

AN-1975 LMP8640/LMP8645 Evaluation Board

1 Introduction

This evaluation board shows a bidirectional high-side current sense made using LMP8640 (LMP8645) and optional differential amplifier in order to have a single output.

2 Connectors

2.1 Power Supply

There are two banana plugs labeled GND and V_{CC} to power the evaluation board. Moreover, a banana plug labeled VCC_Amp is used to power an optional operational amplifier that makes the difference between the outputs of the two LMP8640 (LMP8645).

2.2 Signal Connectors

There are five connectors for signals.

Table 1. Input signals

IN	It connects the non inverting input of U1 and inverting input of U2.
LOAD	It connects the non inverting input of U2 and inverting input of U1.

The device U1 is able to sense the current when it flows in the shunt resistor from the LOAD pin to the IN pin. The device U2 is able to sense the current when it flows in the shunt resistor from IN pin to LOAD pin.

Table 2. Output signals

OUT+	Output of device U2, the voltage at this pin is related to the current that flows from the IN pin to the LOAD pin.
OUT-	Output of device U1, the voltage at this pin is related to the current that flows from the LOAD pin to the IN pin.
OUT	Optional Output of the difference amplifier that makes the difference between OUT+ and OUT-

3 Hardware Setup

3.1 Power Supply Setup

- High side current sense LMP8640 (LMP8645)
 - Connect a supply voltage in the range between 2.7 V and 12 V to the V_{CC} and GND turrets.
- Optional difference amplifier
 - Connect a supply according to the specs of the amplifier to the VCC_Amp and GND turrets.

3.2 Source and Load Setup

First case: Current flows from IN to LOAD plugs.

A voltage supply can be connected between the IN and the GND banana plugs, while a load is connected between the LOAD and the GND banana plugs. The voltage applied at the IN pin should not exceed the maximum common mode voltage allowed by the LMP8640/HV (LMP8645/HV). The maximum allowed common mode voltages are listed in [Table 3](#).

Second case: Current flows from LOAD to IN plugs.

In this case, the voltage supply is connected between the LOAD and the GND banana plugs, while the load is connected between the IN and GND banana plugs. The voltage applied at LOAD pin should not exceed the maximum common mode voltage allowed by the LMP8640/HV (LMP8645/HV). The maximum allowed common mode voltages are listed in [Table 3](#).

Table 3. Max Common Mode Voltage

DEVICE	MAX VCM
LMP8640	42V
LMP8645	42V
LMP8640HV	76V
LMP8645HV	76V

According to the shunt resistor (Rsns), to the gain of LMP8640 (LMP8645) and to the supply voltage different ranges of currents can be sensed with this evaluation board.

3.3 Components

On the evaluation board, there are already the circuit and the footprint of a standard dual op amp (U3) to implement a differential op amp (U3.B) with reference (U3.A) in order to provide a single ended output of the bidirectional current.

Table 4. Optional Differential Circuit

U3	Standard Dual Op Amp 8 pin. U3.1 OUT A U3.2 -IN A U3.3 +IN A U3.4 V- U3.5 +IN B U3.6 -IN B U3.7 OUT B U3.8 V+
R1, R2, R3, R4	resistors that implement the differential circuit according to Equation 1 :
$OUT = -\frac{R4}{R1} * OUT^- + \left(1 + \frac{R4}{R1}\right) * \left(\frac{R2}{R2 + R3} * Vref + \frac{R3}{R2 + R3} * OUT^+\right)$	
(1)	
R5, R6, C5	components for voltage reference and its filter. The voltage reference is calculating according to Equation 2 :
$Vref = \frac{R5}{R5 + R6} * VCC_Amp$	
(2)	

4 Using the Evaluation Board

4.1 Input and Output Signals

The evaluation board allows you to measure a bidirectional current, so the IN and LOAD banana connectors can act either as the Source or LOAD pin. If the current flows from the IN pin to the LOAD pin, a simple way to test the performance of the LMP8640 (LMP8645) is shown in [Figure 1](#).

