AN836

Current Sense Amplifier Performance Comparison: TS1100 vs. Maxim MAX9634

1. Introduction

Overall measurement accuracy in current-sense amplifiers is a function of both gain error and amplifier input offset voltage performance. Of the two error sources, amplifier input offset voltage can impact the design more so than gain error. If the sense resistor needs to be small to maximize power to the load and to minimize power dissipation; then amplifier input offset voltage becomes the dominant error term. To minimize load current sense error, a current-sense amplifier with a lower input offset voltage is required. By comparing the TS1100 against the MAX9634 side-by-side, the TS1100's 3-to-1 improvement in amplifier input offset voltage translates into a 2x improvement in current measurement accuracy.

2. Overview

As shown in Table 1, the TS1100 family of current sense amplifiers provides an input offset voltage of only 30 µV with a gain option of 25, 50, 100, and 200. When compared to the MAX9634, the TS1100 exhibits a factor of three lower input offset voltage.

Table 1. TS1100 and MAX9634 Data Sheet Specifications

TS1100	MAX9634	
TS1100	±30 (typ)	±100 (typ)
Gain Error (%)	±0.1%	±0.1%
Gain Options	25	25
	50	50
	100	100
	200	200

The output voltage is a function of the gain and VSENSE. However, due to a finite gain error and input offset voltage, VOS, the total output voltage is a function of the gain error, VSENSE, and VOS. This is shown in Equations 1 and 2 below.

$$V_{OUT}(\text{ideal}) = \text{Gain} \times V_{SENSE}$$

Equation 1.

$$V_{OUT}(\text{actual}) = \text{Gain} \times V_{SENSE} + \text{Gain} \times (\pm\text{Gain error} \times V_{SENSE} \pm V_{OS})$$

Equation 2.

2.1. Performance Comparison Set-Up

The TS1100 and the MAX9634 evaluation boards were used to perform side-by-side load current measurements. With on-board 50 mΩ sense resistors and a 100 mA load currents, a gain of 50 current sense amplifier and 5mV sense resistor voltage should ideally generate a 250 mV output voltage. Figures 1 and 2 show the TS1100-50 evaluation board and evaluation board circuit schematic while Figures 3 and 4 show the MAX9634 evaluation board and evaluation board and circuit schematic, respectively. Figure 5 shows the lab bench setup used to perform the measurements. Both set-ups were independent and separate instruments were used to perform the measurements on each evaluation board. In addition, a separate active load was used for each evaluation board. The only common piece of equipment used was the power supply.

