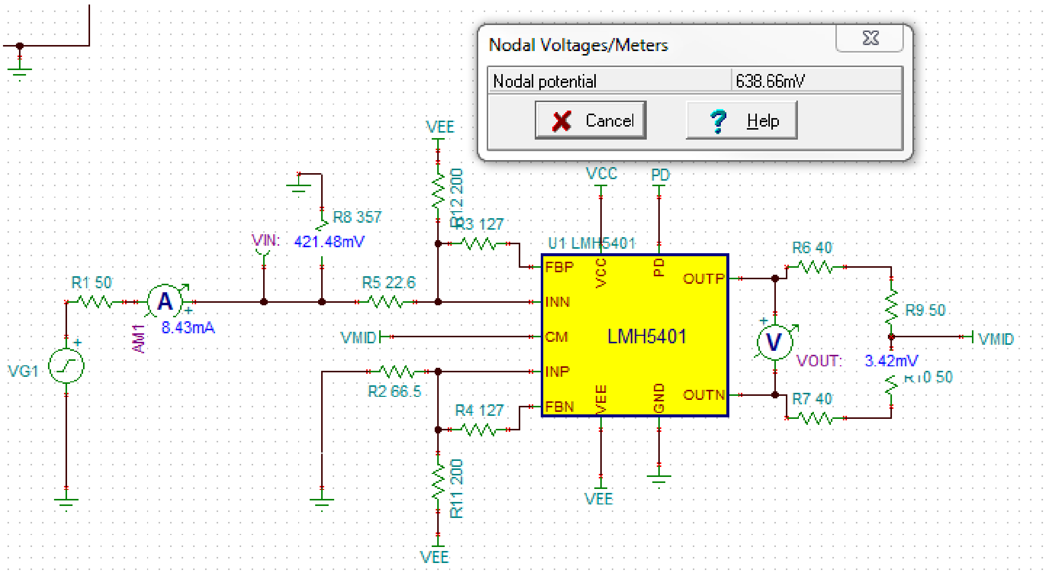


Figure 10 Bias Resistors Pulling Down

Figure 10 shows the opposite case where resistors are added to reduce the current required from the signal source. In this example the current from the signal source was reduced to 8.4mA, however the amplifier input pins are now well outside the optimal operating range and the signal source is still required to provide significant current. In order to reduce the signal source current and preserve amplifier performance two stages would be required.

6 Getting Started Firmware

There is no software associated with the TIDA-00659.

7 Test Setup

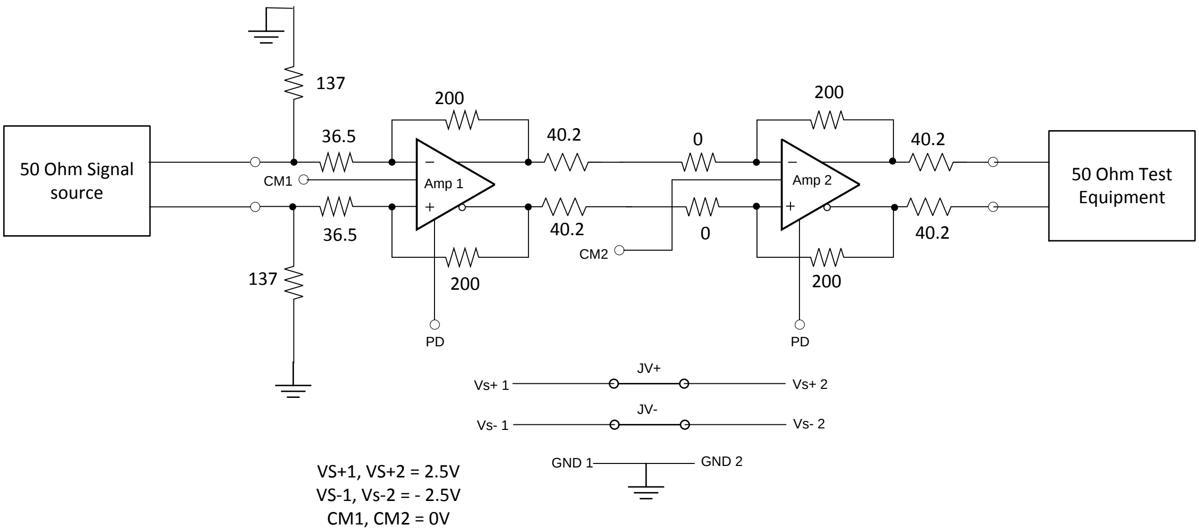


Figure 11 Frequency Response Test

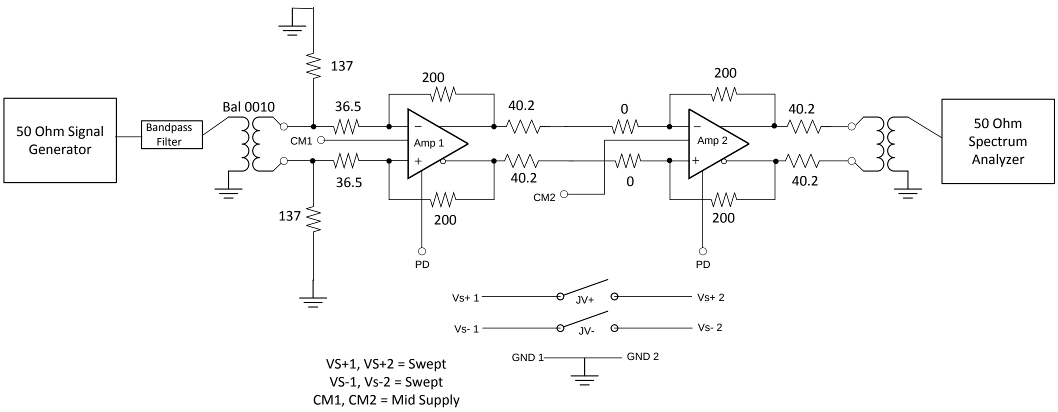


Figure 12 Test Setup Harmonic Distortion

8 Test Data

8.1 Frequency Response Cascaded 5401

The cascaded reference design board was tested for AC performance. The frequency response curves are shown in Figure 13. The frequency response shows some loss in bandwidth compared to a single amplifier, this is normal when cascading gain stages. To improve frequency response in your final design remove any components on the TIDA-00659 reference board that are not used in your system. The components that are most likely to be unused would be the input bias resistors (either one set or both sets). Also resistors R7 and Ri2- could be eliminated and resistors Ro1+ and Ro1- could be adjusted accordingly. With fewer components on the board the two amplifiers could be moved closer together.

While the LMH3401 is pin compatible with the LMH5401 and can be used on the same board layout it would be better to change the board layout to eliminate unnecessary components. In particular, resistors Ri1-, Ri1+, Rf1-, RF1+ are unnecessary if using an LMH3401 for the first stage. Because the LMH3401 is optimized for single ended to differential operation using 50 Ohm sources it is most likely that the second stage in a cascade system would be an LMH5401.

