



# Precision LOGARITHMIC AND LOG RATIO AMPLIFIERS

## FEATURES

- EASY-TO-USE COMPLETE FUNCTION
- OUTPUT SCALING AMPLIFIER
- ON-CHIP 2.5V VOLTAGE REFERENCE
- HIGH ACCURACY: 0.2% FSO Over 5 Decades
- WIDE INPUT DYNAMIC RANGE:  
7.5 Decades, 100pA to 3.5mA
- LOW QUIESCENT CURRENT: 1.75mA
- WIDE SUPPLY RANGE:  $\pm 4.5V$  to  $\pm 18V$
- PACKAGES: SO-14 (narrow) and SO-16

## APPLICATIONS

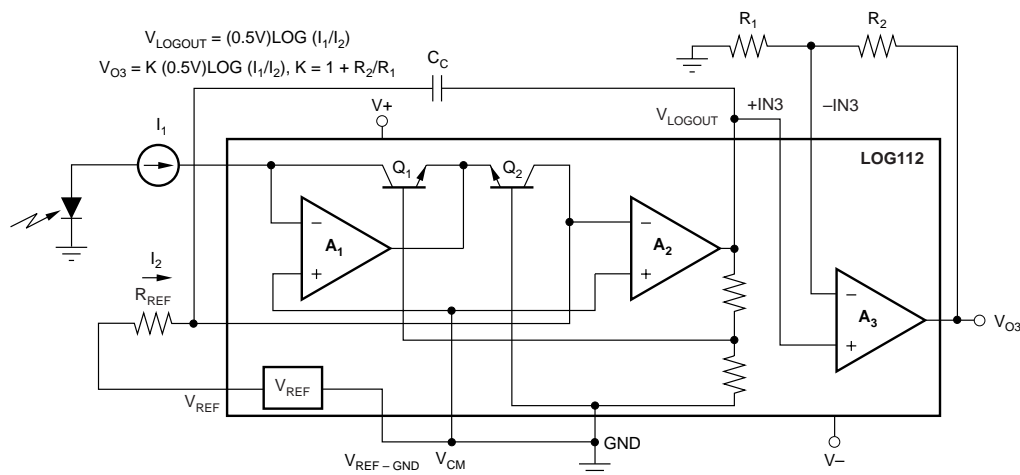
- LOG, LOG RATIO:  
Communication, Analytical, Medical, Industrial,  
Test, General Instrumentation
- PHOTODIODE SIGNAL COMPRESSION AMP
- ANALOG SIGNAL COMPRESSION IN FRONT  
OF ANALOG-TO-DIGITAL (A/D) CONVERTER
- ABSORBANCE MEASUREMENT
- OPTICAL DENSITY MEASUREMENT

## DESCRIPTION

The LOG112 and LOG2112 are versatile integrated circuits that compute the logarithm or log ratio of an input current relative to a reference current.  $V_{\text{LOGOUT}}$  of the LOG112 and LOG2112 are trimmed to 0.5V per decade of input current, ensuring high precision over a wide dynamic range of input signals.

The LOG112 and LOG2112 features a 2.5V voltage reference that may be used to generate a precision current reference using an external resistor.

Low DC offset voltage and temperature drift allow accurate measurement of low-level signals over the specified temperature range of  $-5^{\circ}\text{C}$  to  $+75^{\circ}\text{C}$ .



NOTE: Internal resistors are used to compensate gain change over temperature. The  $V_{\text{CM}}$  pin is internally connected to GND in the LOG2112.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

Supply Voltage, V+ to V- .....	±18V
Inputs .....	±18V
Input Current .....	±10mA
Output Short-Circuit Current <sup>(2)</sup> .....	Continuous
Operating Temperature .....	-40°C to +85°C
Storage Temperature .....	-55°C to +125°C
Junction Temperature .....	+150°C
Lead Temperature (soldering, 10s) .....	+300°C

NOTES: (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. (2) One output per package.



## ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

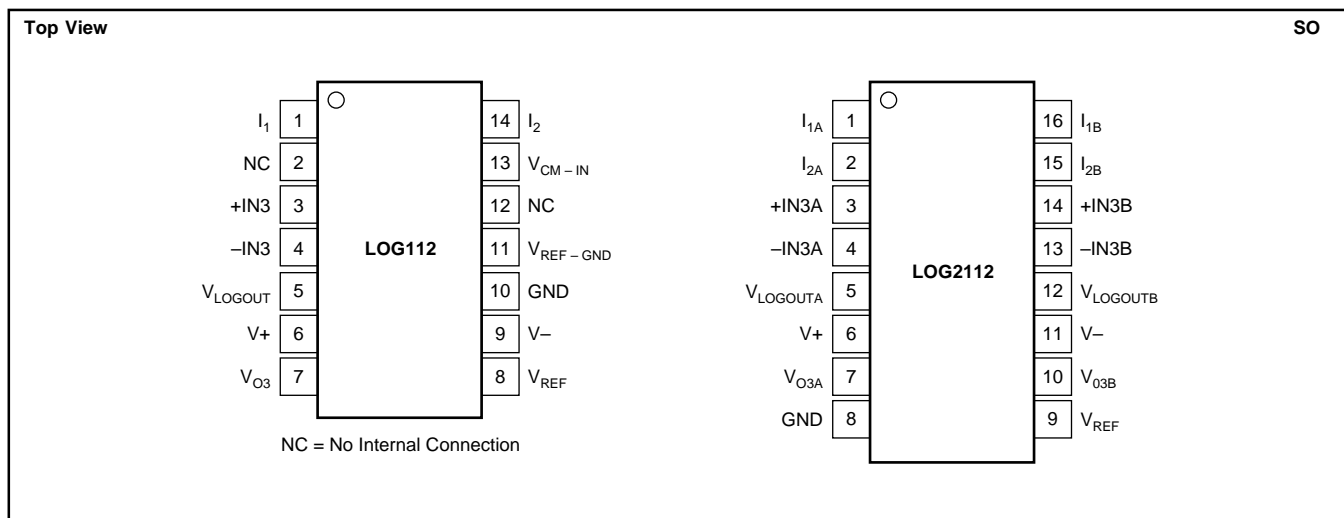
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR <sup>(1)</sup>	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
LOG112	SO-14	D	-5°C to +75°C	LOG112A	LOG112AID	Rails, 250
"	"	"	"	"	LOG112AIDR	Tape and Reel, 2500
LOG2112	SO-16	DW	-5°C to +75°C	LOG2112A	LOG2112AIDW	Rails, 250
"	"	"	"	"	LOG2112AIDWR	Tape and Reel, 2500

NOTE: (1) For the most current specifications and package information, refer to our web site at [www.ti.com](http://www.ti.com).

## PIN CONFIGURATION



# ELECTRICAL CHARACTERISTICS

**Boldface** limits apply over the specified temperature range,  $T_A = -5^{\circ}\text{C}$  to  $+75^{\circ}\text{C}$ .

At  $T_A = +25^{\circ}\text{C}$ ,  $V_S = \pm 5\text{V}$ , and  $R_{OUT} = 10\text{k}\Omega$ , unless otherwise noted.

