Current Sense Amplifier Performance Comparison: Touchstone TS1100 versus Maxim MAX9634

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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.

As shown in Table 1, the TS1100 family of current sense amplifiers provides an input offset voltage of only 30µV 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.

	TS1100	**MAX9634**
Input offset (µV)	±30 (typ)	±100 (typ)
Gain error(%)	±0.1%	±0.1%
Gain options	25 50 100 200	25 50 100 200

Table 1: TS1100 and MAX9634 datasheet specifications

The output voltage is a function of the gain and V_{SENSE}. However, due to a finite gain error and input offset voltage, V_{OS}, the total output voltage is a function of the gain error, V_{SENSE}, and V_{OS}. This is shown in Equations 1 and 2 below.

$$V_{OUT}(\text{ideal}) = \text{Gain} \times V_{SENSE} \quad (1)$$

$$V_{OUT}(\text{actual}) = \text{Gain} \times V_{SENSE} + \text{Gain} \times (\pm \text{Gain error} \times V_{SENSE} \pm V_{OS}) \quad (2)$$

Performance Comparison Set-Up

The TS1100 and the MAX9634 evaluation boards were used to perform side-by-side load current measurements. With on-board 50mΩ sense resistors and a 100mA load currents, a gain of 50 current sense amplifier and 5mV sense resistor voltage should ideally generate a 250mV 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.