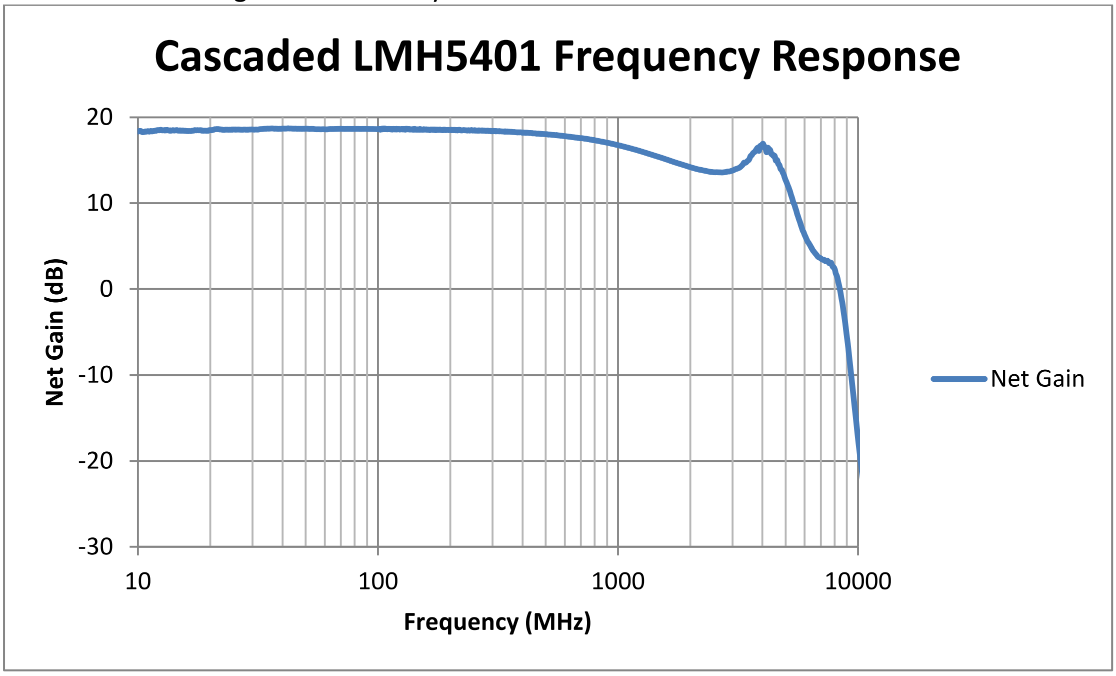


Figure 13 Cascaded Frequency Response (no common mode shift)

8.2 Distortion

The TIDA-00659 reference design board was characterized over a wide range of common mode voltage shifts. The results of these measurements are shown in Figure 14 below. The results indicate that the combination of two amplifiers does give a wider range of useful common mode shifts as well as increased gain. This chart was generated with both of the amplifiers using fixed output common mode voltages set to the exact midrange of the supply pins. The common mode shift was generated by shifting the power supplies between the two amplifiers. Because the signal source was ground referenced the input amplifier was set up on +-2.5V supplies while the output amplifier was shifted from +0V and +5V to +0% and -5V power supplies. Note that, just like with a single stage, there is more flexibility with negative common mode voltage shifts than with positive shifts.

Using AC coupling capacitors other combinations of input and output common mode voltages were also tested. The results were the same as reported below. Regardless of absolute voltages applied it is the difference in input common mode voltage compared with the output common mode voltage that determines performance. Because the output common mode voltage range is fairly small all testing was done with the outputs at mid-supply. Your design should keep the output common mode within +-0.25V of the supply voltage mid-point.

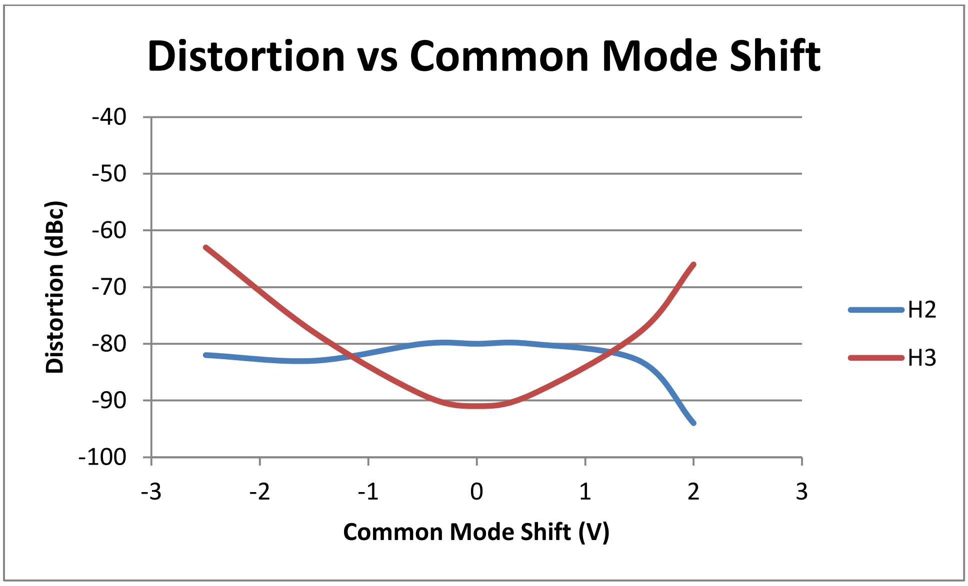


Figure 14 Cascaded Harmonic Distortion, Vout = 2vpp, Vsupply =5 V

8.3 Using LMH3401

The TIDA-00659 can accommodate both the LMH3401 and LMH5401 amplifiers. To use the LMH3401 requires a slight change in loaded components. The LMH3401 has on chip feedback and gain set resistors, so there is a net reduction in required external components. The LMH3401 can be used as the first stage, the second stage or both stages. However, it is most useful as the first stage amplifier as detailed above in section 8.3.

As shown in Figure 15 below, there are minor changes required to use the LMH3401. Remove resistors R1, Rf1-, and Rf1+. Replace resistors Ri1- and R2 with zero Ohm resistors. Resistor Ri1+ can either be replaced with a 50 Ohm resistor, or it can be removed. If resistor Ri1+ is removed, then a 50 Ohm SMA termination needs to be placed on the IN+ SMA connector. The LMH3401 is designed to operate with a single ended 50 Ohm source, so the signal applied to IN- should be a 50 Ohm single ended signal.

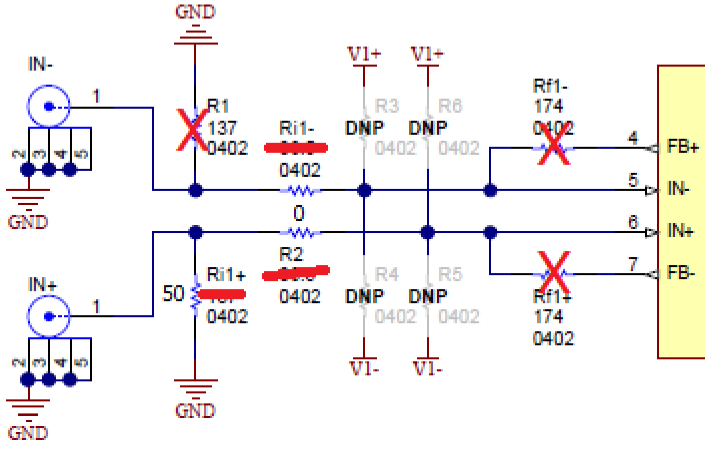


Figure 15 LMH3401 as First Stage

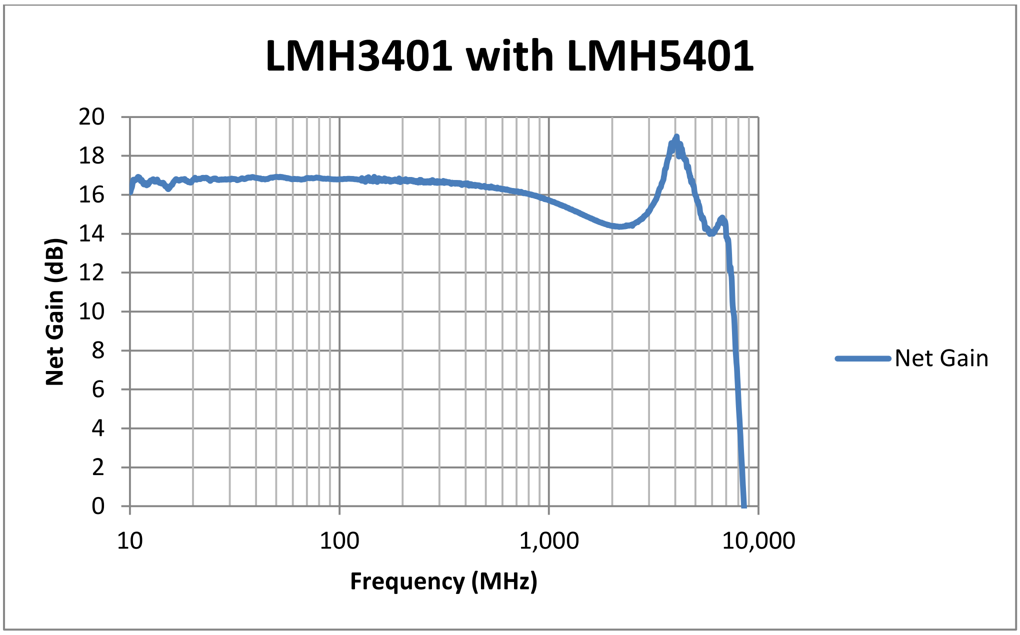


Figure 16 LMH3401 First Stage, LMH5401 Second Stage, Single Ended Input

The LMH3401 is optimized for use with single ended 50 Ohm signal sources. A frequency response plot is shown in Figure 16 above. The gain peaking at 4GHz can be reduced by removing the component pads that are not used for the LMH3401. This is shown in Figure 17.