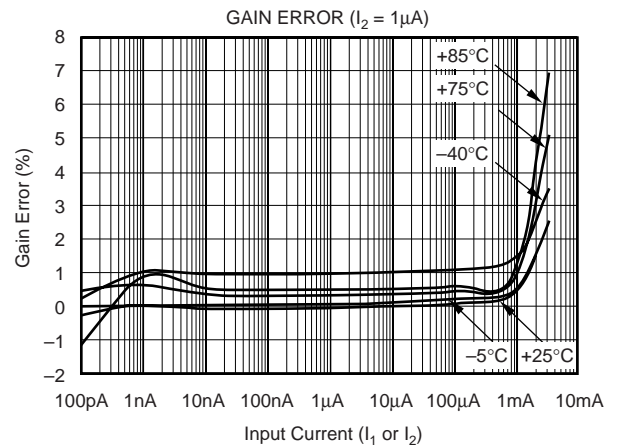
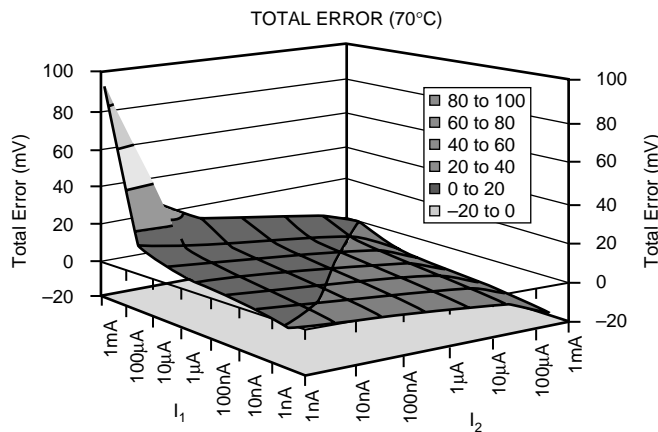
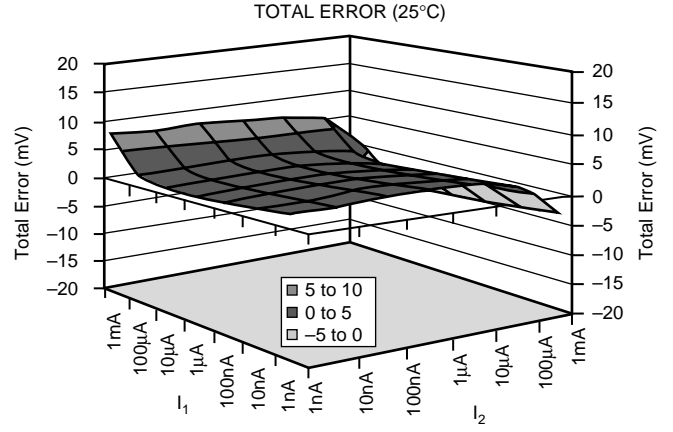
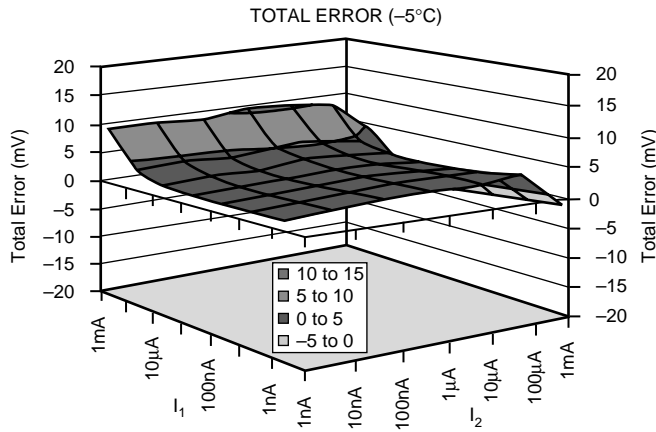
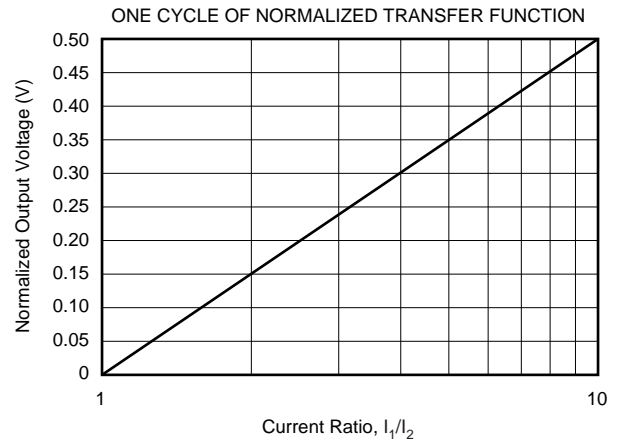
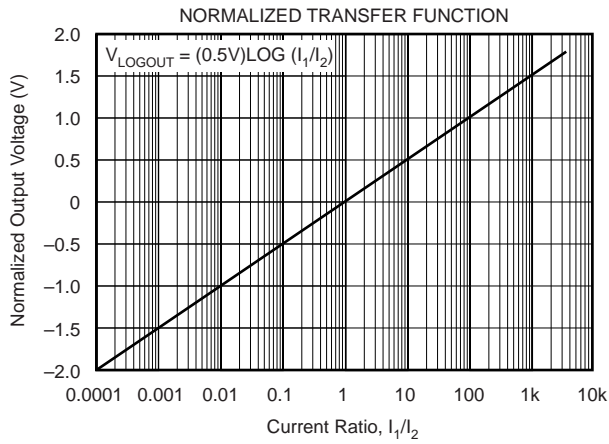
PARAMETER	CONDITION	LOG112, LOG2112			UNITS
		MIN	TYP	MAX	
<b>CORE LOG FUNCTION</b> $V_{IN}/V_{OUT}$ Equation		$V_{LOGOUT} = (0.5V)\text{LOG}(I_1/I_2)$			V
<b>LOG CONFORMITY ERROR<sup>(1)</sup></b> Initial	1nA to 100 $\mu$ A (5 decades) 100pA to 3.5mA (7.5 decades)		0.01 0.13	0.2	% %
<b>over Temperature</b>	<b>1nA to 100<math>\mu</math>A (5 decades)</b> <b>100pA to 3.5mA (7.5 decades)</b>		0.0001 0.005		<b>%/<math>^{\circ}\text{C}</math></b> <b>%/<math>^{\circ}\text{C}</math></b>
<b>GAIN<sup>(2)</sup></b> Initial Value	1nA to 100 $\mu$ A		0.5		V/decade
Gain Error	1nA to 100 $\mu$ A		0.10	$\pm 1$	%
<b>vs Temperature</b>	<b><math>T_{MIN}</math> to <math>T_{MAX}</math></b>		<b>0.003</b>	<b>0.01</b>	<b>%/<math>^{\circ}\text{C}</math></b>
<b>INPUT, <math>A_{1A}</math> and <math>A_{1B}</math>, <math>A_{2A}</math>, <math>A_{2B}</math></b> Offset Voltage	$T_{MIN}$ to $T_{MAX}$ $V_S = \pm 4.5\text{V}$ to $\pm 18\text{V}$		$\pm 0.3$	$\pm 1.5$	mV
<b>vs Temperature</b>			$\pm 2$		$\mu\text{V}/^{\circ}\text{C}$
vs Power Supply (PSRR)			5	20	$\mu\text{V}/\text{V}$
Input Bias Current			$\pm 5$		pA
<b>vs Temperature</b>		<b><math>T_{MIN}</math> to <math>T_{MAX}</math></b>		<b>Doubles Every <math>10^{\circ}\text{C}</math></b>	
Voltage Noise	f = 10Hz to 10kHz		3		$\mu\text{Vrms}$
Current Noise	f = 1kHz		30		nV/ $\sqrt{\text{Hz}}$
Common-Mode Voltage Range (Positive)	f = 1kHz	(V+) - 2	(V+) - 1.5		V
(Negative)		(V-) + 2	(V-) + 1.2		V
Common-Mode Rejection Ratio (CMRR)			10		$\mu\text{V}/\text{V}$
<b>OUTPUT, (<math>V_{LOG OUT}</math>) <math>A_{2A}</math>, <math>A_{2B}</math></b> Output Offset, $V_{OSO}$ , Initial	$T_{MIN}$ to $T_{MAX}$ $V_S = \pm 5\text{V}$		$\pm 3$	$\pm 15$	mV
<b>vs Temperature</b>			$\pm 10$		$\mu\text{V}/^{\circ}\text{C}$
Full-Scale Output (FSO)		(V-) + 1.2			(V+) - 1.5
Short-Circuit Current			$\pm 18$		mA
<b>TOTAL ERROR<sup>(3)(4)</sup></b> Initial	$I_1$ or $I_2$ remains fixed while other varies. Min to Max $I_1$ or $I_2 = 5\text{mA}$ ( $V_S \geq \pm 6\text{V}$ )			$\pm 150$	mV
	$I_1$ or $I_2 = 3.5\text{mA}$			$\pm 75$	mV
	$I_1$ or $I_2 = 1\text{mA}$			$\pm 20$	mV
	$I_1$ or $I_2 = 100\mu\text{A}$			$\pm 20$	mV
	$I_1$ or $I_2 = 10\mu\text{A}$			$\pm 20$	mV
	$I_1$ or $I_2 = 1\mu\text{A}$			$\pm 20$	mV
	$I_1$ or $I_2 = 100\text{nA}$			$\pm 20$	mV
	$I_1$ or $I_2 = 10\text{nA}$			$\pm 20$	mV
	$I_1$ or $I_2 = 1\text{nA}$			$\pm 20$	mV
	$I_1$ or $I_2 = 350\text{pA}$			$\pm 20$	mV
	$I_1$ or $I_2 = 100\text{pA}$			$\pm 20$	mV
<b>vs Temperature</b>	<b><math>I_1</math> or <math>I_2 = 3.5\text{mA}</math></b>		$\pm 1.2$		<b>mV/<math>^{\circ}\text{C}</math></b>
	<b><math>I_1</math> or <math>I_2 = 1\text{mA}</math></b>		$\pm 0.4$		<b>mV/<math>^{\circ}\text{C}</math></b>
	<b><math>I_1</math> or <math>I_2 = 100\mu\text{A}</math></b>		$\pm 0.1$		<b>mV/<math>^{\circ}\text{C}</math></b>
	<b><math>I_1</math> or <math>I_2 = 10\mu\text{A}</math></b>		$\pm 0.05$		<b>mV/<math>^{\circ}\text{C}</math></b>
	<b><math>I_1</math> or <math>I_2 = 1\mu\text{A}</math></b>		$\pm 0.05$		<b>mV/<math>^{\circ}\text{C}</math></b>
	<b><math>I_1</math> or <math>I_2 = 100\text{nA}</math></b>		$\pm 0.09$		<b>mV/<math>^{\circ}\text{C}</math></b>
	<b><math>I_1</math> or <math>I_2 = 10\text{nA}</math></b>		$\pm 0.2$		<b>mV/<math>^{\circ}\text{C}</math></b>
	<b><math>I_1</math> or <math>I_2 = 1\text{nA}</math></b>		$\pm 0.3$		<b>mV/<math>^{\circ}\text{C}</math></b>
	<b><math>I_1</math> or <math>I_2 = 350\text{pA}</math></b>		$\pm 0.1$		<b>mV/<math>^{\circ}\text{C}</math></b>
	<b><math>I_1</math> or <math>I_2 = 100\text{pA}</math></b>		$\pm 0.3$		<b>mV/<math>^{\circ}\text{C}</math></b>
<b>vs Supply</b>	$I_1$ or $I_2 = 3.5\text{mA}$		$\pm 3.0$		mV/V
	$I_1$ or $I_2 = 1\text{mA}$		$\pm 0.1$		mV/V
	$I_1$ or $I_2 = 100\mu\text{A}$		$\pm 0.1$		mV/V
	$I_1$ or $I_2 = 10\mu\text{A}$		$\pm 0.1$		mV/V
	$I_1$ or $I_2 = 1\mu\text{A}$		$\pm 0.1$		mV/V
	$I_1$ or $I_2 = 100\text{nA}$		$\pm 0.1$		mV/V
	$I_1$ or $I_2 = 10\text{nA}$		$\pm 0.1$		mV/V
	$I_1$ or $I_2 = 1\text{nA}$		$\pm 0.25$		mV/V
	$I_1$ or $I_2 = 350\text{pA}$		$\pm 0.1$		mV/V
	$I_1$ or $I_2 = 100\text{pA}$		$\pm 0.1$		mV/V

