AN-1945 LMH6554LE-EVAL High Speed Differential Amplifier Evaluation Board

1 General Description

The LMH6554LE−EVAL evaluation board is designed to aid in the characterization of Texas Instruments LMH6554 fully differential amplifier in an 14 lead UQFN package. The LMH6554 is part of the LMH™ high-speed amplifier family.

Use the evaluation board as a guide for high frequency layout and as a tool to aid in device testing and characterization.

The evaluation board schematic is shown in Figure 1. For recommended for component values, see the device-specific data sheets.

2 Basic Operation

The LMH6554LE−EVAL evaluation board has been set up to provide maximum flexibility for evaluating TI's differential LMH6554 operational amplifier. The board supports fully differential operation as well as single-ended to differential and single-ended to single-ended operation. For fully differential operation, use resistors R_2 and R_3 to set the input impedance of the amplifier. The differential input resistance will be equal to $2*R_2 \parallel 2*R_{G\_M}$. Where $R_2 = R_3$ and $R_{G\_M} = R_{G\_P}$. In this mode resistors R_{G_M}, R_{G_F}, R_{F_M} and R_{F_P} set the gain of the amplifier. Amplifier gain = $R_{F\_M}/R_{G\_M} = R_{F\_P}/R_{G\_P}$ where $R_{G\_M} = R_{G\_P}$ and $R_{F\_M} = R_{F\_P}$. For more details on gain component value selections, see Table 2. For single-ended input mode of operation, the input and termination resistance must be properly configured to give the correct gain and input impedance (R_{IN}). For example, in the case of the LMH6554, if a gain of 2 V/V is desired, $R_2 = R_3 = 76.8\ \Omega$, $R_{G\_M} = R_{G\_P} = 90\ \Omega$, $R_{F\_M} = R_{F\_P} = 200\ \Omega$, C_2 and R_{14} = OPEN, $C_3 = 0.1\ \mu F$, and $R_{15} = 50\ \Omega$, which will make $R_{IN} = 50\ \Omega$ at the most positive node of R_3 looking into R_{G_M}. Further details of single-ended input mode calculations can be found in the *LMH6554 2.8 GHz Ultra Linear Fully Differential Amplifier Data Sheet* (SNOSB30). Components $C_3 = 0.1\ \mu F$ and $R_{15} = 50\ \Omega$ should be used to AC-couple and balance the inputs, otherwise can be left empty. In this example the input signal would be connected to the VIN- input. For more details on gain component value selections, see Table 1.

For differential output applications, load R_6 and R_7 with the desired values to match the output load and leave C_{14} and C_{15} empty. Typically to match a test equipment, $R_6 = R_7 = 50\ \Omega$.

If single-ended output is desired an output transformer such as the TC4-19 from mini circuits can be utilized. The TC4-19 has a 4:1 impedance ratio (2:1 turns/voltage ratio). This is particularly useful for interfacing to a 50 Ω test equipment. When referencing the transformer data sheet, the LMH6554LE−EVAL evaluation board has the primary windings on the output side of the evaluation board and the amplifier is driving the secondary windings. This provides a step down transformation from the differential amplifier output to the test equipment. The center-tapped secondary winding also allows a differential to single ended conversion (Balun). The impedance seen by the differential amplifier = ($R_6 + R_7 + R_L*4$), where R_L is the impedance from pin 4 of the transformer to the load. For example, if $R_L = 50\ \Omega$ for the test equipment, to achieve an impedance of 500 Ω seen by the LMH6554 differential output $R_6 = R_7 = 150\ \Omega$ with $C_{14} = C_{15} = R_{12} = R_{13} = 0\ \Omega$. The LMH6554LE−EVAL board is equipped with pads to add additional filtering schemes using C_{14} - C_{18} and R_8 - R_{13}.