Figure 1. TS1100-50 Evaluation Board

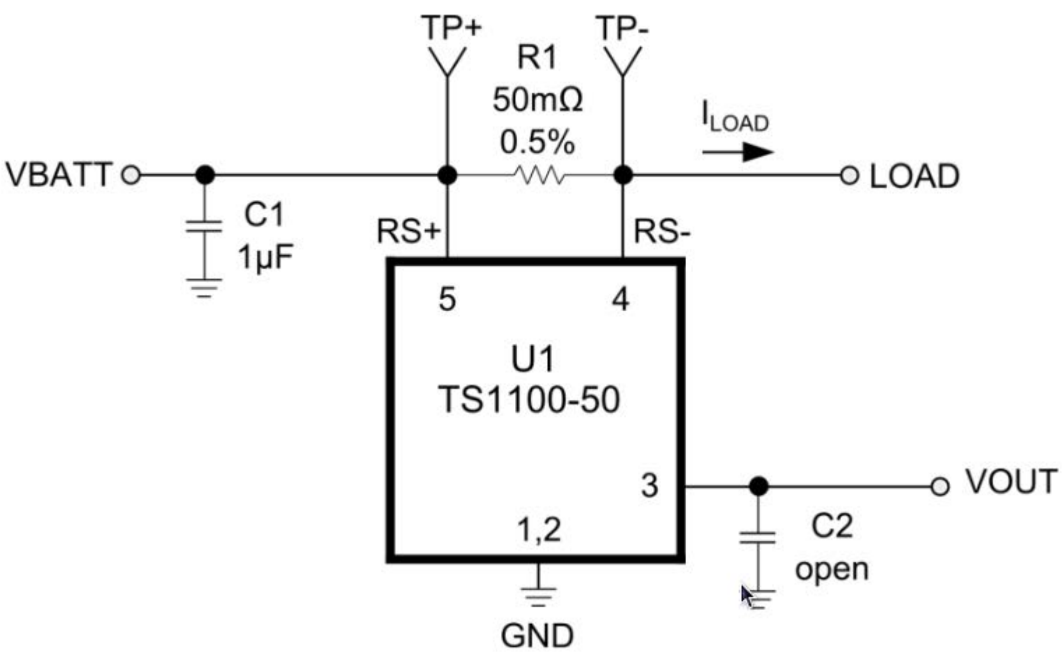


Figure 2. TS1100-50 Evaluation Board Circuit Schematic

Figure 3. MAX9634 Evaluation Board

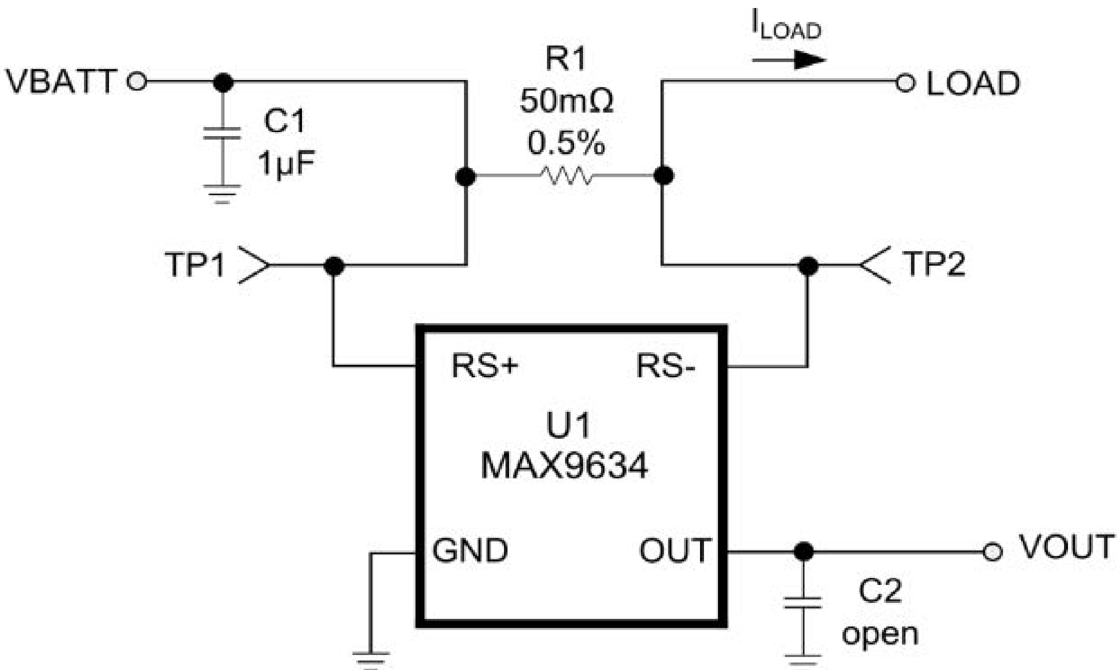


Figure 4. MAX9634F Evaluation Board Circuit Schematic