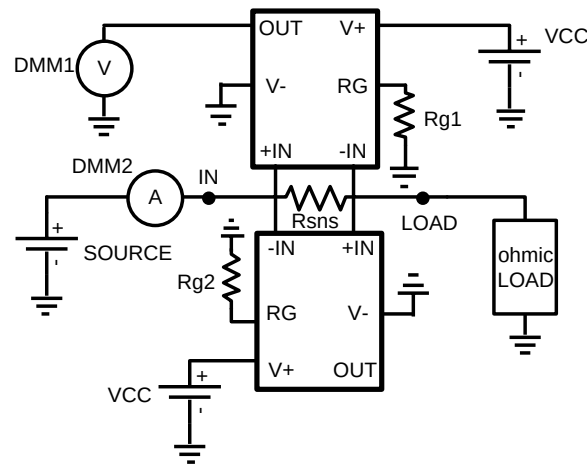


Figure 1. LMP8640 (LMP8645) Measurement Setup

The DMM1 is configured as a voltmeter, which measures the output of the LMP8640 (LMP8645), while the DMM2 is configured as an Ammeter, which measures the current that flows in the LOAD. The source is a voltage supply that makes sure to set a voltage in the range of -2 V to +46 V for LMP8640 (LMP8645) or -2 V to +76 V for LMP8640HV (LMP8645HV).

4.2 Gain Selection of LMP8645

The evaluation board is provided with a shunt resistor R_{sns} (10 mΩ, @ 1%, 1W), while two gain resistors R_{g1} and R_{g2} (10 kΩ, @1%) ensure a gain of 2 V/V for each current sense. The Gain is evaluated according to formula in [Equation 3](#):

$$\text{Gain} = \frac{R_g}{5k\Omega} \text{ V/V} \quad (3)$$

The gain resistor must be chosen such that the max output voltage does not exceed the LMP8645 max output voltage rating for a given common mode voltage (further details in the Datasheet).

4.3 Single Output

In the applications where a single measurement of a bidirectional current sense is needed is possible to populate the evaluation board with two amplifiers and some resistors (see [Section 3.3](#)).

For instance, in the following configuration:

$$R_1 = R_2 = R_3 = R_4 = 10 \text{ k}\Omega,$$

$$R_5 = R_6 = 10 \text{ k}\Omega$$

$$\text{OUT} = V_{\text{REF}} + (\text{OUT}^+ - \text{OUT}^-)$$

$$V_{\text{REF}} = 0.5 \cdot V_{\text{CC_Amp}}.$$

The V_{REF} level represents the zero level; the voltages greater than V_{REF} are related to a current that flows from IN pin to the LOAD pin while the voltages less than V_{REF} are related to a current that flows from the LOAD pin to the IN pin. To ensure good results in the measurements, the resistors R4 and R3 and the resistors R1 and R2 need to be well matched.

5 Bill Of Materials (BOM)

Table 5. Bill Of Materials ^{(1), (2)}

Designator	Component	Value	Tolerance	Package Type
C1, C3	Capacitor	0.01 μ F	5%	0603
C2, C6*	Capacitor	1 μ F	10%	3216–18
C4	Capacitor	0.1 μ F	10%	0805
C5*, C7	Capacitor	0.1 μ F	10%	0603
C_Filt1*, C_Filt2*	Capacitor			0805
CG1*, CG2*	Capacitor			0805
R1*, R2*, R3*, R4*, R5*, R6*	Resistor	min 10 k Ω	1%	0603
RG1**, RG2**	Resistor	10.0 k Ω	1%	0603
Rsns**	Resistor	0.01 Ω	1%, 1W	2010
Rsns	Resistor	0.01 Ω	0.1%, 1W	2512
R_Filt_1, R_Filt2	Resistor		5%	0805
U3*	Dual Op Amp			SOT-8

⁽¹⁾ Components Marked With (*) are not soldered on the board.

⁽²⁾ Components marked with (**) are soldered only on LMP8645 board.

This schematic shows the evaluation board with a LMP8645 mounted on the PCB. The only difference for the version of the PCB stuffed with LMP8640 will be the gain resistors RG1, RG2. The LMP8640 is a current sense with fixed gain, so it doesn't require any external gain resistor.