NOTES: (1) Log Conformity Error is the peak deviation from the best-fit-straight line of  $V_O$  versus  $\text{LOG}(I_1/I_2)$  curve expressed as a percent of peak-to-peak full-scale output. K, scale factor, equals 0.5V output per decade of input current. (2) Scale factor of core log function is trimmed to 0.5V output per decade change of input current. (3) Worst-case Total Error for any ratio of  $I_1/I_2$ , as the largest of the two errors, when  $I_1$  and  $I_2$  are considered separately. (4) Total Error includes offset voltage, bias current, gain, and log conformity. (5) Bandwidth (3dB) and transient response are a function of both the compensation capacitor and the level of input current.



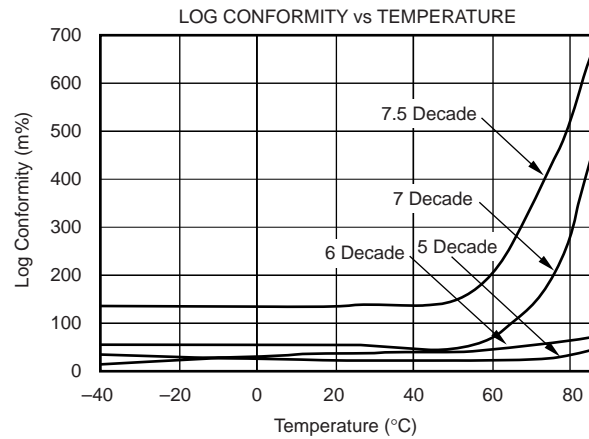
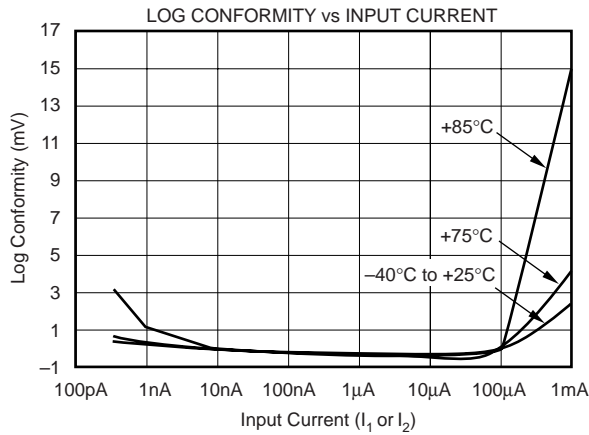
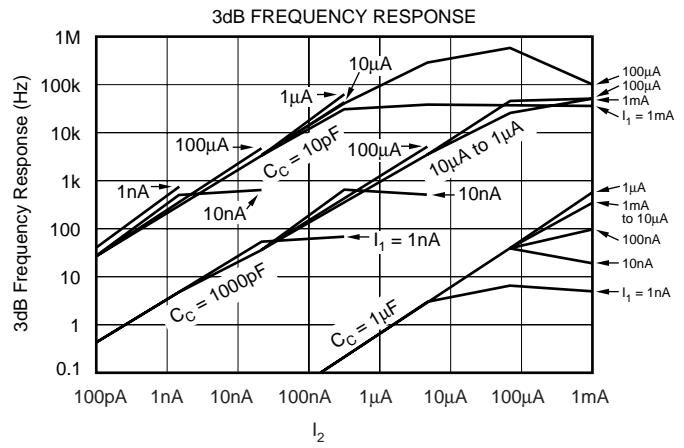
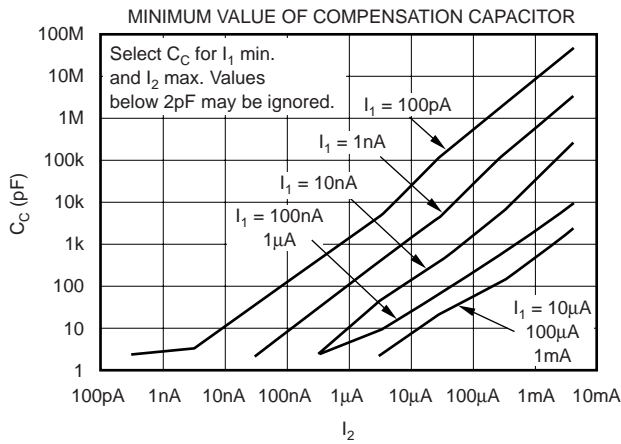
# TYPICAL CHARACTERISTICS

At  $T_A = +25^\circ\text{C}$ ,  $V_S = \pm 5\text{V}$ , and  $R_L = 10\text{k}\Omega$ , unless otherwise noted.



# TYPICAL CHARACTERISTICS (Cont.)

At  $T_A = +25^\circ\text{C}$ ,  $V_S = \pm 5\text{V}$ , and  $R_L = 10\text{k}\Omega$ , unless otherwise noted.



# APPLICATION INFORMATION

The LOG112 is a true logarithmic amplifier that uses the base-emitter voltage relationship of bipolar transistors to compute the logarithm, or logarithmic ratio of a current ratio.

Figure 1 and Figure 2 show the basic connections required for operation of the LOG112 and LOG2112. In order to reduce the influence of lead inductance of power-supply lines, it is recommended that each supply be bypassed with a 10µF tantalum capacitor in parallel with a 1000pF ceramic capacitor, as shown in Figure 1 and Figure 2. Connecting the capacitors as close to the LOG112 and LOG2112 as possible will contribute to noise reduction as well.