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Pin 9 on the LMH6554 device is the enable (VEN) pin that can be used to disable the device with an external signal. Pin 11 and 14 have no internal package connections and should be connected to analog ground by using 0 Ω resistors for R_4 and R_5. For more details, see the *LMH6554 2.8 GHz Ultra Linear Fully Differential Amplifier Data Sheet* (SNOSB30).

3 Layout Considerations

The printed circuit board (PCB) layout and supply bypassing play major roles in determining high frequency performance. Use these evaluation boards as a guide when designing your own board and follow these steps to optimize high frequency performance:

1. Symmetry is of the utmost importance.
2. Use precision resistors 0.1% or 0.01%.
3. Use a ground plane.
4. Include large (~ 10 μF) ceramic capacitors on both supplies (C_{19} and C_{20}).
5. Near the device use ceramic capacitors 0.1 μF for $C_{22–25}$ and 0.01 μF for C_7, C_8, C_{12}, and C_{13} from supplies to ground.
6. Remove the ground and power planes from under and around the part, especially the input and output pins.
7. Minimize all trace lengths.
8. Use terminated and matched transmission lines for long traces.

Sample artwork for the LMH6554LE−EVAL evaluation board is shown in Figure 2 and Figure 3.

4 Measurement Hints

Balance, CMRR and HD2 are highly dependent on resistor matching. Use 0.1 or 0.01% resistors.

The LMH6554LE−EVAL™ evaluation board is designed for differential or single-ended output measurements, but not both at the same time. When not using the transformer make sure to leave C_{14} and C_{15} empty. Likewise, when making single-ended output measurements populate components C_{14}, C_{15}, R_{12} and R_{13}.

Many differential amplifiers are optimized for the higher impedances represented by most ADCs.

On a differential amplifier both inputs are inverting, keep parasitic capacitance to a minimum on both inputs. Also, using probes of any kind on a differential circuit is not recommended.