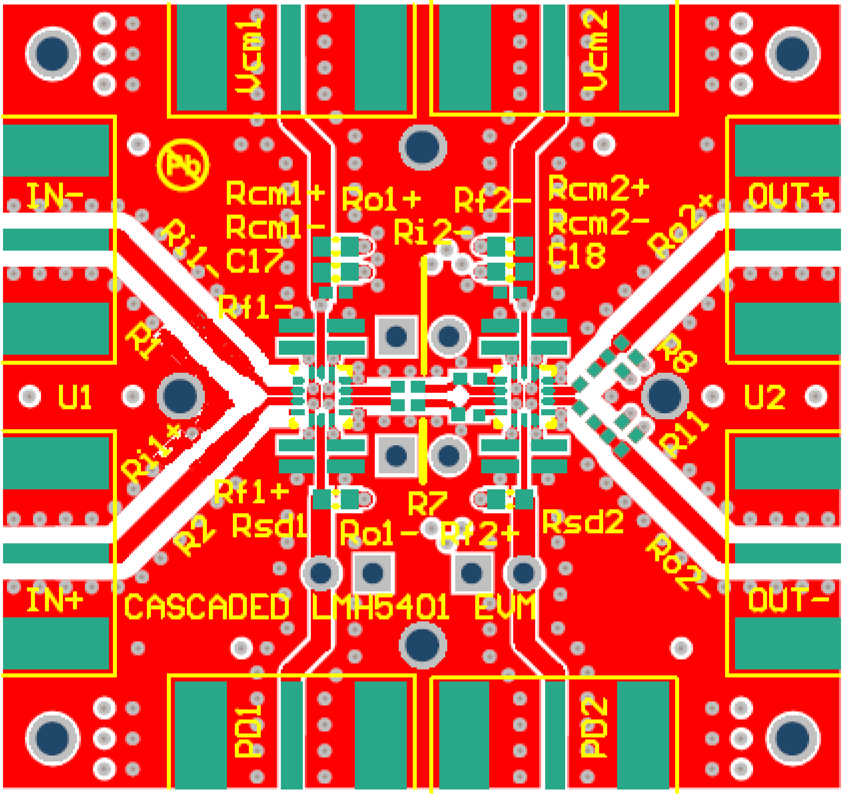


Figure 17 Layout Suggestion for LMH3401 as First Stage

Note that simulating both the LMH3401 and LMH5401 circuits in the same schematic can cause unexpected results. This is shown in Figure 18 below. The work around for this is to use the LMH5401 for both stages and insert the following resistor values to duplicate the LMH3401 internal components: Rf = 200 Ohms, Rg = 12.5 Ohms, Rout = 10 Ohms. The TI modeling group is working to fix this, but at the time of publication it still has not been resolved.

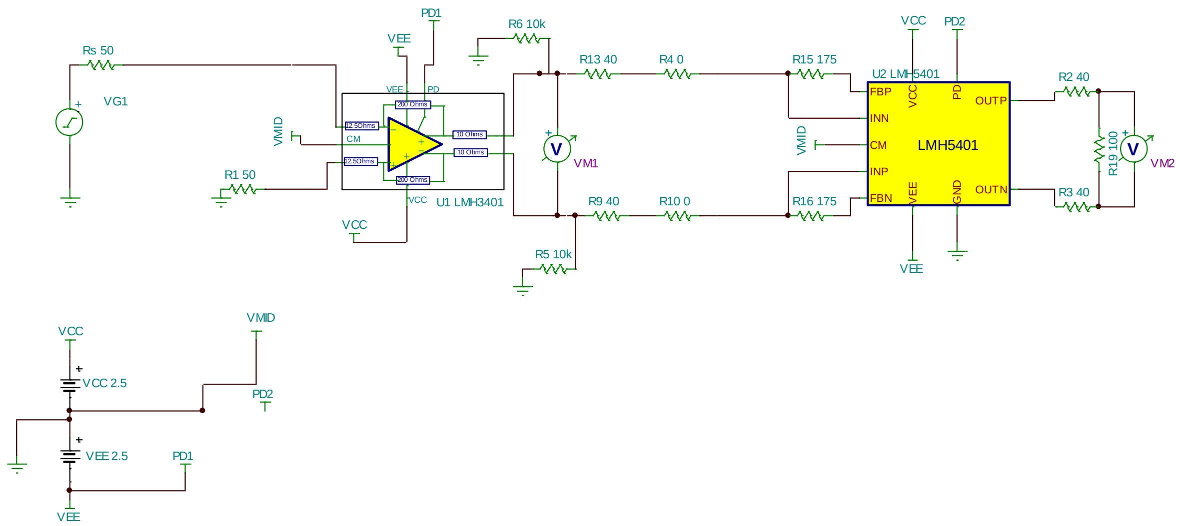


Figure 18 Schematic using LMH3401 and LMH5401.

