# LMH6554LE−EVAL High Speed Differential Amplifier Evaluation Board

National Semiconductor
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## General Description

The LMH6554LE−EVAL evaluation board is designed to aid in the characterization of National Semiconductor's LMH6554 fully differential amplifier in an 14 lead LLP 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 below in *Figure 1*. Refer to the product datasheets for recommended for component values.

## Basic Operation

The LMH6554LE−EVAL evaluation board has been set up to provide maximum flexibility for evaluating National'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 $R_{F\_M} = R_{F\_P}$. Refer to Table 2 for more details on gain component value selections. 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, $C_3$ = 0.1uF, 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 for the LMH6554 can be found in the datasheet. Components $C_3$= 0.1uF and $R_{15}$= 50Ω 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. Refer to Table 1 for more details on gain component value selections.

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 50Ω test equipment. When referencing the transformer datasheet, the LMH6554LE−EVALevaluation 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 500Ω 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 $R_8$ - $R_{13}$.

Pin 11 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 0Ω resistors for $R_4$ and $R_5$. Refer to the LMH6554 datasheet for more details.

## Layout Considerations

Printed circuit board layout and supply bypassing play major roles in determining high frequency performance. When designing your own board use these evaluation boards as a guide 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*.

## 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.

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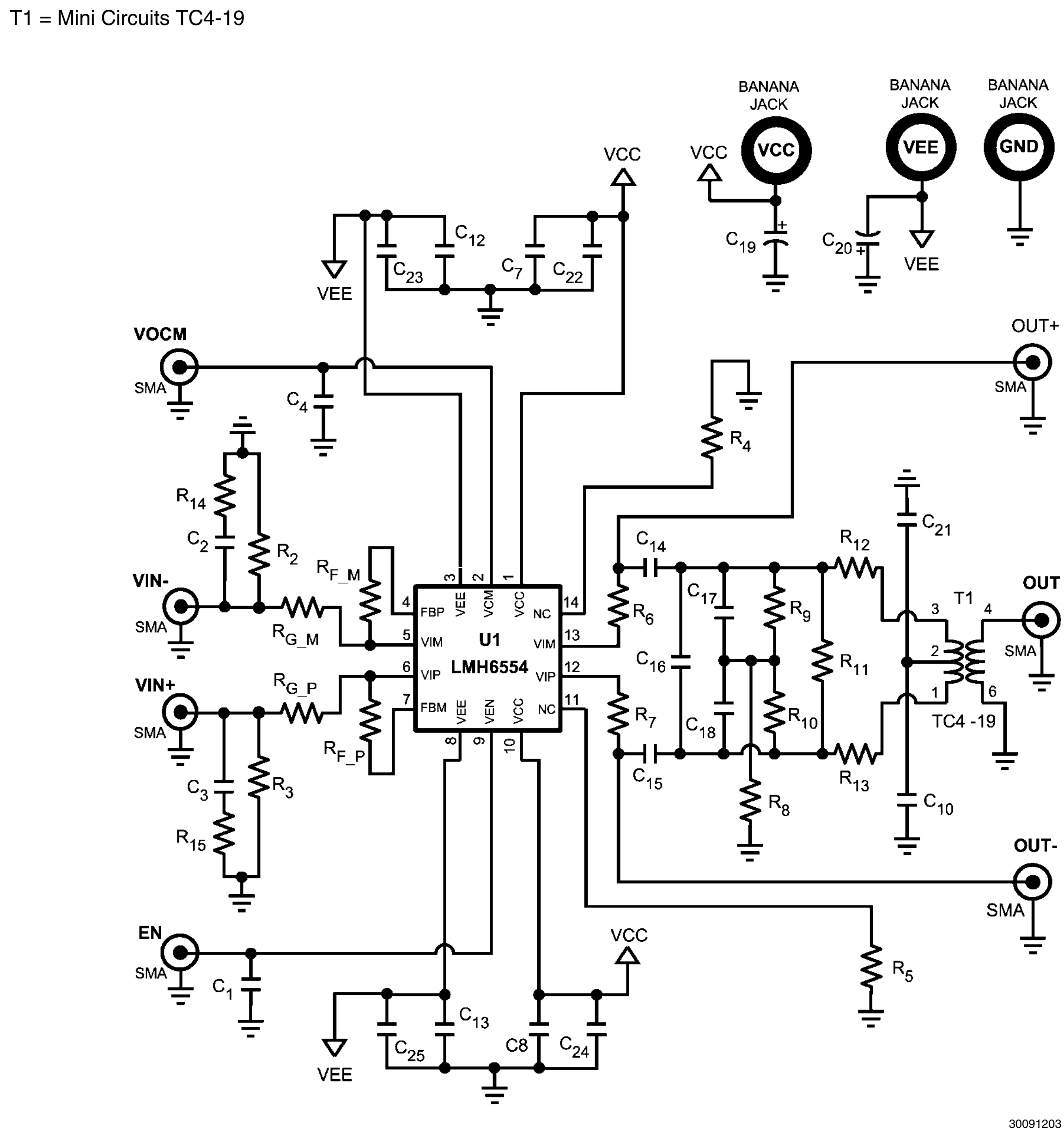