5 LMH6554LE_EVAL Schematic

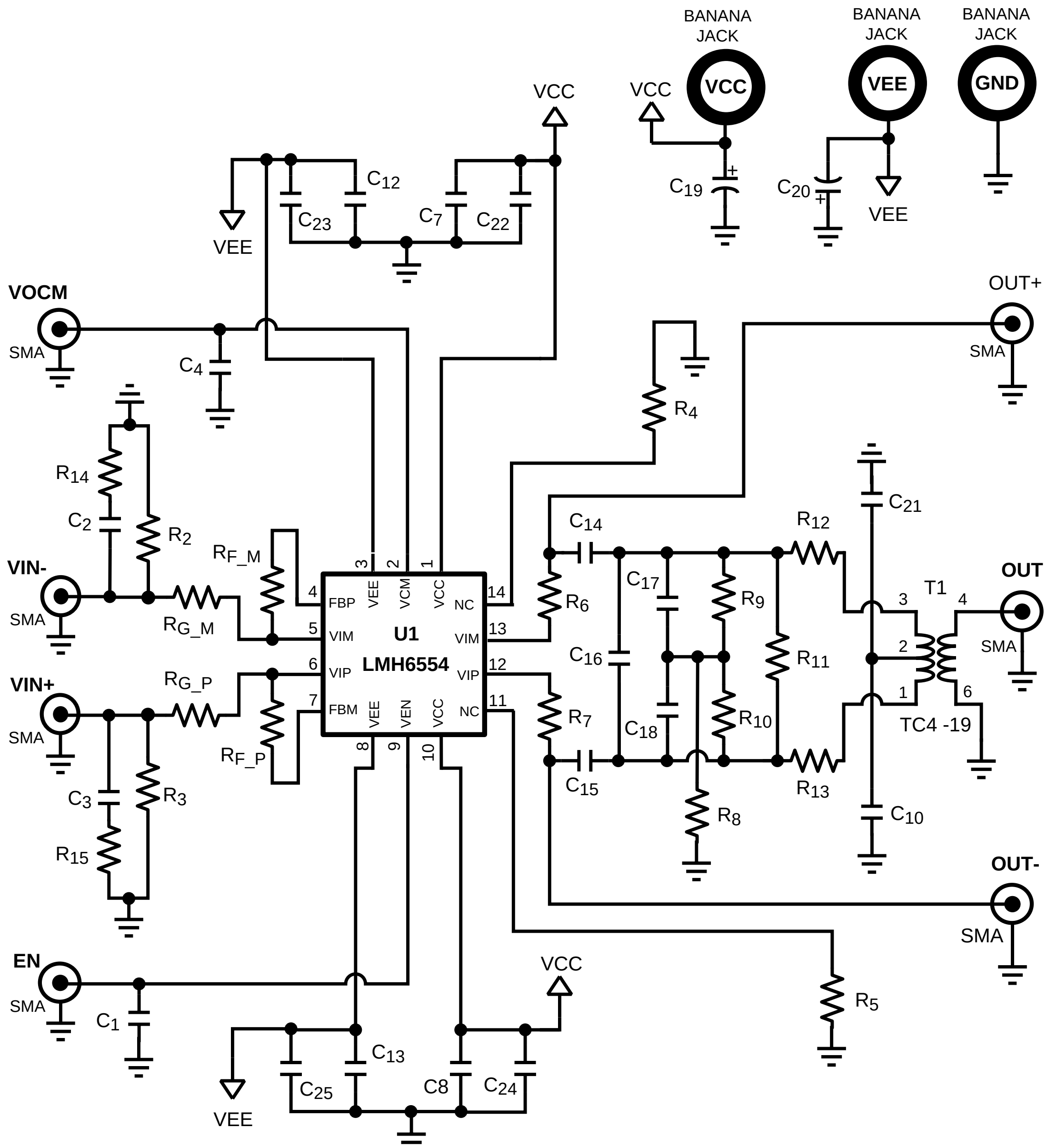

Figure 1. Board Schematic

Table 1. Single-Ended Input Gain Resistor Values for 50 Ω System

Gain	R_{F_M} = R_{F_P}	R_{G_M}=R_{G_P}	R3	R_M	R6 = R7
0dB	200 Ω	191 Ω	62 Ω	27.7 Ω	50 Ω
6dB	200 Ω	91 Ω	76.8 Ω	30.3 Ω	50 Ω
12dB	200 Ω	35.7 Ω	147 Ω	37.3 Ω	50 Ω

Table 2. Differential Input Gain Resistor Selection for 50 Ω System

Gain	$R_{F\_M} = R_{F\_P}$	$R_{G\_M} = R_{G\_P}$	R2 = R3	R6 = R7
0dB	200 Ω	200 Ω	66.67 Ω	50 Ω
6dB	200 Ω	100 Ω	100 Ω	50 Ω
12dB	200 Ω	50 Ω	—	50 Ω