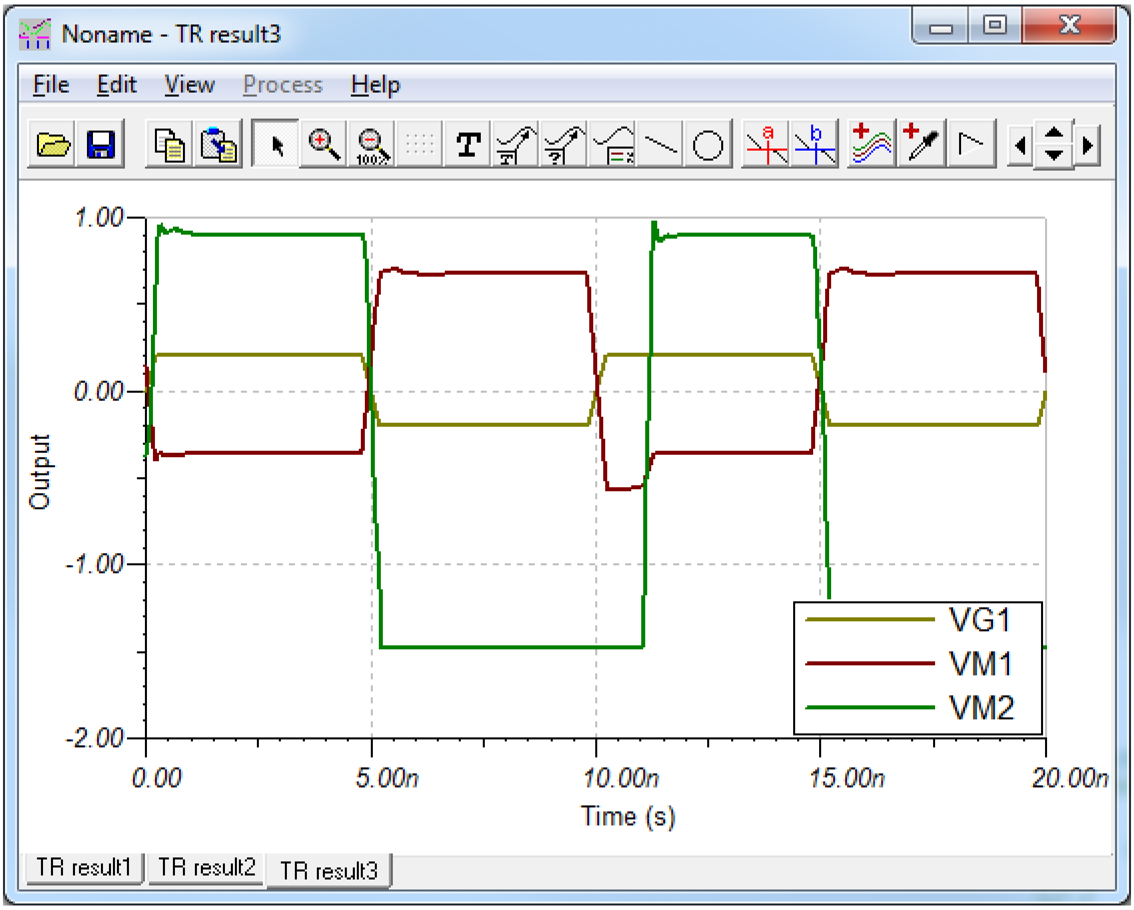


Figure 19 Transient Response for Cascaded LMH3401, LMH5401

The LMH3401 can also be used as the second stage of the TIDA-00659, as shown in Figure 20 below. The resistors Ro1+, Ro1-, Ri2- and R7 can be adjusted to suit the desired gain between the stages. There are two sets of resistors for flexibility in testing; however, it is only necessary to have one set of resistors.

Please note that both the LMH3401 and the LMH5401 have 10 Ohm on chip resistors on each output pin. Keep this in mind when calculating the system gain.

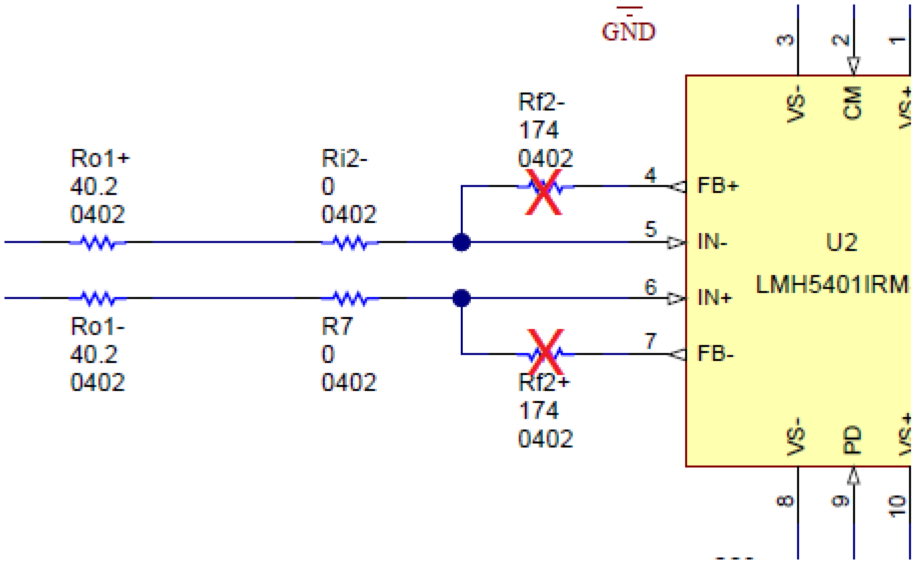


Figure 20 LMH3401 as Second Stage

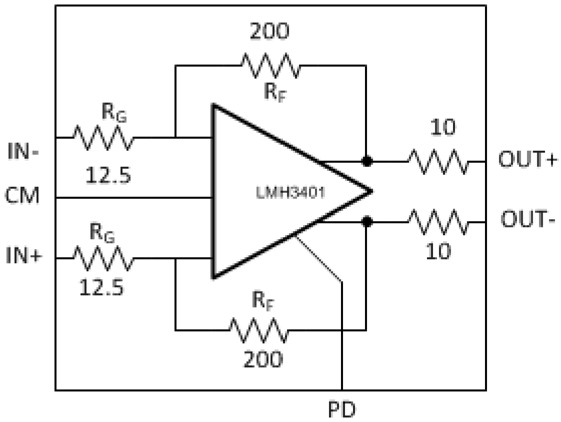


Figure 21 LMH3401 On-Chip Resistors

When using the LMH3401 as a second stage amplifier the required changes are shown in Figure 22. The feedback resistors are removed. While the LMH3401 has on chip gain set resistors they are too small for most applications and external resistors will be required. The gain in Figure 22 would be equal to Rf/(Ro1+ + Ri2- + 10 + 12.5) or 3.2V/V. The maximum gain available from the second stage would be 17.8 V/V which would be using only the internal resistors of the LMH3401. This would present a load of 45 Ohms to the first stage. Loading below 100 Ohms is not ideal, leading to a maximum gain of 4V/V if high linearity is required.

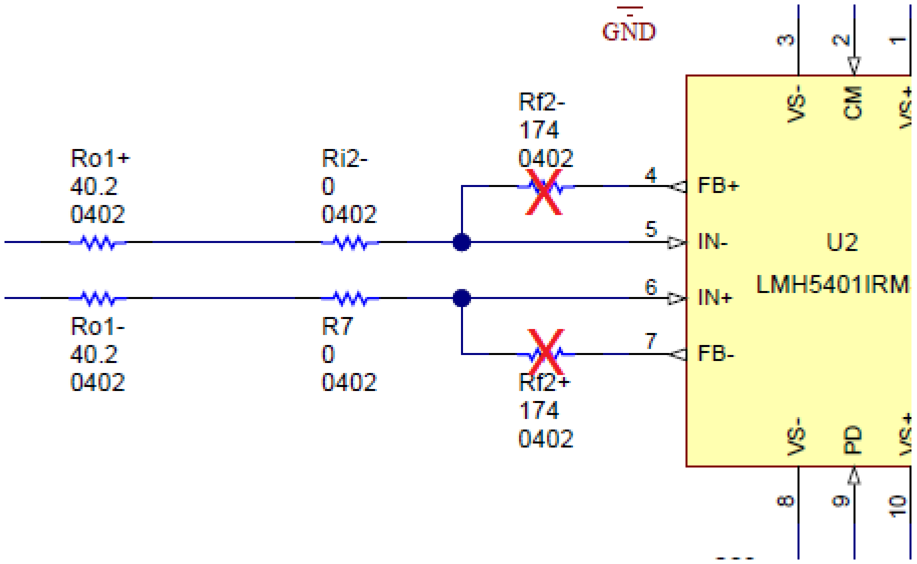


Figure 22 LMH3401 as Second Stage

9 Design Files

9.1 Schematics

To download the Schematics for each board, see the design files at http://www.ti.com/tool/TIDA-00659