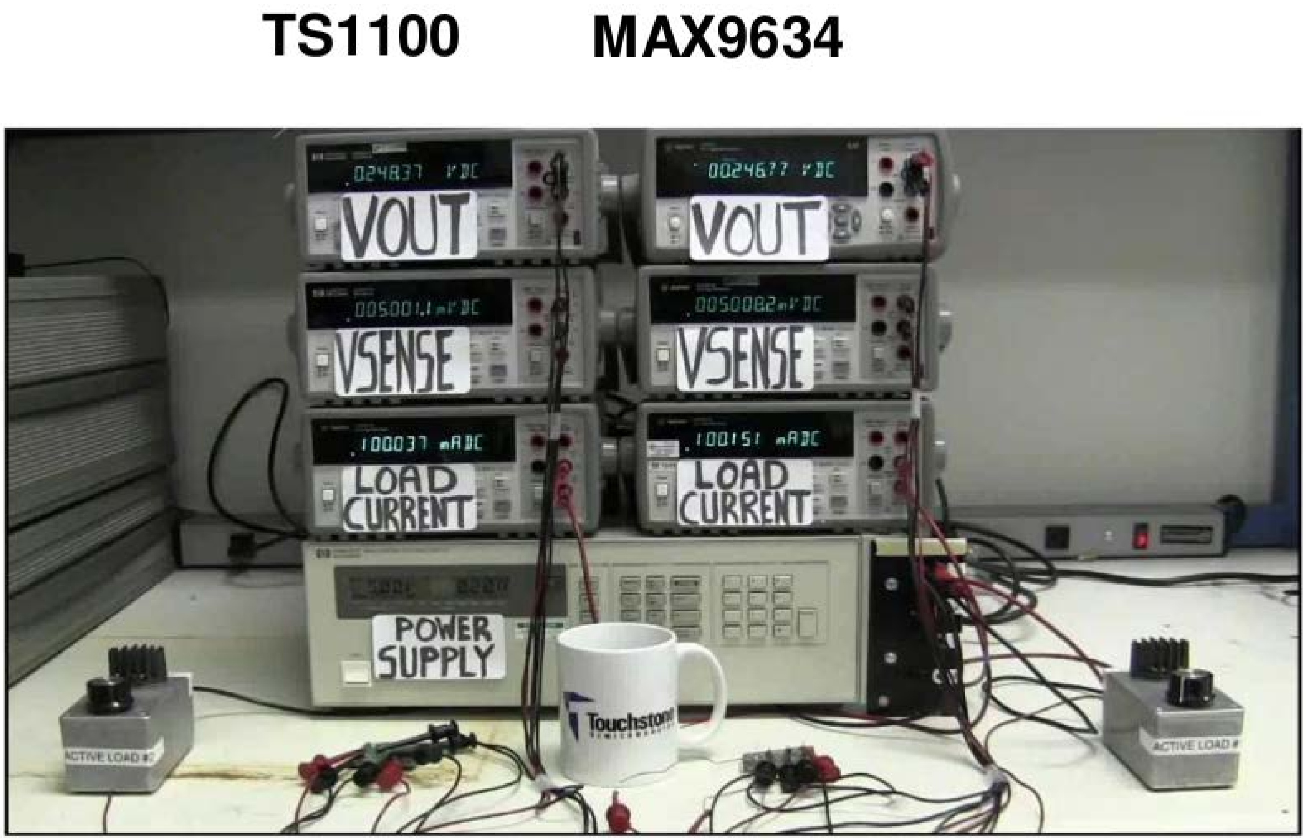


Figure 5. TS1100 and MAX9634 Side-by-Side Lab Bench Setup

2.2. Performance Comparison Results

The results are shown in Table 2 where VSENSE, ILOAD, and VOUT were measured for both devices.