6 LMH6554LE_EVAL Board Layout Views

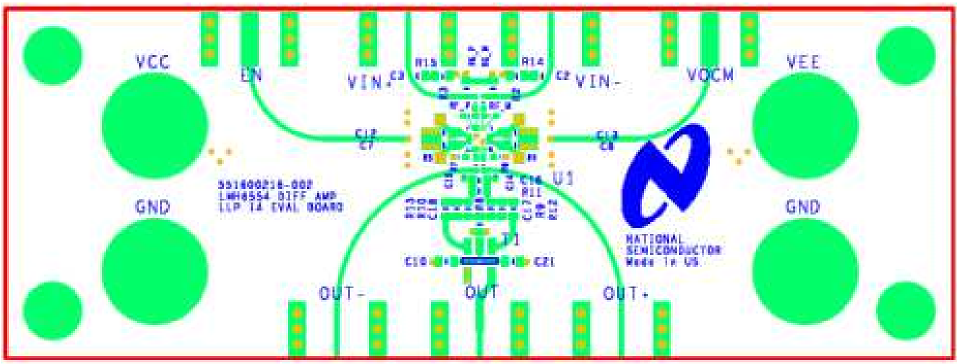

Figure 2. Board Layout Top View

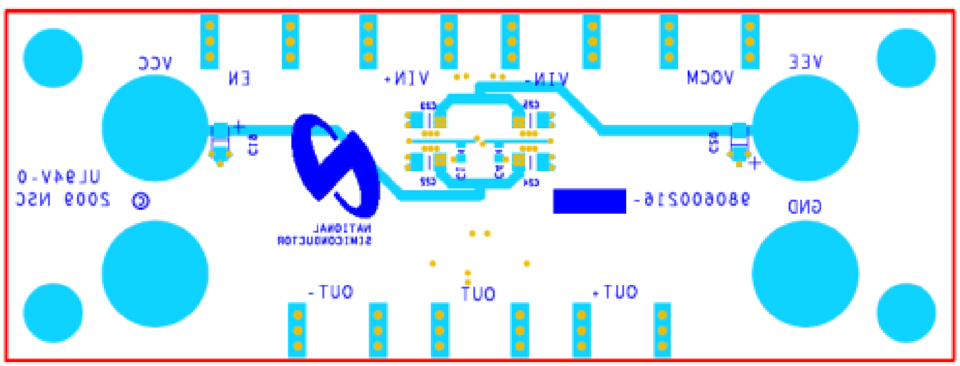

Figure 3. Board Layout Bottom View

7 Bill of Materials (BOM)

Table 3. LMH6554LE_EVAL BOM

Item No	P/N	Manufacturer	Qty	Reference	Description
1	GRM188F51C224ZA01D	Murata	2	C1,C4	Ceramic cap 0.22 µF 16 V 0603
2	C1608X8R1H103K	TDK Corporation	4	C7,C8,C12,C13	Ceramic cap 0.01 µF 50 V 10% 0603
3	C3216X5R1C106M	TDK Corporation	2	C19,C10	Ceramic cap 10 µF 16 V 20% 1206
4	C0603C104K4RACTU	Kemet	1	C2	Ceramic cap 0.1uF 16 V X7R 0603
5	CC0805KRX7R7BB104	Yageo	4	C22–C25	Ceramic cap 0.1uF 16 V X7R 0805
6	142–0701–806	Emerson (Johnson)	7	EN,OUT,OUT+, OUT-,VIN+, VIN-, VOCM	Connector Jack rcpt end launch nickel
7	SPC15363	SPC TECHNOLOGY	1	VCC	RED insulated banana jack
8	SPC15182	SPC TECHNOLOGY	1	VEE	GREEN insulated banana jack
9	SPC15354	SPC TECHNOLOGY	1	GND	BLACK insulated banana jack
10	RC0603FR-0749R9L	Yageo	1	R14	Resistor 49.9 Ω 1/10W 1% 0603 SMD
11	RC0603FR-0776R8L	Yageo	2	R2,R3	Resistor 76.8 Ω 1/10W 1% 0603 SMD
12	RC0402JR-070RL	Yageo	2	R4,R5	Resistor 0 Ω 1/6W 5% 0402 SMD
13	TNPW040249R9BEED	Vishay/Dale	2	R6,R7	Resistor 49.9 Ω 1/16W 0.1% 0402
14	ERA-2AEB201X	Panasonic	2	RF_M,RF_P	Resistor 200 Ω 1/16W 0.1% 0402 SMD
15	ERA-2AEB910X	Panasonic	2	RG_M,RG_P	Resistor 91 Ω 1/16W 0.1% 0402 SMD
16	TC4–19+	Mini-Circuits	1	T1	Surface Mount RF transformer, 50 Ω, 10 to 1900 MHz
17	LMH6554	Texas Instruments	1	U1	2.5 GHz Fully Differential Amplifier, 14 pin UQFN package

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