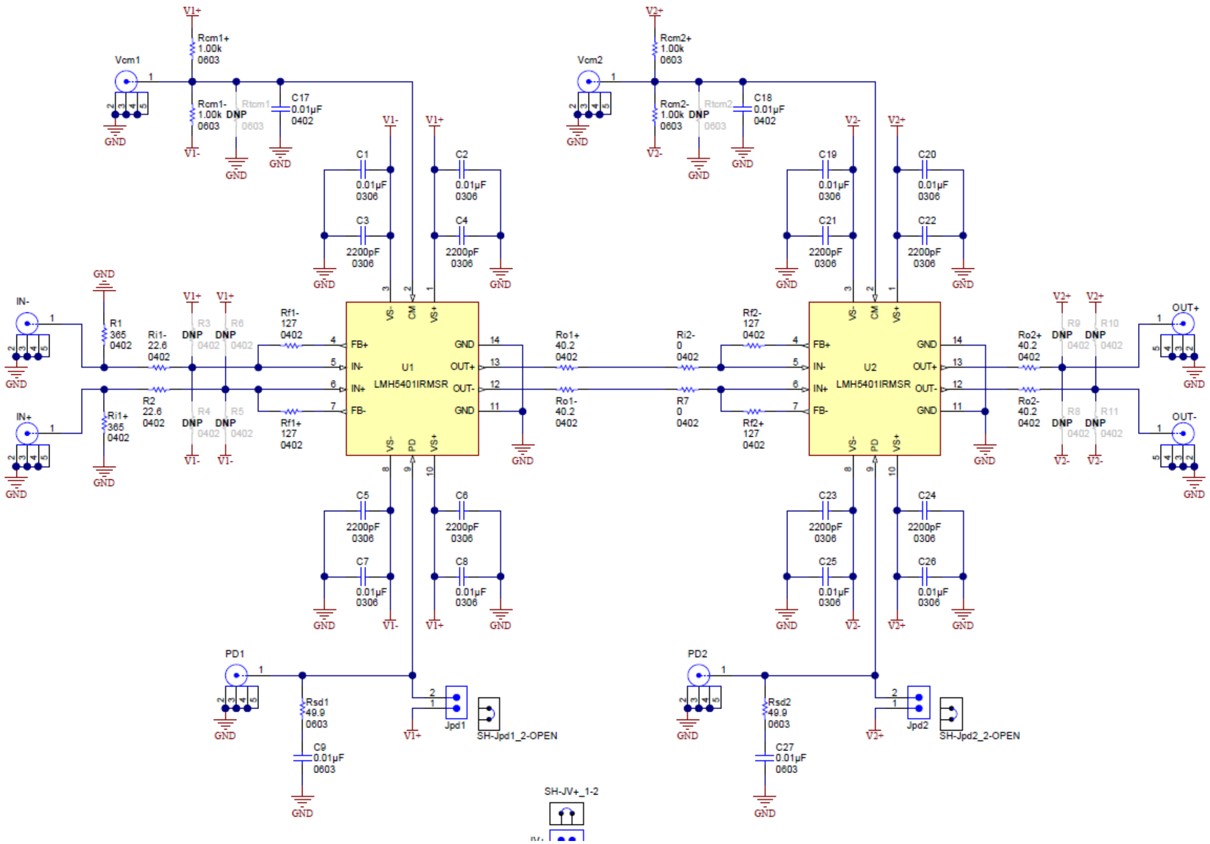


Figure 23: Signal Path Schematic

9.2 Bill of Materials

To download the Bill of Materials for each board, see the design files at http://www.ti.com/tool/TIDA-00659

Table 4 Bill of Materials

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
!PCB	1		Printed Circuit Board		???????	Any
C1, C2, C7, C8, C19, C20, C25, C26	8	0.01uF	CAP, CERM, 0.01uF, 25V, +/-20%, X7R, 0306	0306	LLL185R71E103MA01L	MuRata
C3, C4, C5, C6, C21, C22, C23, C24	8	2200pF	CAP, CERM, 2200pF, 50V, +/-20%, X7R, 0306	0306	LLL185R71H222MA01L	MuRata
C9, C27	2	0.01uF	CAP, CERM, 0.01uF, 16V, +/-10%, X7R, 0603	0603	GRM188R71C103KA01D	MuRata
C10, C13, C14, C28, C32, C34	6	10uF	CAP, TA, 10uF, 10V, +/-10%, 0.9 ohm, SMD	3216-18	TPSA106K010R0900	AVX
C11, C29	2	0.1uF	CAP, CERM, 0.1uF, 10V, +/-10%, X5R, 0402	0402	C1005X5R1A104K	TDK
C12, C17, C18, C30	4	0.01uF	CAP, CERM, 0.01uF, 25V, +/-10%, X7R, 0402	0402	C1005X7R1E103K	TDK
GND1, GND2, TPG1, TPG2	4	Black	Test Point, TH, Multipurpose, Black		5011	Keystone Electronics

IN+, IN-, OUT+, OUT-, PD1, PD2, Vcm1, Vcm2	8		Connector, SMT, End launch SMA 50 ohm	SMA End Launch	142-0701-851	Emerson Network Power
Jpd1, Jpd2, JV+, JV-	4		Header, TH, 100mil, 2x1, Gold plated, 230 mil above insulator	TSW-102-07-G-S	TSW-102-07-G-S	Samtec, Inc.
L1, L2	2	330 ohm	Ferrite Bead, 330 ohm @ 100 MHz, 1.5 A, 0603	0603	BLM18SG331TN1D	MuRata
R1, Ri1+	2	137	RES, 137, 1%, 0.063 W, 0402	0402	CRCW0402137RFKED	Vishay-Dale
R2, Ri1-	2	36.5	RES, 36.5, 1%, 0.063 W, 0402	0402	CRCW040236R5FKED	Vishay-Dale
R7, Ri2-	2	0	RES, 0, 5%, 0.063 W, 0402	0402	CRCW04020000Z0ED	Vishay-Dale
Rcm1+, Rcm1-, Rcm2+, Rcm2-	4	1.00k	RES, 1.00k ohm, 1%, 0.1W, 0603	0603	CRCW06031K00FKEA	Vishay-Dale
Rf1+, Rf1-, Rf2+, Rf2-	4	174	RES, 174, 1%, 0.063 W, 0402	0402	CRCW0402174RFKED	Vishay-Dale
Ro1+, Ro1-, Ro2+, Ro2-	4	40.2	RES, 40.2 ohm, 1%, 0.063W, 0402	0402	CRCW040240R2FKED	Vishay-Dale
Rsd1, Rsd2	2	49.9	RES, 49.9 ohm, 1%, 0.1W, 0603	0603	CRCW060349R9FKEA	Vishay-Dale
SH-Jpd1_2-OPEN, SH-Jpd2_2-OPEN, SH-JV+_1-2, SH-JV-_1-2	4	1x2	Shunt, 100mil, Gold plated, Black		382811-6	AMP
U1, U2	2		8GHz Ultra Wideband Fully Differential Amplifier, RMS0014A	RMS0014A	LMH5401IRMSR	Texas Instruments
V1+, V2+	2	Red	Test Point, TH, Multipurpose, Red		5010	Keystone Electronics

V1-, V2-	2	Yellow	Test Point, Multipurpose, Yellow, TH	Yellow Multipurpose Testpoint	5014	Keystone
C15, C16, C31, C33	0		CAP, CERM, xxxF, xxV, [TempCo], xx%, [PackageReference]	0603	Used in BOM report	Used in BOM report
R3, R4, R5, R6, R8, R9, R10, R11	0		RES, xxx ohm, x%, xW, [PackageReference]	0402	Used in BOM report	Used in BOM report
RB1+, RB1-, RB2+, RB2-, Rtcm1, Rtcm2	0		RES, xxx ohm, x%, xW, [PackageReference]	0603	Used in BOM report	Used in BOM report

9.3 PCB Layout Recommendations

The TIDA-00659 design board was designed to be easy to use with conventional 50 Ohm test equipment. Included on the board are SMA connectors for the four inputs, the two common mode inputs and the two power down pins. Most system designs will require fully differential, balanced signal paths. For these systems a board layout as shown in Figure 24 will be more appropriate.

The TIDA-00659 design board has fully independent power supply planes for each amplifier. This was done to facilitate common mode shifts between the two stages. For designs where no common mode shift is needed combine the two planes together into one continuous plane. Note also that the two power planes are adjacent in the board stack up. This configuration produces a large, low inductance capacitor that serves as a bypass capacitor between the supplies. There is also a ground plane adjacent to each power plane. Again, these adjacent planes create excellent capacitors for supply bypassing. These PCB fabricated capacitors are the most effective means of high frequency supply bypassing. For lower frequency bypassing there are several ceramic capacitors on the board. It is important to keep these capacitors close to the amplifiers.