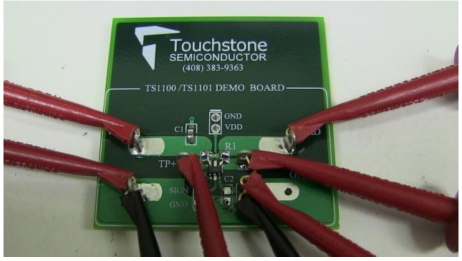

Figure 1: TS1100-50 Evaluation Board

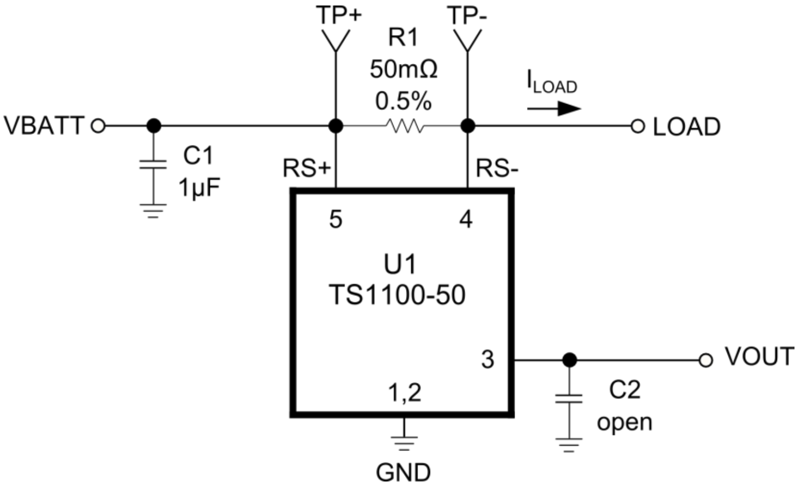

Figure 2: TS1100-50 Evaluation Board Circuit Schematic

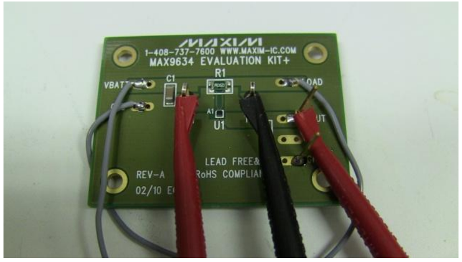

Figure 3: MAX9634 Evaluation Board

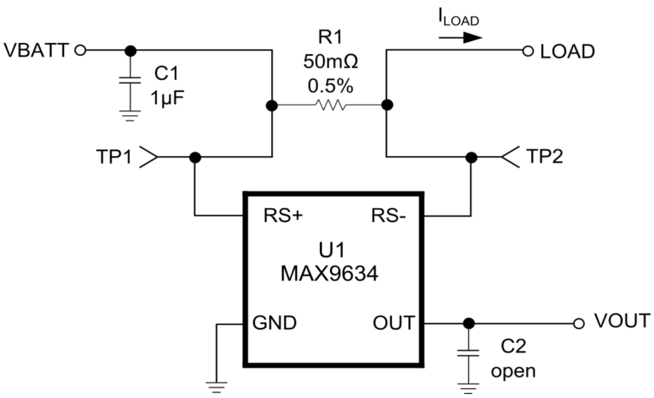

Figure 4: MAX9634F Evaluation Board Circuit Schematic

TS1100 **MAX9634**

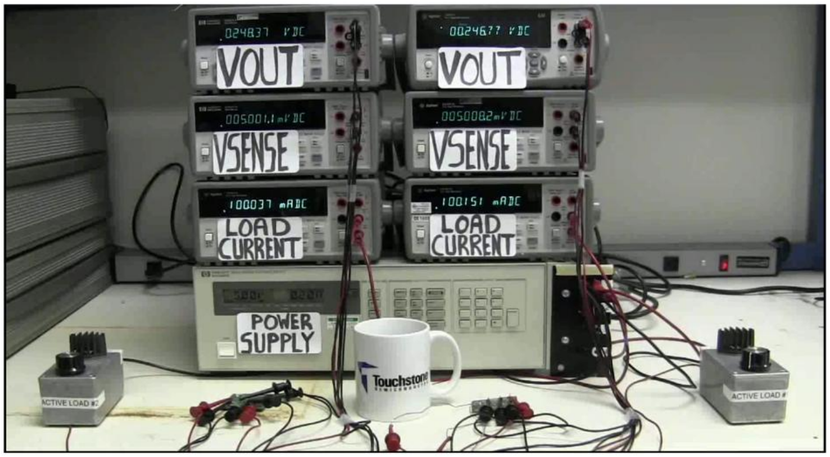

Figure 5: TS1100 and MAX9634 side-by-side lab bench set-up

Performance Comparison Results

The results are shown in Table 2 where V_{SENSE}, I_{LOAD}, and V_{OUT} were measured for both devices.

TS1100-50	MAX9634F
Input Offset Voltage(at $I_{LOAD}=0$) = $\frac{V_{OUT}}{50}$ = **32µV**	Input Offset Voltage(at $I_{LOAD}=0$) = $\frac{V_{OUT}}{50}$ = 89µV
$\%error=\frac{[V_{OUT}(measured)-V_{OUT}(ideal)]}{V_{OUT}(ideal)}\ x100$	
%error = 0.64%	%error = 1.28%
I_{LOAD} = ±100mA R_{SENSE} = 50mΩ ±1% V_{SENSE} = 5mV V_{OUT}(measured) = **248.4mV** V_{OUT} (ideal) = 250mV	I_{LOAD} = ±100mA R_{SENSE} = 50mΩ ±1% V_{SENSE} = 5mV V_{OUT}(measured) = **246.8mV** V_{OUT} (ideal) = 250mV

Table 2: TS1100 and MAX9634 Performance Results

While the MAX9634 operates within its datasheet limits and given the exact same test conditions, the TS1100 output voltage accuracy of 0.64% is two times *more* accurate than the MAX9634's output voltage accuracy of 1.28%.

Parasitic Resistance Considerations

Because the R_{SENSE} resistor and trace resistances can vary from board to board, each demo board's I_{LOAD} was adjusted using its own active load in order to equalize the V_{SENSE} 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.

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 2V to 25V, 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.

For additional information, please follow the links to the corresponding product pages:

- TS1100 Current-Sense Amplifier
- TS9634 Current-Sense Amplifier

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