**FIGURE 1. Board Schematic**

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

| Gain | $R_{F\_M} = R_{F\_P}$ | $R_{G\_M}=R_{G\_P}$ | R3 | $R_M$ | R6 = R7 |
|---|---|---|---|---|---|
| 0dB | 200Ω | 191Ω | 62Ω | 27.7Ω | 50Ω |
| 6dB | 200Ω | 91Ω | 76.8Ω | 30.3Ω | 50Ω |
| 12dB | 200Ω | 35.7Ω | 147Ω | 37.3Ω | 50Ω |

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

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

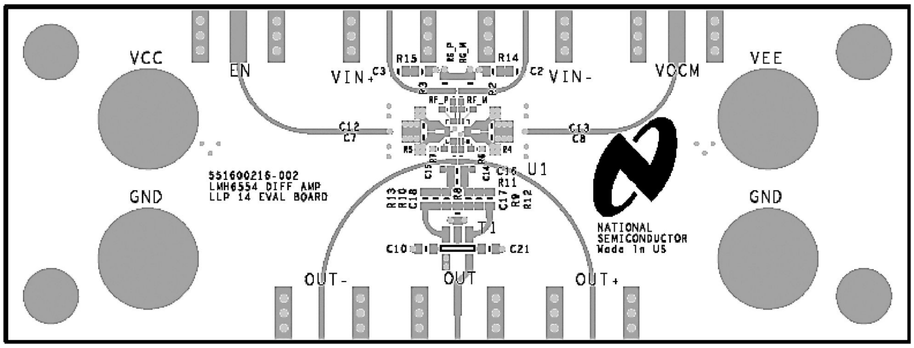


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**FIGURE 2. Board Layout Top View**

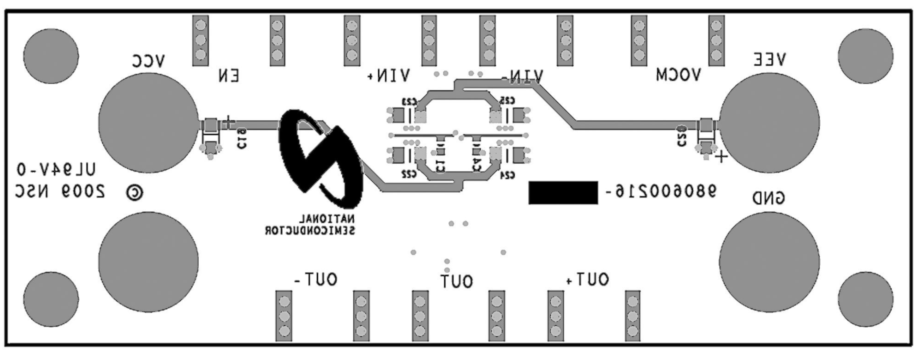

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**FIGURE 3. Board Layout Bottom View**

# Notes

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