The LMH3401 and LMH5401 are LLP style packages, but they do not have exposed thermal pads. All of the thermal management is accomplished with copper traces connected to the package pins. Vias from the power pins to the power planes are the most efficient means of thermal management. With no exposed pad, it is possible to put power supply vias underneath the package. This was done on the reference design board; see Figure 25 and Figure 24. The thermal vias are shown in greater detail in Figure 32.

Controlled impedance and low loss are critical for high speed systems. For this reason the TIDA-00659 uses a high performance dielectric from Roger's corporation. With the signal path confined to the top layer it was only necessary to use this dielectric between Layer 1 and Layer 2. The rest of the board is conventional FR4.

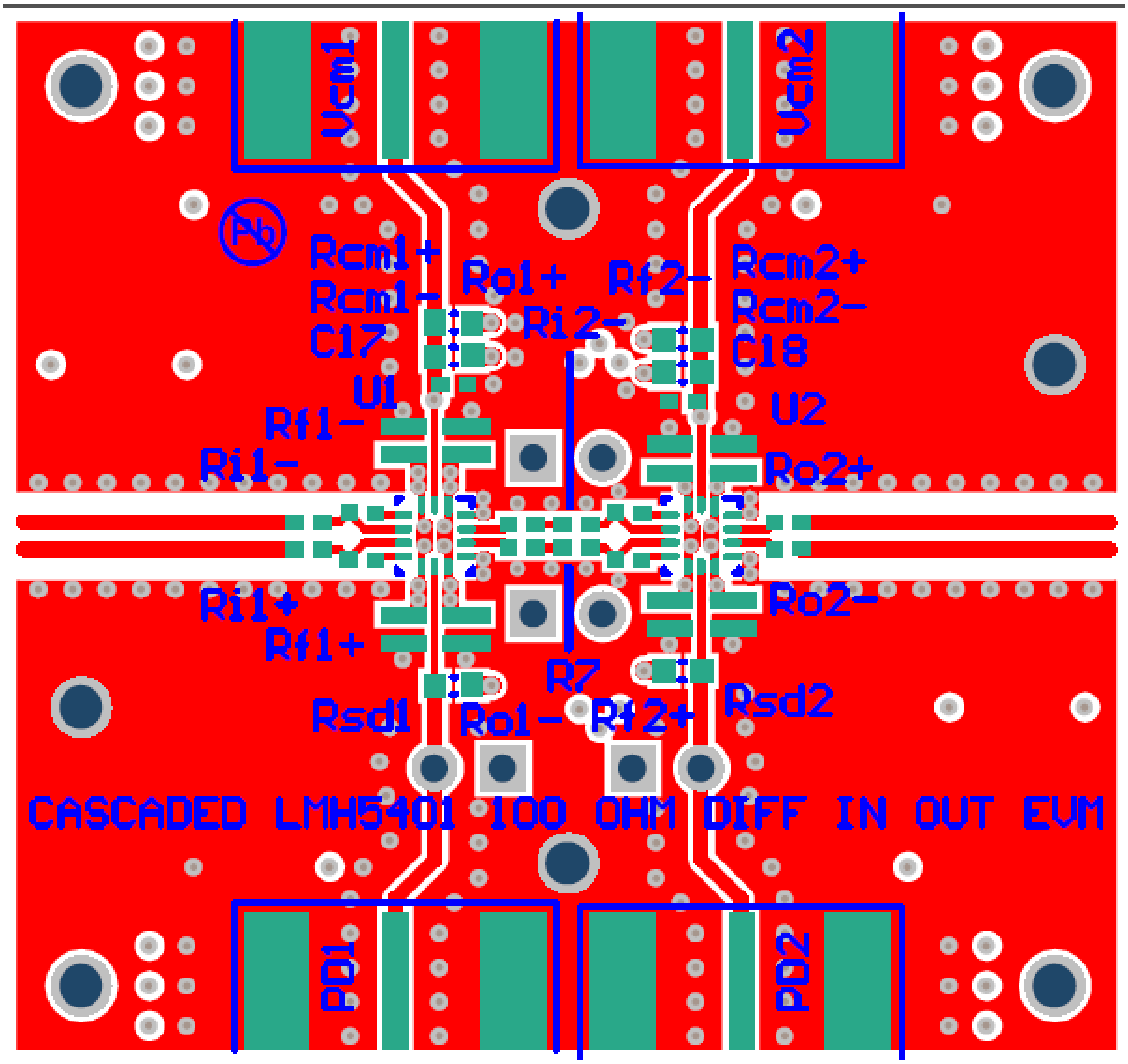


Figure 24 Board Example for Differential System

9.3.1 Layout Prints

To download the Layout Prints for each board, see the design files at http://www.ti.com/tool/TIDA-00659