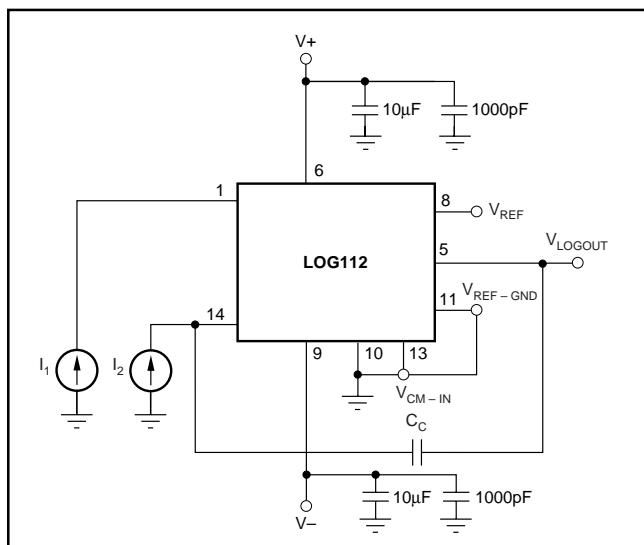


FIGURE 1. Basic Connections of the LOG112.

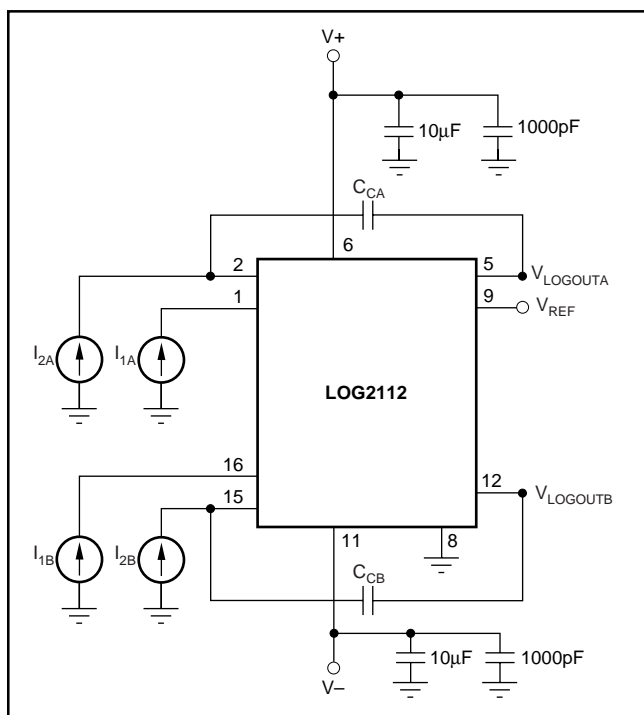


FIGURE 2. Basic Connections of the LOG2112.

## INPUT CURRENT RANGE

To maintain specified accuracy, the input current range of the LOG112 and LOG2112 should be limited from 100pA to 3.5mA. Input currents outside of this range may compromise the LOG112 performance. Input currents larger than 3.5mA result in increased nonlinearity. An absolute maximum input current rating of 10mA is included to prevent excessive power dissipation that may damage the input transistor.

On ±5V supplies, the total input current ( $I_1 + I_2$ ) is limited to 4.5mA. Due to compliance issues internal to the LOG112 and LOG2112, to accommodate larger total input currents, supplies should be increased.

## SETTING THE REFERENCE CURRENT

When the LOG112 and LOG2112 are used to compute logarithms, either  $I_1$  or  $I_2$  can be held constant to become the reference current to which the other is compared.

$V_{LOGOUT}$  is expressed as:

$$V_{LOGOUT} = (0.5V) \text{LOG} (I_1/I_{REF}) \quad (1)$$

$I_{REF}$  can be derived from an external current source (such as that shown in Figure 3), or it may be derived from a voltage source with one or more resistors. When a single resistor is used, the value may be large depending on  $I_{REF}$ . If  $I_{REF}$  is 10nA and +2.5V is used:

$$R_{REF} = 2.5V/10nA = 250M\Omega \quad (2)$$

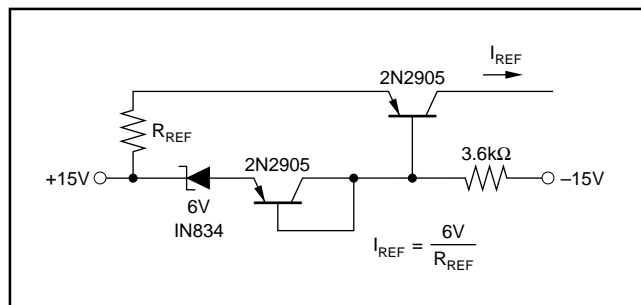


FIGURE 3. Temperature Compensated Current Source.

A voltage divider may be used to reduce the value of the resistor, as shown in Figure 4. When using this method, one must consider the possible errors caused by the amplifier's input offset voltage. The input offset voltage of amplifier  $A_1$  has a maximum value of 1.5mV, making  $V_{REF}$  a suggested value of 100mV.

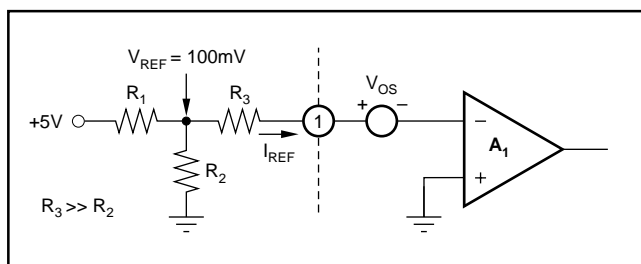


FIGURE 4. T Network for Reference Current.

Figure 5 shows a low-level current source using a series resistor. The low offset op amp reduces the effect of the LOG112 and LOG2112's input offset voltage.

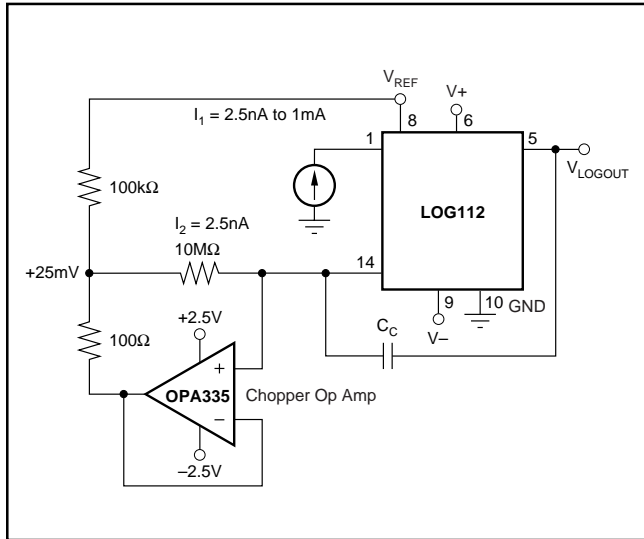


FIGURE 5. Current Source with Offset Compensation.

### FREQUENCY RESPONSE

The frequency response curves seen in the Typical Characteristic curves are shown for constant DC  $I_1$  and  $I_2$  with a small-signal AC current on one input.

The 3dB frequency response of the LOG112 and LOG2112 are a function of the magnitude of the input current levels and of the value of the frequency compensation capacitor. See typical characteristic curve "3dB Frequency Response" for details.

The transient response of the LOG112 and LOG2112 are different for increasing and decreasing signals. This is due to the fact that a log amp is a nonlinear gain element and has different gains at different levels of input signals. Smaller input currents require greater gain to maintain full dynamic range, and will slow the frequency response of the LOG112 and LOG2112.

### FREQUENCY COMPENSATION

Frequency compensation for the LOG112 is obtained by connecting a capacitor between pins 5 and 14. Frequency compensation for the LOG2112 is obtained by connecting a capacitor between pins 2 and 5, or 15 and 12. The size of the capacitor is a function of the input currents, as shown in the Typical Characteristic curves (Minimum Value of Compensation Capacitor). For any given application, the smallest value of the capacitor which may be used is determined by the maximum value of  $I_2$  and the minimum value of  $I_1$ . Larger values of  $C_C$  make the LOG112 and LOG2112 more stable, but reduce the frequency response.

In an application, highest overall bandwidth can be achieved by detecting the signal level at  $V_{OUT}$ , then switching in appropriate values of compensation capacitors.

### NEGATIVE INPUT CURRENTS

The LOG112 and LOG2112 function only with positive input currents (conventional current flows into input current pins). In situations where negative input currents are needed, the circuits in Figures 6, 7, and 8 may be used.