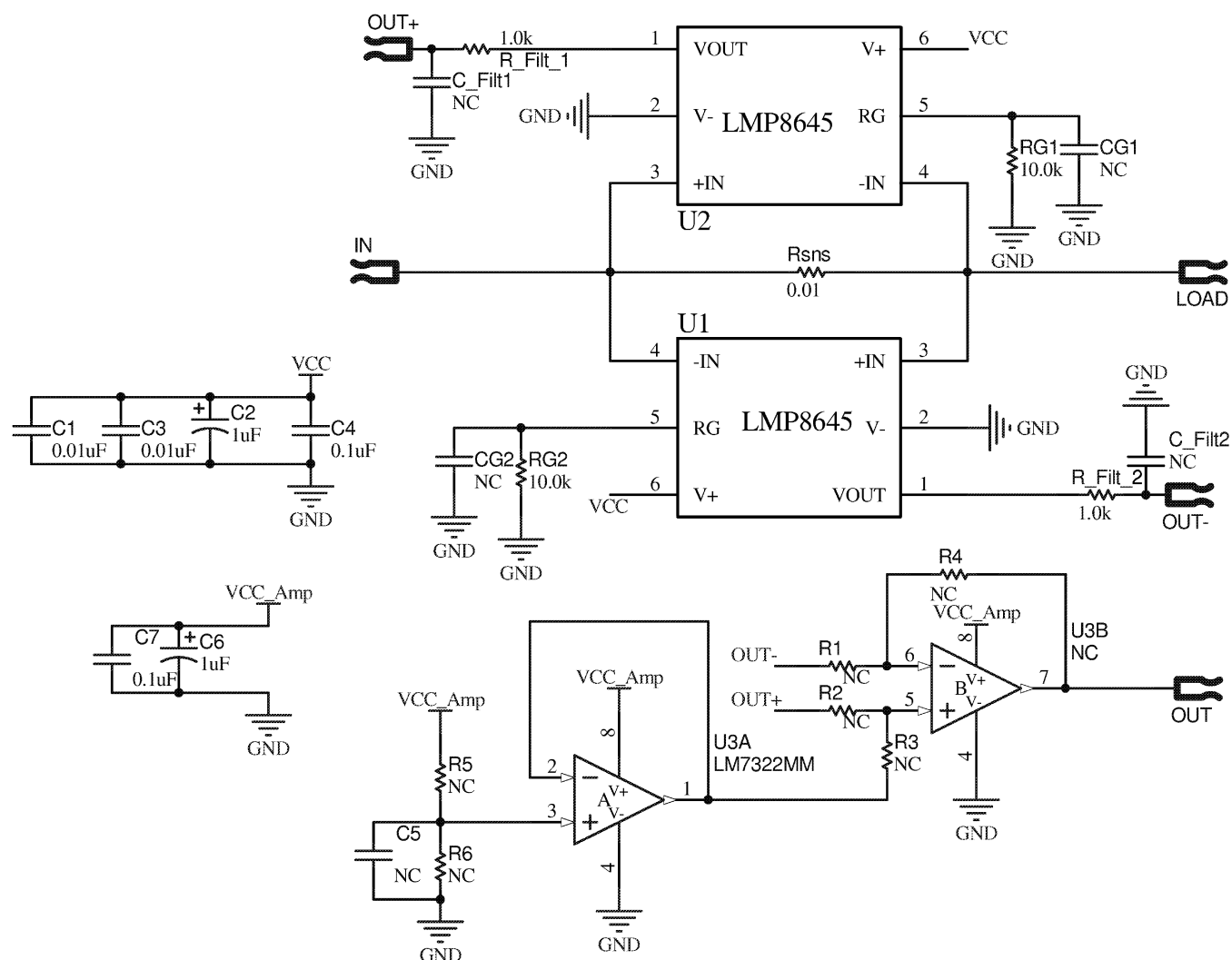


Figure 2. Schematic Diagram

Appendix B Layout

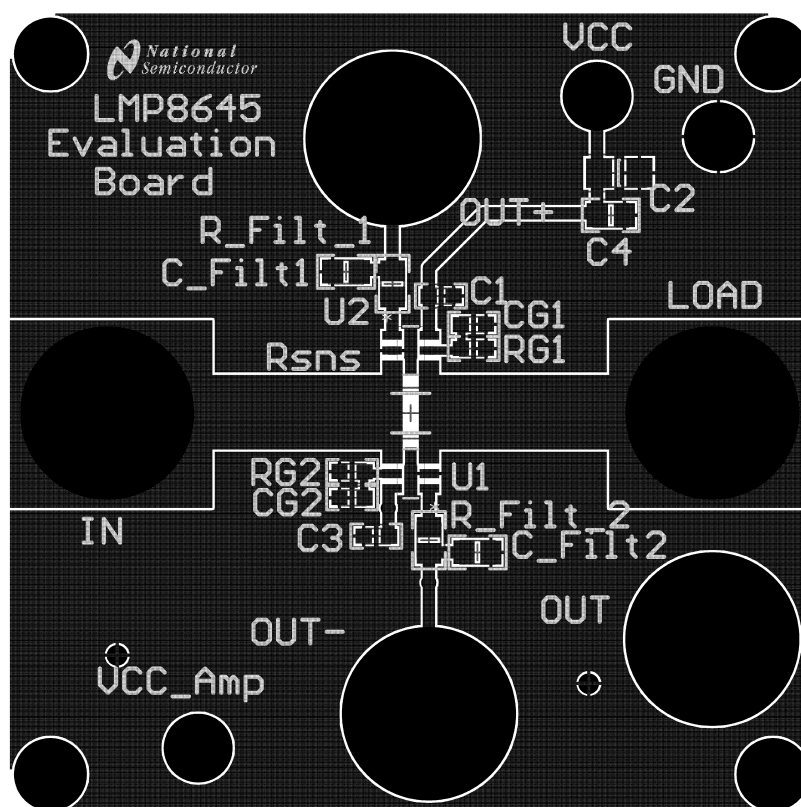