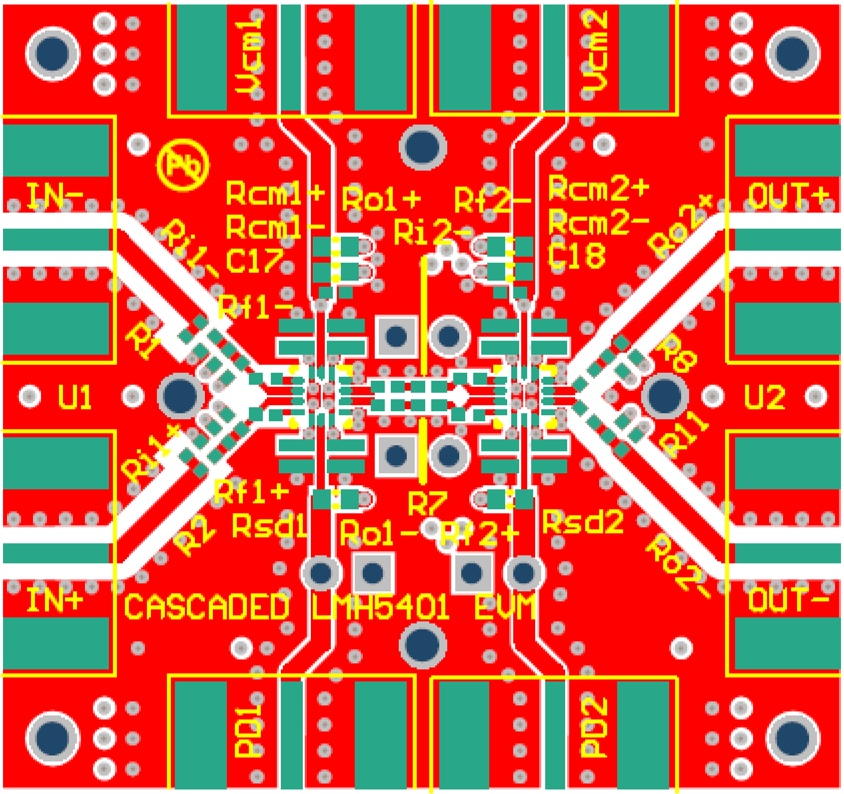


Figure 25: Top Layer, Signal Path

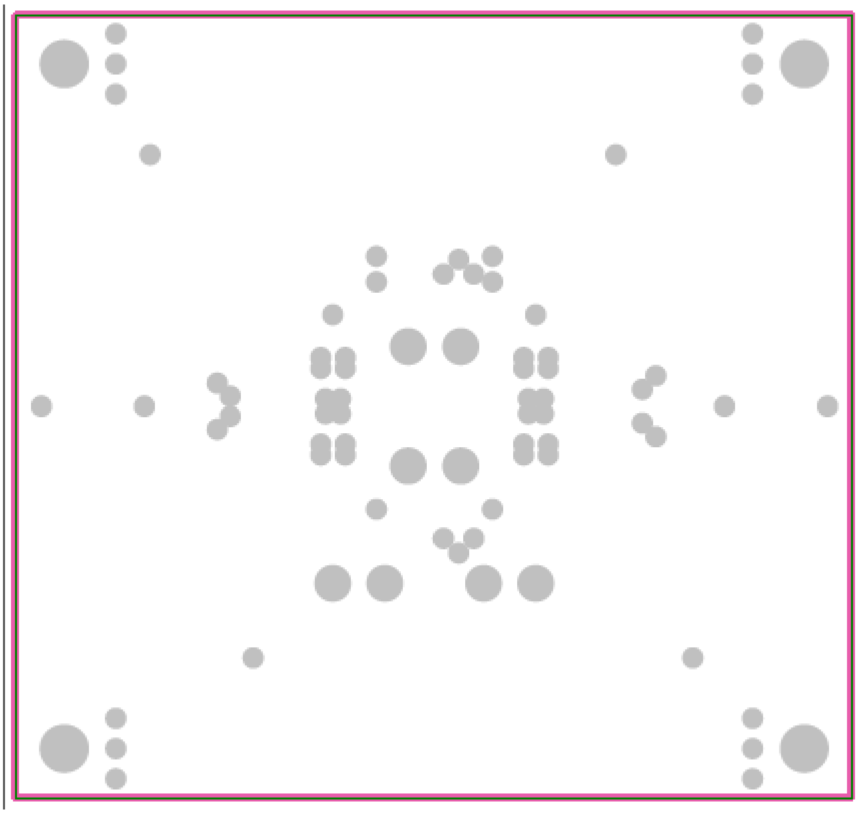


Figure 26: Layer 2, Ground

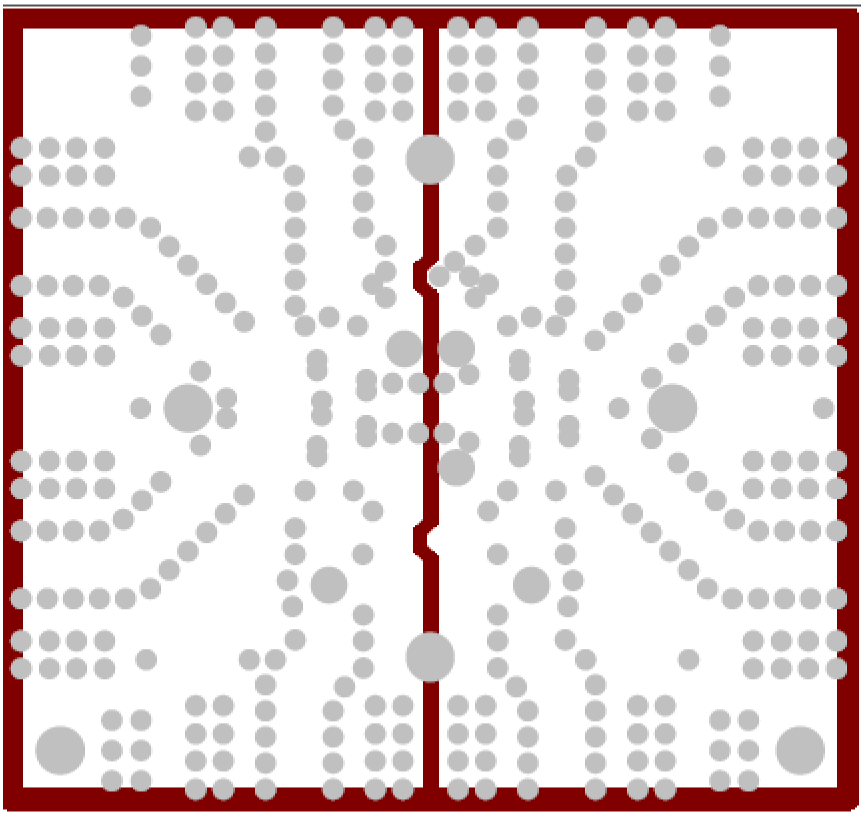


Figure 27: Layer 3, Positive Supplies

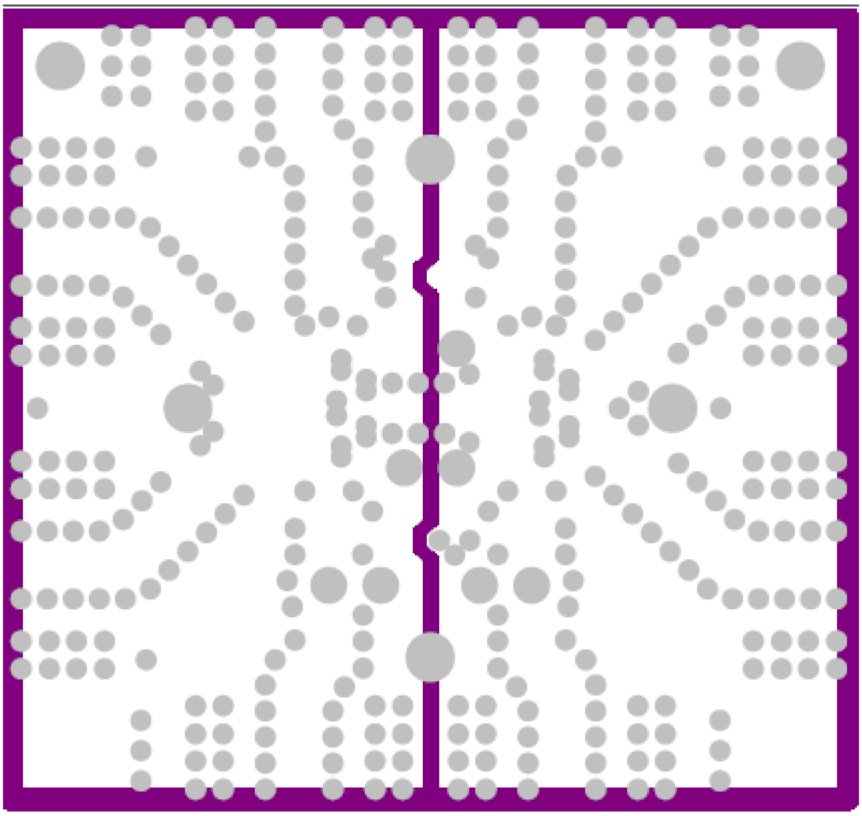


Figure 28: Layer 4, Negative Supplies

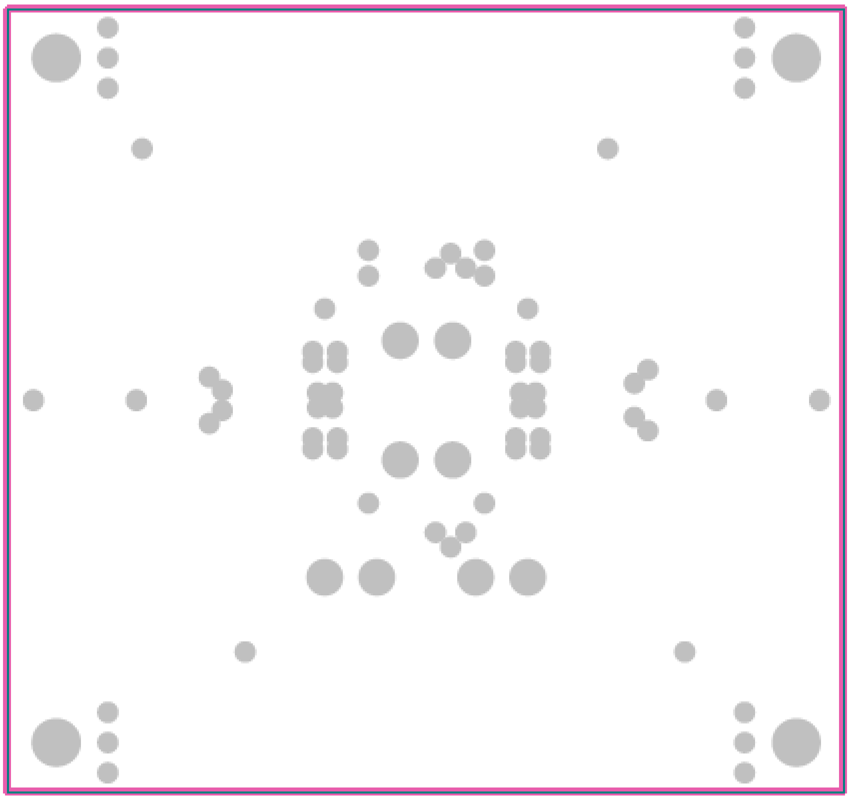


Figure 29: Layer 5, Ground

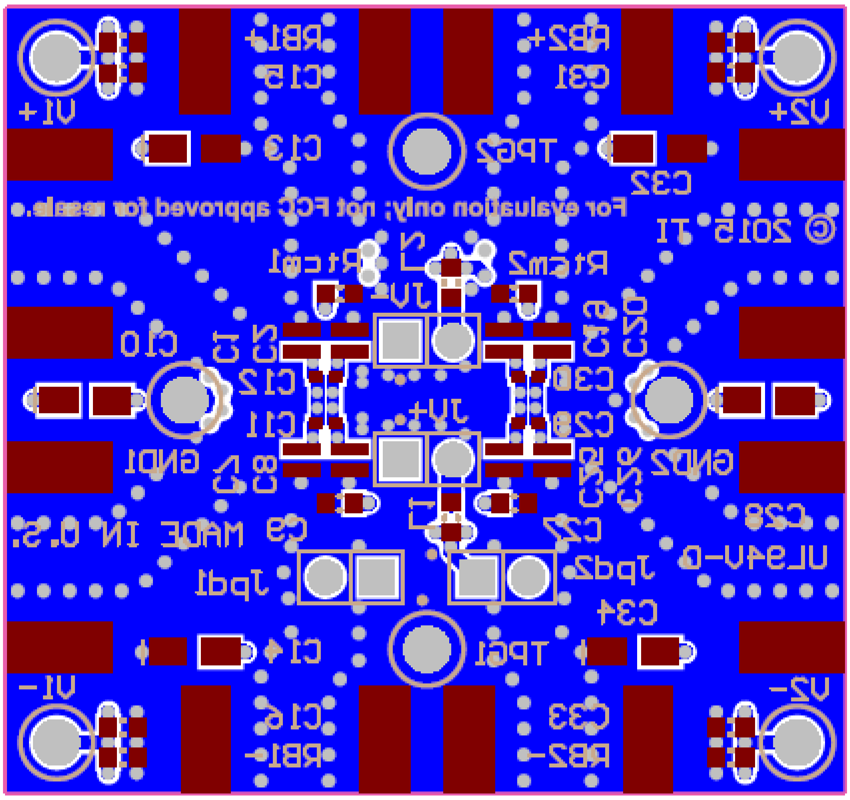


Figure 30: Layer 6, Bypassing capacitors and Power Connectors

9.4 Altium Project

To download the Altium project files for each board, see the design files at http://www.ti.com/tool/TIDA-00659

9.5 Layout Guidelines

As described in section 9.3 split power supply planes may not be necessary. Using a full power supply plane is critical to device performance. Similarly, if the design calls for +5V and ground power supplies, the negative supply layer (Layer 4) can be converted to a ground layer and the ground layer (Layer 5)can be used for other signal routing.

The signal path was confined to the top layer for the reference design, running high speed, analog signals through vias to other layers will create undesirable impedance distortions.