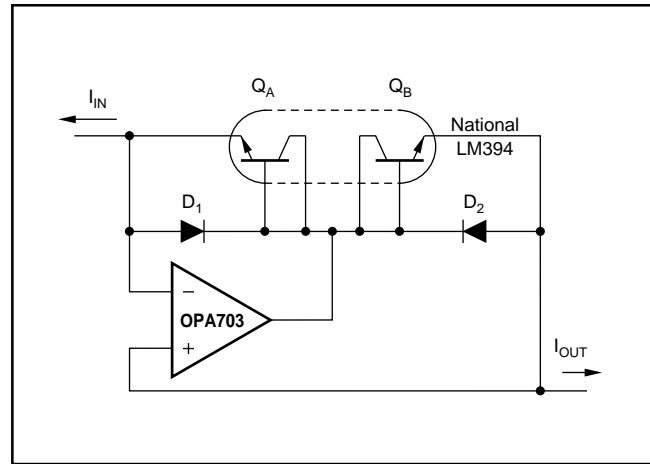


FIGURE 6. Current Inverter/Current Source.

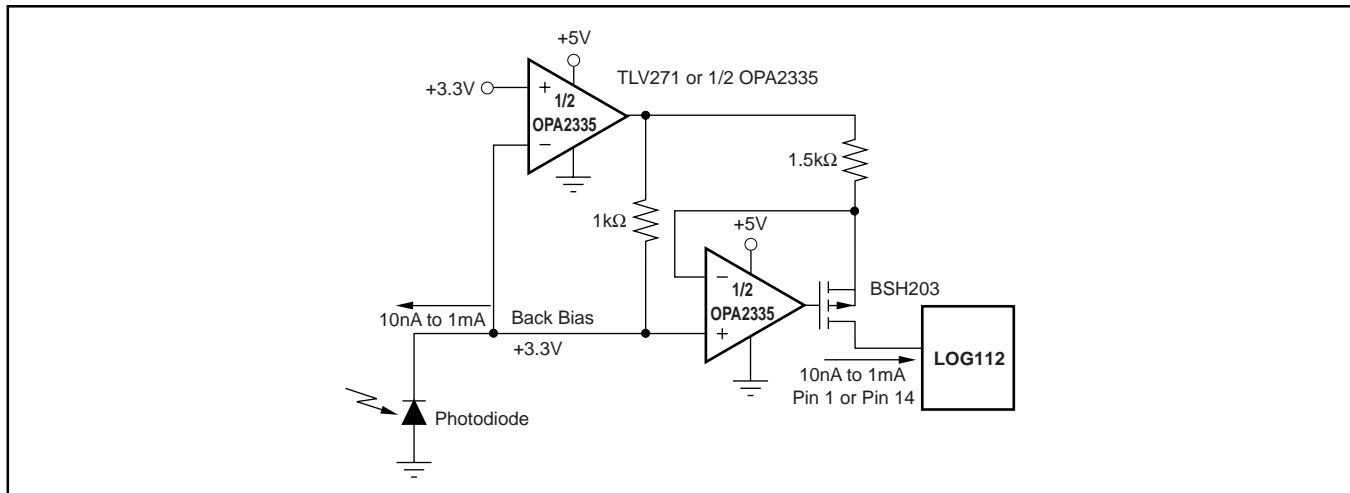


FIGURE 7. Precision Current Inverter/Current Source.



## VOLTAGE INPUTS

The LOG112 and LOG2112 give the best performances with current inputs. Voltage inputs may be handled directly with series resistors, but the dynamic input range is limited to approximately three decades of input voltage by voltage noise and offsets. The transfer function of Equation 13 applies to this configuration.

## ACHIEVING HIGHER ACCURACY WITH HIGHER INPUT CURRENTS

As input current to the LOG112 increases, output accuracy degrades. For a 4.5mA input current on  $\pm 5V$  supplies and a 10mA input current on  $\pm 12V$  supplies, total output error can be between 15% and 25%. Applying a common-mode volt-

age to  $V_{CM}$  of at least +1V and up to 2.5V, brings the log transistors out of saturation and reduces output error to approximately 10%. To avoid forward biasing a photodiode, return the cathode to the  $V_{CM}$  pin, as shown in Figure 9. To reverse bias the photodiode, apply a more positive voltage to the cathode than the anode.

## APPLICATION CIRCUITS

### LOG RATIO

One of the more common uses of log ratio amplifiers is to measure absorbance. See Figure 10 for a typical application.

$$\text{Absorbance of the sample is } A = \log \lambda_1 / \lambda_1 \quad (3)$$

$$\text{If } D_1 \text{ and } D_2 \text{ are matched } A \propto (0.5V) \log I_1 / I_2 \quad (4)$$

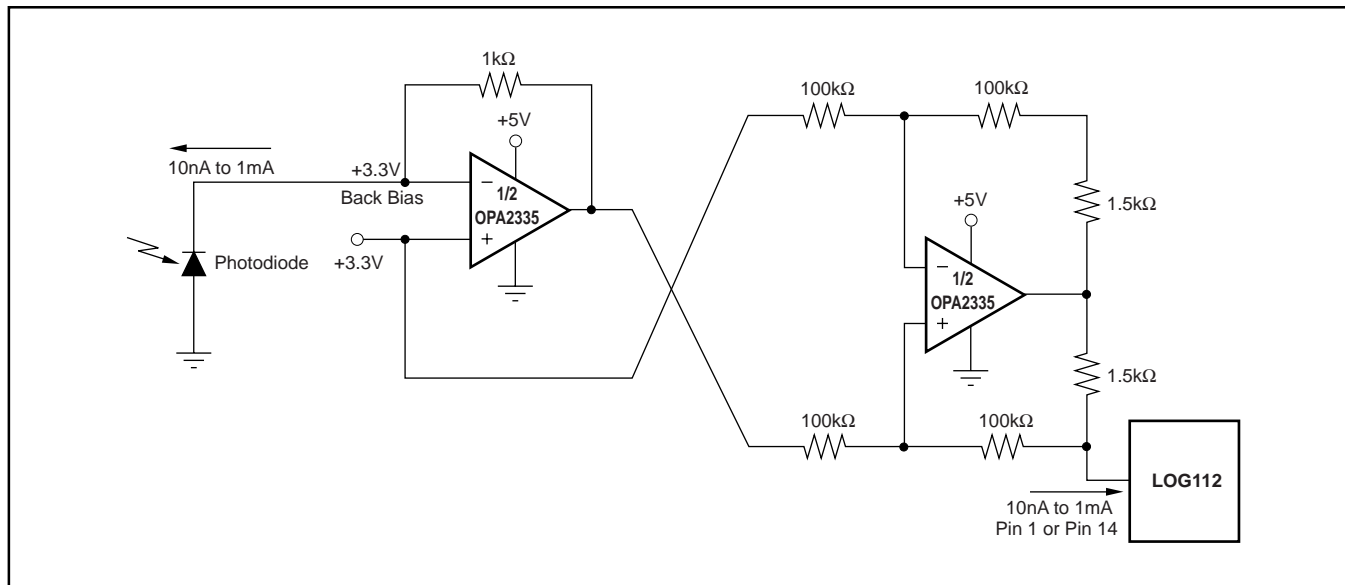


FIGURE 8. Precision Current Inverter/Current Source.

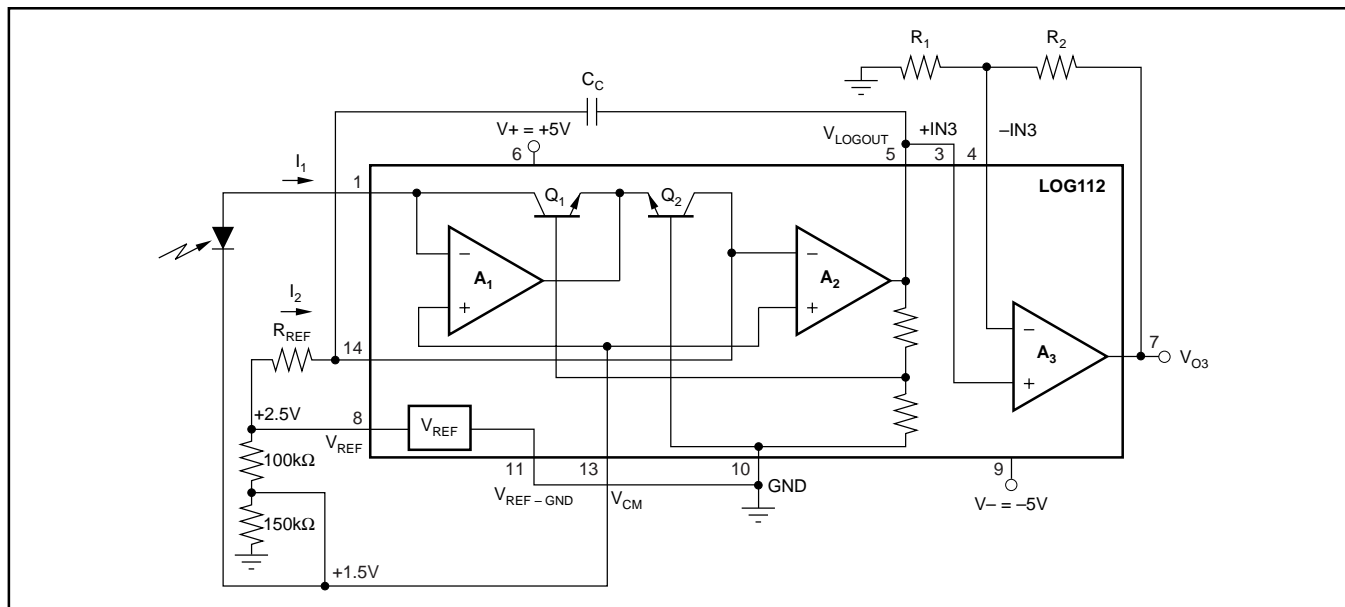


FIGURE 9. Extending Input Current Level and Improving Accuracy by Applying a Common-Mode Voltage.