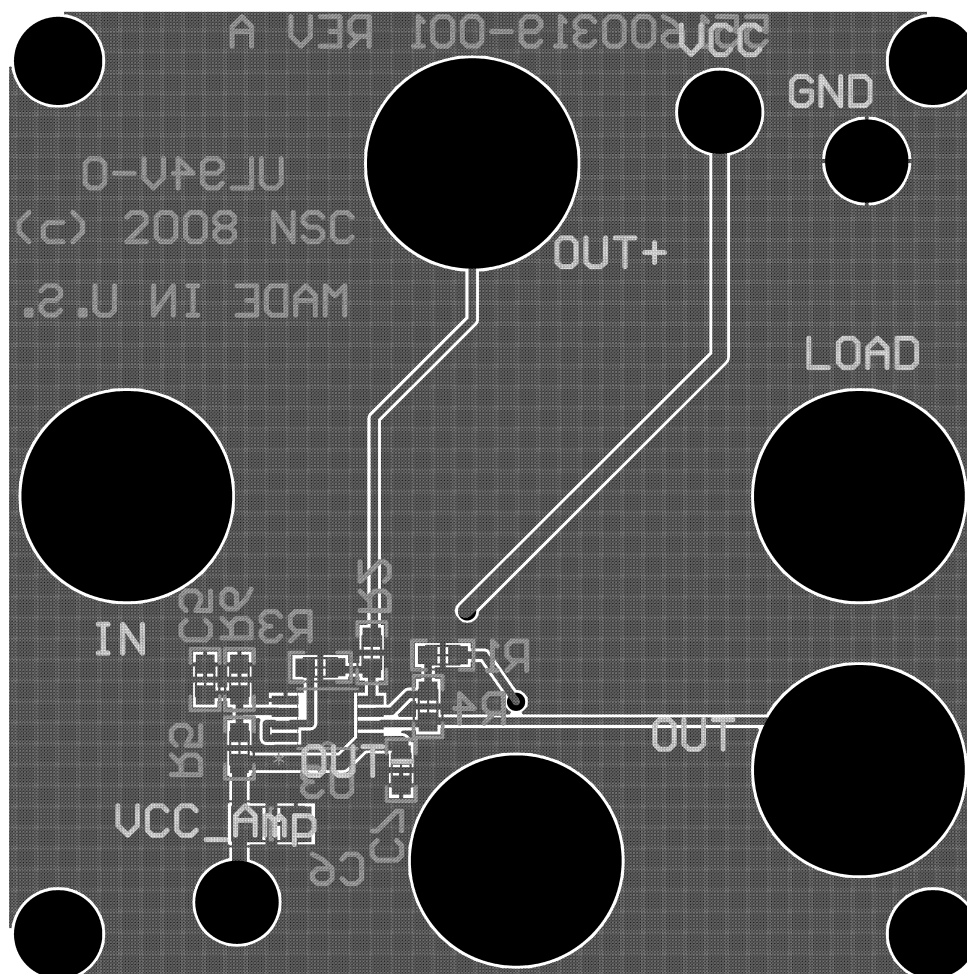


Figure 3. Top Layer



**Figure 4. Bottom Layer
PCB Layout**

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