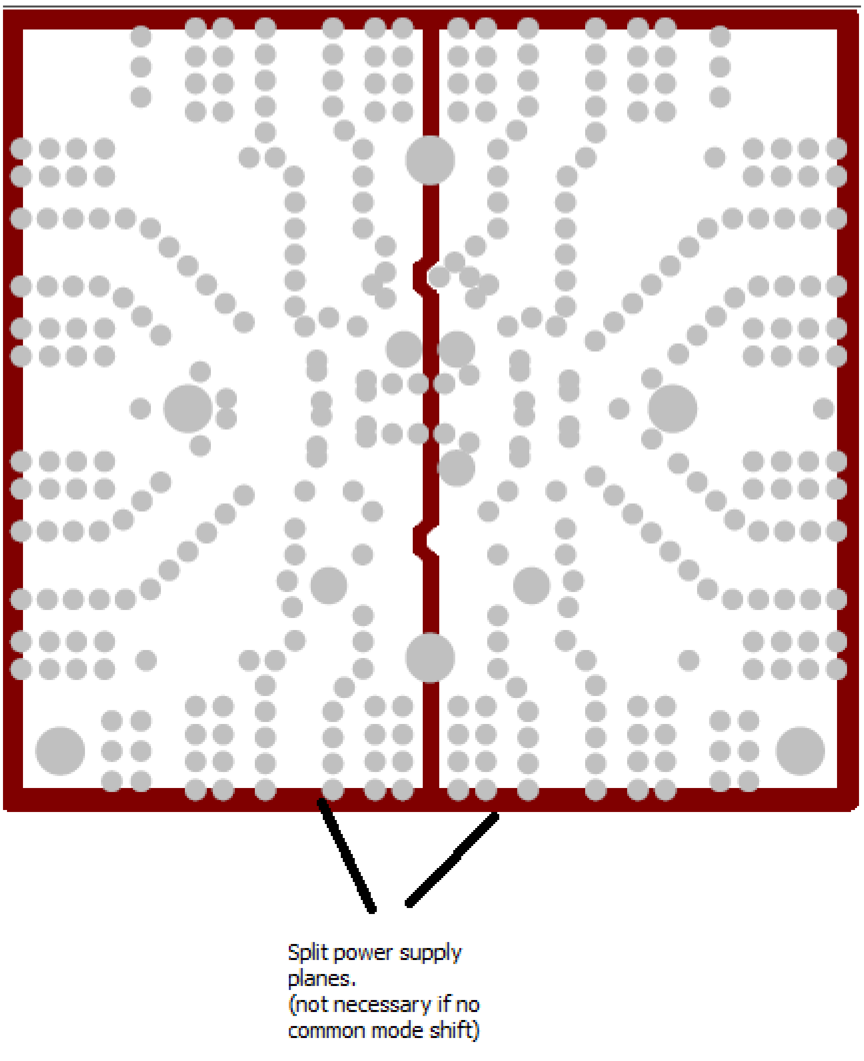


Figure 31: To insert a caption, right click picture > Insert Caption

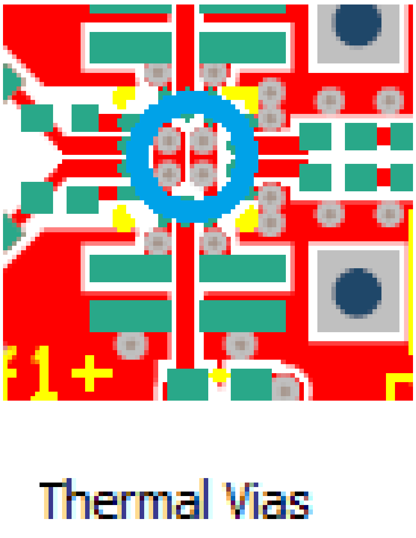


Figure 32 Thermal vias

9.6 Gerber files

To download the Gerber files for each board, see the design files at http://www.ti.com/tool/TIDA-00659

9.7 Assembly Drawings

To download the Assembly Drawings for each board, see the design files at http://www.ti.com/tool/TIDA-00659

10 Software Files

This design has no software.

11 References

1. Texas Instruments Reference Design, TIDA-00522, 2015

12 Terminology

13 About the Author

Loren Siebert is an Applications Engineer at Texas Instruments, where he is responsible for product development, customer support as well as developing reference design solutions for high speed amplifiers. Loren brings to this role his extensive experience in communications systems and high speed amplifiers. Loren earned his Bachelor of Science in Electrical Engineering and Computer Science (BSEE/CS) from University of Michigan in Ann Arbor, MI.

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