## DATA COMPRESSION

In many applications, the compressive effects of the logarithmic transfer function are useful. For example, a LOG112 preceding a 12-bit A/D converter can produce the dynamic range equivalent to a 20-bit converter.

## OPERATION ON SINGLE SUPPLY

Many applications do not have the dual supplies required to operate the LOG112 and LOG2112. Figure 11 shows the LOG112 and LOG2112 configured for operation with a single +5V supply.

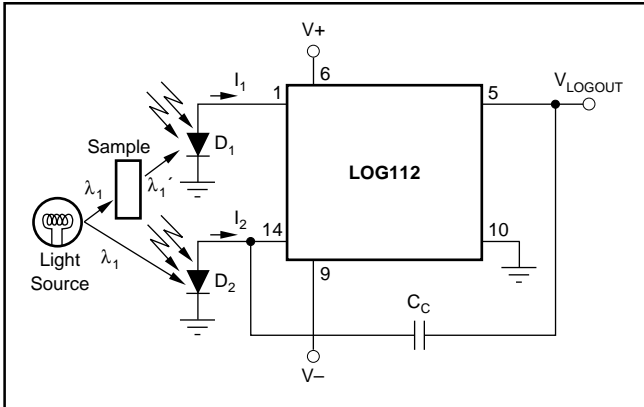


FIGURE 10. Absorbance Measurement.

## MEASURING AVALANCHE PHOTODIODE CURRENT

The wide dynamic range of the LOG112 and LOG2112 is useful for measuring avalanche photodiode current (APD), as shown in Figure 12.

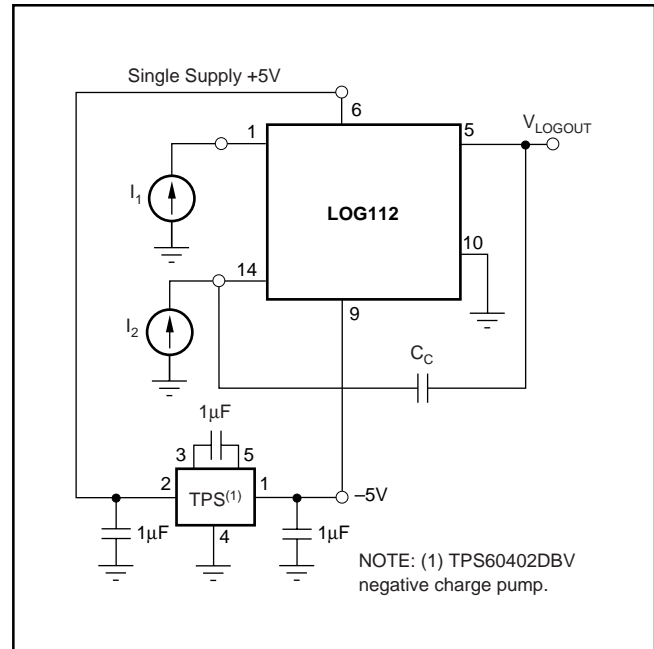


FIGURE 11. Single +5V Power-Supply Operation.

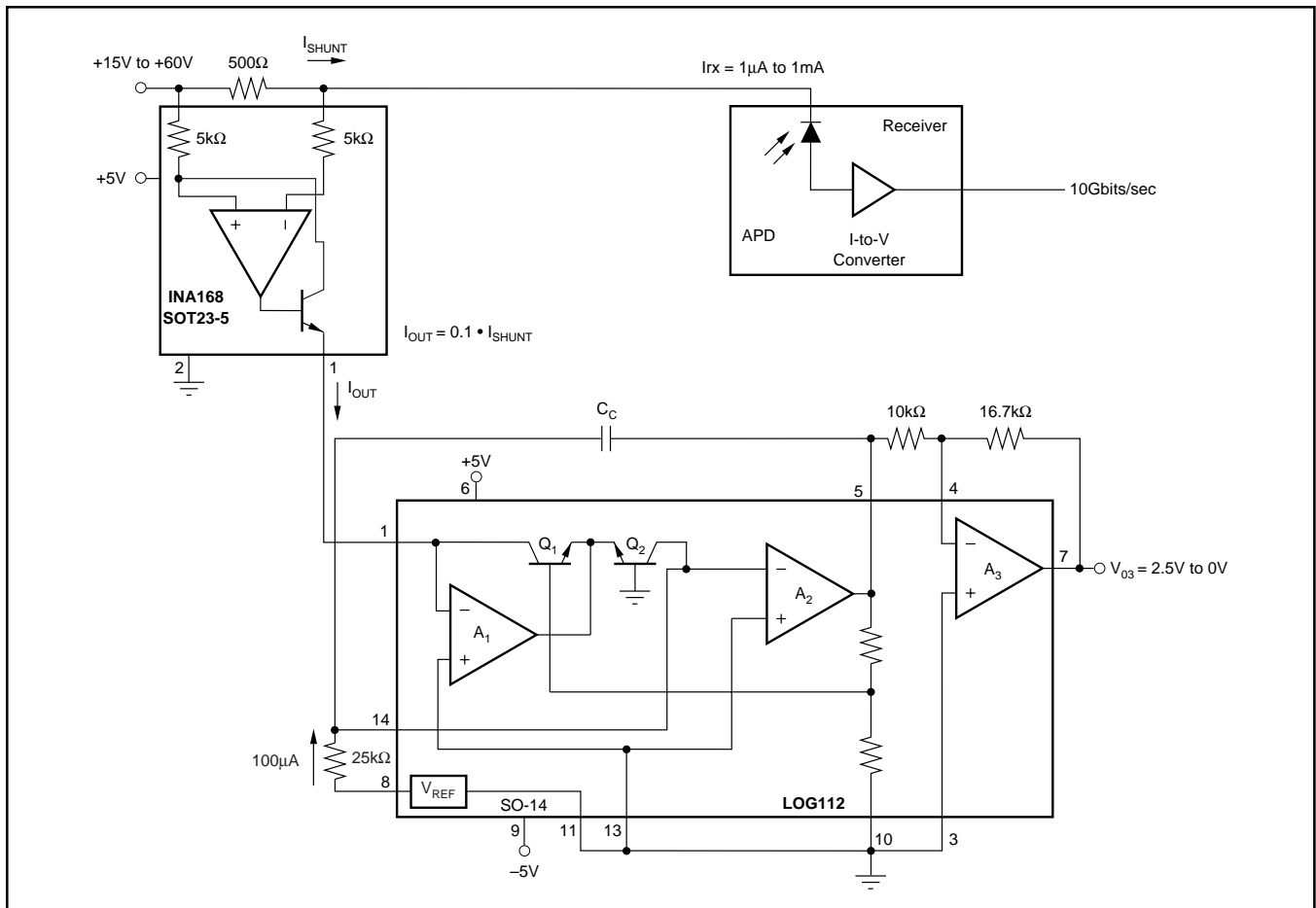


FIGURE 12. High-Side Shunt for APD Measures 3 Decades of APD Current.