Table 2. TS1100 and MAX9634 Data Sheet Specifications

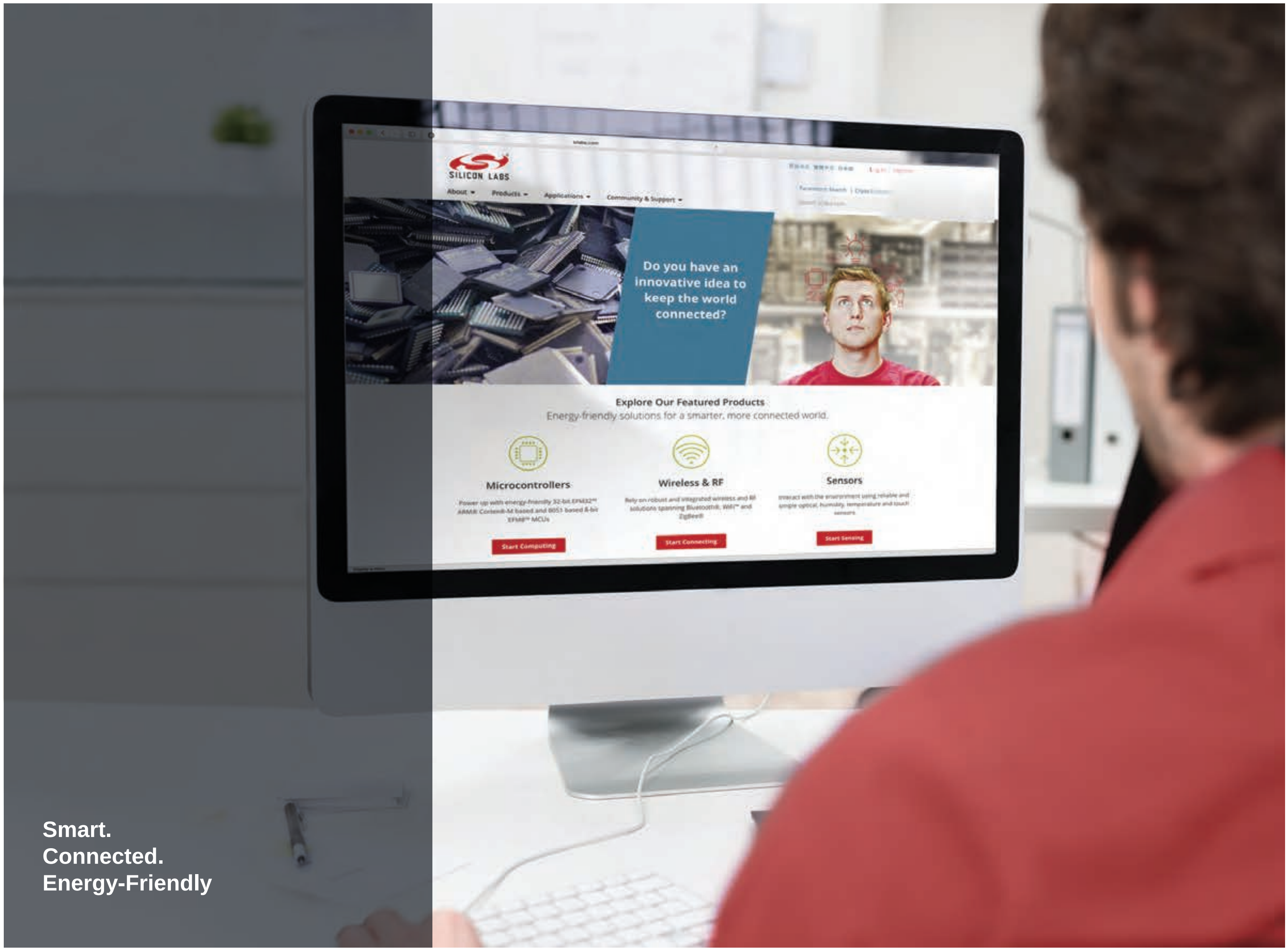
TS1100-50	MAX9634F
$\text{Input Offset Voltage(at } I_{LOAD} = 0) = \frac{V_{OUT}}{50} =$ **32µV**	$\text{Input Offset Voltage(at } I_{LOAD} = 0) = \frac{V_{OUT}}{50} =$ 89µV
$\%error = \frac{[V_{OUT}(measured) - V_{OUT}(ideal)]}{V_{OUT}(ideal)} \times 100$	
%error = 0.64%	%error = 1.28%
I_{LOAD} = ±100 mA R_{SENSE} = 50mΩ ±1% V_{SENSE} = 5 mV V_{OUT}(measured) = 248.4 mV V_{OUT}(ideal) = 250 mV	I_{LOAD} = ±100 mA R_{SENSE} = 50mΩ ±1% V_{SENSE} = 5 mV V_{OUT}(measured) = 248.4 mV V_{OUT}(ideal) = 250 mV

2.3. Parasitic Resistance Considerations

Because the RSENSE resistor and trace resistances can vary from board to board, each demo board's ILOAD was adjusted using its own active load in order to equalize the VSENSE voltage. In a design, it is important to measure the exact sense resistor value and then calculate the necessary load current while taking into account any small trace resistances that can affect the load current measurement.

3. Conclusion

Because its input offset voltage is 3 times lower than the MAX9634, the TS1100 exhibits an improved load current sense accuracy by a factor of 2 over the MAX9634. Available in a pcb-space saving SOT23-5 package, the TS1100 consumes less than 1µA of supply current, can be used in applications that operate from 2 V to 25 V, and is available in four gain options: 25, 50, 100, and 200. This makes the TS1100 an ideal solution for load current measurement in power conscious applications. See documentation on the TS1100 Current-Sense Amplifier and TS9634 Current-Sense Amplifier. For additional information, contact Silicon Labs.



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