# INSIDE THE LOG112

Using the base-emitter voltage relationship of matched bipolar transistors, the LOG112 establishes a logarithmic function of input current ratios. Beginning with the base-emitter voltage defined as:

$$V_{BE} = V_T \ln \frac{I_C}{I_S} \quad \text{where: } V_T = \frac{kT}{q} \quad (1)$$

$k$  = Boltzman's constant =  $1.381 \cdot 10^{-23}$

$T$  = Absolute temperature in degrees Kelvin

$q$  = Electron charge =  $1.602 \cdot 10^{-19}$  Coulombs

$I_C$  = Collector current

$I_S$  = Reverse saturation current

From the circuit in Figure 12:

$$V_L = V_{BE1} - V_{BE2} \quad (2)$$

Substituting (1) into (2) yields:

$$V_L = V_{T1} \ln \frac{I_1}{I_{S1}} - V_{T2} \ln \frac{I_2}{I_{S2}} \quad (3)$$

If the transistors are matched and isothermal and  $V_{T1} = V_{T2}$ , then (3) becomes:

$$V_L = V_{T1} \left[ \ln \frac{I_1}{I_S} - \ln \frac{I_2}{I_S} \right] \quad (4)$$

$$V_L = V_T \ln \frac{I_1}{I_2} \quad \text{and since} \quad (5)$$

$$\ln x = 2.3 \log_{10} x \quad (6)$$

$$V_L = n V_T \log \frac{I_1}{I_2} \quad (7)$$

$$\text{where } n = 2.3 \quad (8)$$

also

$$V_{OUT} = V_L \frac{R_1 + R_2}{R_1} \quad (9)$$

$$V_{OUT} = \frac{R_1 + R_2}{R_1} n V_T \log \frac{I_1}{I_2} \quad (10)$$

or

$$V_{OUT} = (0.5V) \text{LOG} \left( \frac{I_1}{I_2} \right) \quad (11)$$

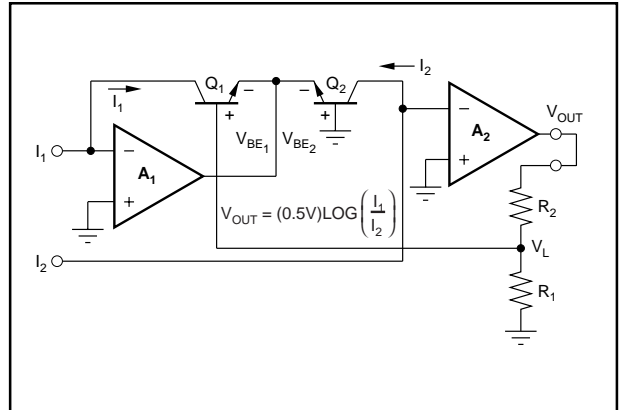


FIGURE 13. Simplified Model of a Log Amplifier.

NOTE:  $R_1$  is a metal resistor used to compensate for gain over temperature.

## DEFINITION OF TERMS

### TRANSFER FUNCTION

The ideal transfer function is:

$$V_{\text{LOGOUT}} = (0.5V) \text{LOG} (I_1/I_2)$$

Figure 14 shows the graphical representation of the transfer over valid operating range for the LOG112 and LOG2112.

### ACCURACY

Accuracy considerations for a log ratio amplifier are somewhat more complicated than for other amplifiers. This is because the transfer function is nonlinear and has two inputs, each of which can vary over a wide dynamic range. The accuracy for any combination of inputs is determined from the total error specification.

### TOTAL ERROR

The total error is the deviation (expressed in mV) of the actual output from the ideal output of  $V_{\text{LOGOUT}} = (0.5V) \text{LOG} (I_1/I_2)$ .

Thus,

$$V_{\text{LOGOUT(ACTUAL)}} = V_{\text{LOGOUT(IDEAL)}} \pm \text{Total Error} \quad (6)$$

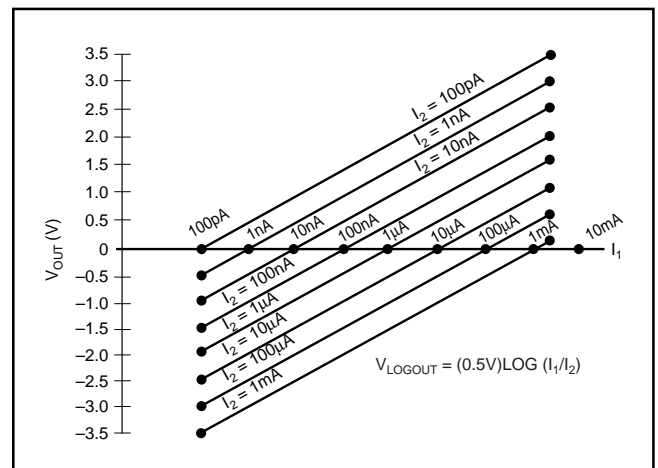


FIGURE 14. Transfer Function with Varying  $I_2$  and  $I_1$ .

It represents the sum of all the individual components of error normally associated with the log amp when operated in the current input mode. The worst-case error for any given ratio of  $I_1/I_2$  is the largest of the two errors when  $I_1$  and  $I_2$  are considered separately. Temperature can affect total error.

## ERRORS RTO AND RTI

As with any transfer function, errors generated by the function may be Referred-to-Output (RTO) or Referred-to-Input (RTI). In this respect, log amps have a unique property: given some error voltage at the log amp's output, that error corresponds to a constant percent of the input regardless of the actual input level.

## LOG CONFORMITY

For the LOG112 and LOG2112, log conformity is calculated the same as linearity and is plotted  $I_1/I_2$  on a semi-log scale. In many applications, log conformity is the most important specification. This is true because bias current errors are negligible (5pA compared to input currents of 100pA and above) and the scale factor and offset errors may be trimmed to zero or removed by system calibration. This leaves log conformity as the major source of error.

Log conformity is defined as the peak deviation from the best fit straight line of the  $V_{\text{LOGOUT}}$  versus  $\log(I_1/I_2)$  curve. This is expressed as a percent of ideal full-scale output. Thus, the nonlinearity error expressed in volts over  $m$  decades is:

$$V_{\text{LOGOUT (NONLIN)}} = 0.5\text{V/dec} \cdot 2NmV \quad (7)$$

where  $N$  is the log conformity error, in percent.

## INDIVIDUAL ERROR COMPONENTS

The ideal transfer function with current input is:

$$V_{\text{LOGOUT}} = (0.5\text{V})\text{LOG}\left(\frac{I_1}{I_2}\right) \quad (8)$$

The actual transfer function with the major components of error is:

$$V_{\text{LOGOUT}} = (0.5\text{V})(1 \pm \Delta K) \log\left(\frac{I_1 - I_{B1}}{I_2 - I_{B2}}\right) \pm Nm \pm V_{\text{OSO}} \quad (9)$$

The individual component of error is:

$\Delta K$  = gain error (0.10%, typ), as specified in the specification table.

$I_{B1}$  = bias current of  $A_1$  (5pA, typ)

$I_{B2}$  = bias current of  $A_2$  (5pA, typ)

$N$  = log conformity error (0.01%, 0.13%, typ)

0.01% for  $m = 5$ , 0.13% for  $m = 7.5$

$V_{\text{OSO}}$  = output offset voltage (3mV, typ)

$m$  = number of decades over which  $N$  is specified

For example, what is the error when:

$$I_1 = 1\mu\text{A} \text{ and } I_2 = 100\text{nA} \quad (10)$$

(11)

$$V_{\text{LOGOUT}} = (0.5 \pm 0.001) \log\left(\frac{10^{-6} - 5 \cdot 10^{-12}}{10^{-7} - 5 \cdot 10^{-12}}\right) \pm (2)(0.0001)5 \pm 3.0\text{mV} \\ = 0.505\text{V}$$

Since the ideal output is 0.5V, the error as a percent of the reading is:

$$\% \text{ error} = \frac{0.505\text{V}}{0.5} \cdot 100\% = 1.01\% \quad (12)$$

For the case of voltage inputs, the actual transfer function is:

(13)

$$V_{\text{LOGOUT}} = (0.5\text{V})(1 \pm \Delta K) \log\left(\frac{\frac{V_1}{R_1} - I_{B1} \pm \frac{E_{\text{OS1}}}{R_1}}{\frac{V_2}{R_2} - I_{B2} \pm \frac{E_{\text{OS2}}}{R_2}}\right) \pm Nm \pm V_{\text{OSO}}$$

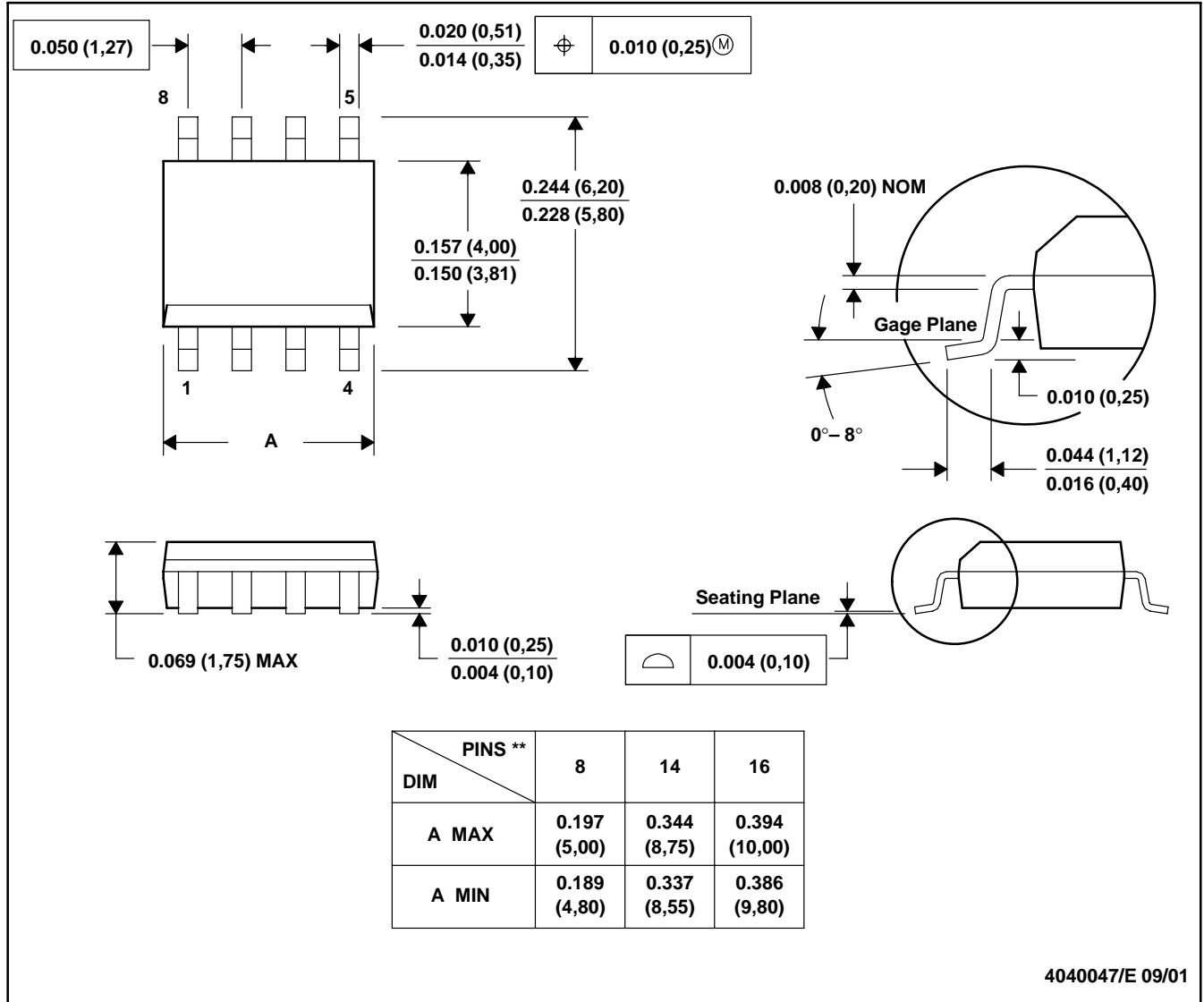
Where  $\frac{E_{\text{OS1}}}{R_1}$  and  $\frac{E_{\text{OS2}}}{R_2}$  (offset error) are considered to be zero for large values of resistance from external input current sources.

PACKAGE DRAWINGS

D (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

8 PINS SHOWN



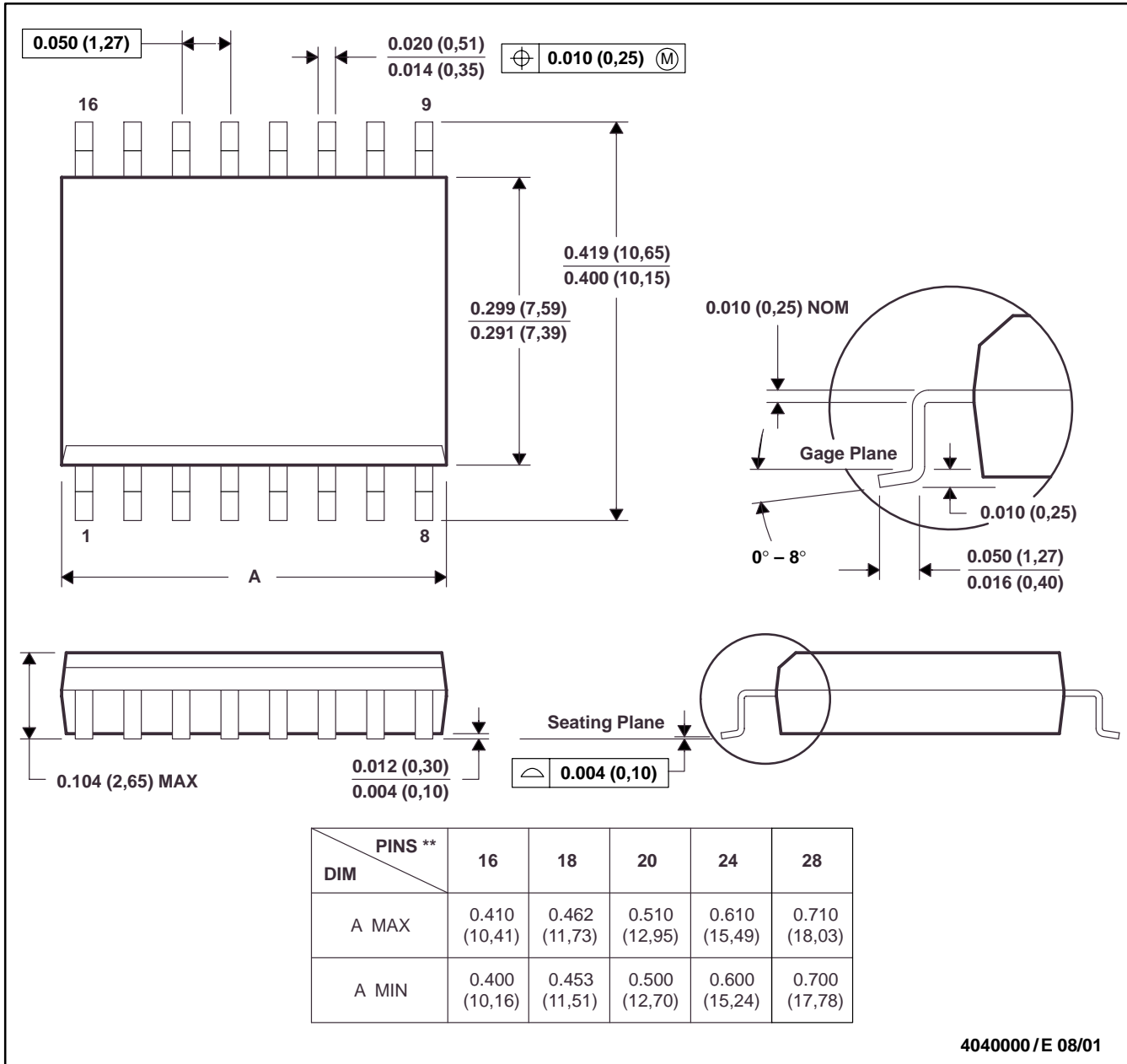
4040047/E 09/01

- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).  
 D. Falls within JEDEC MS-012

DW (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

16 PINS SHOWN



- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).  
 D. Falls within JEDEC MS-013

**PACKAGING INFORMATION**

ORDERABLE DEVICE	STATUS(1)	PACKAGE TYPE	PACKAGE DRAWING	PINS	PACKAGE QTY
LOG112AID	ACTIVE	SOIC	D	14	58
LOG112AIDR	ACTIVE	SOIC	D	14	2500
LOG2112AIDW	ACTIVE	SOIC	DW	16	48
LOG2112AIDWR	ACTIVE	SOIC	DW	16	48

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

---

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

<b>Products</b>		<b>Applications</b>	
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>	Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>	Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>	Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>	Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>	Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>	Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>	Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
		Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
		Video & Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
		Wireless	<a href="http://www.ti.com/wireless">www.ti.com/wireless</a>

Mailing Address: Texas Instruments  
Post Office Box 655303 Dallas, Texas 75265

Copyright © 2003, Texas Instruments Incorporated