Precision
LOGARITHMIC AND LOG RATIO AMPLIFIER

FEATURES

- **EASY-TO-USE COMPLETE LOG RATIO FUNCTION**
- **OUTPUT AMPLIFIERS FOR SCALING AND SIGNAL LOSS INDICATION**
- **HIGH ACCURACY: 0.15% FSO Total Error Over 6 Decades**
- **WIDE INPUT DYNAMIC RANGE: 6 Decades, 1nA to 1mA**
- **LOW QUIESCENT CURRENT: 1.25mA**
- **SO-14 PACKAGE**

APPLICATIONS

- **ONET, OPTICAL POWER METERS**
- **LOG, LOG RATIO COMPUTATION: Communication, Analytical, Medical, Industrial, Test, General Instrumentation**
- **PHOTODIODE SIGNAL COMPRESSION AMP**
- **ANALOG SIGNAL COMPRESSION IN FRONT OF A/D CONVERTER**
- **ABSORBANCE MEASUREMENT**
- **OPTICAL DENSITY MEASUREMENT**

DESCRIPTION

The LOG102 is a versatile integrated circuit that computes the logarithm or log ratio of an input current relative to a reference current.
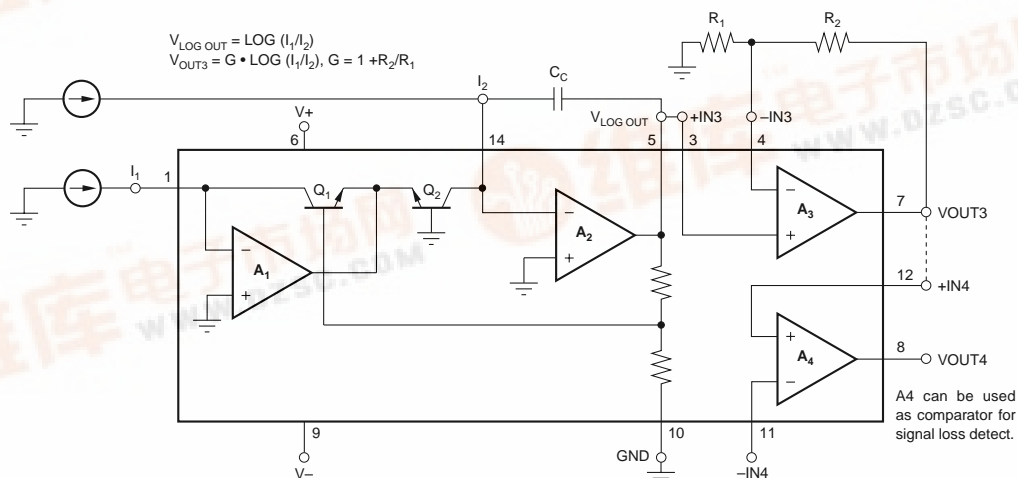
The LOG102 is tested over a wide dynamic range of input signals. In log ratio applications, a signal current can be generated by a photodiode, and a reference current from a resistor in series with a precision external voltage reference.

A3 and A4 are identical, uncommitted op amps that can be used for a variety of functions, such as filtering, offsetting, adding gain or as a comparator to detect loss of signal.

The output signal at $V_{LOG\ OUT}$ is trimmed to 1V per decade of input current. It can be scaled with an output amplifier, either A3 or A4.

Low dc offset voltage and temperature drift allow accurate measurement of low-level signals over a wide environmental temperature range. The LOG102 is specified over the temperature range, 0°C to +70°C, with operation over –40°C to +85°C.

NOTE: U.S. Patent Pending.

$V_{LOG\ OUT} = LOG\ (I_1/I_2)$
$V_{OUT3} = G \cdot LOG\ (I_1/I_2),\ G = 1 + R_2/R_1$

A4 can be used as comparator for signal loss detect.

TEXAS

ABSOLUTE MAXIMUM RATINGS[(1)]

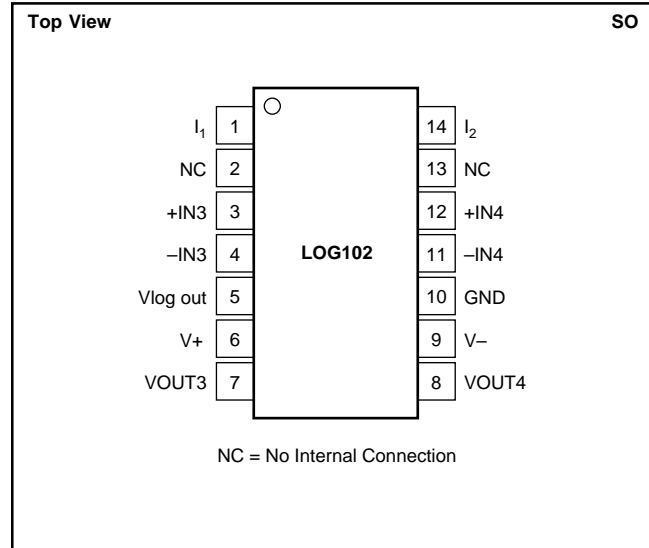|	
Supply Voltage, V+ to V–	36V
Input Voltage .... V– (–0.5) to V+ (+0.5V)	
Input Current	±10mA
Output Short-Circuit[(2)]	Continuous
Operating Temperature	–40°C to +85°C
Storage Temperature	–55°C to +125°C
Junction Temperature	+150°C
Lead Temperature (soldering, 10s)	+300°C

NOTES: (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. (2) Short circuit to ground, one amplifier 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.

PIN DESCRIPTION

Top View   **SO**

I_1	1		14	I_2
NC	2		13	NC
+IN3	3		12	+IN4
–IN3	4	**LOG102**	11	–IN4
Vlog out	5		10	GND
V+	6		9	V–
VOUT3	7		8	VOUT4

NC = No Internal Connection

PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR[(1)]	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
LOG102AID	SO-14	D	0°C to +70°C	LOG102A	LOG102AID	Rails, 58
"	"	"	"	"	LOG102AIDR	Tape and Reel, 2500

NOTES: (1) For the most current specifications and package information, refer to our web site at www.ti.com.

ELECTRICAL CHARACTERISTICS

Boldface limits apply over the specified temperature range, T_A = 0°C to +70°C.

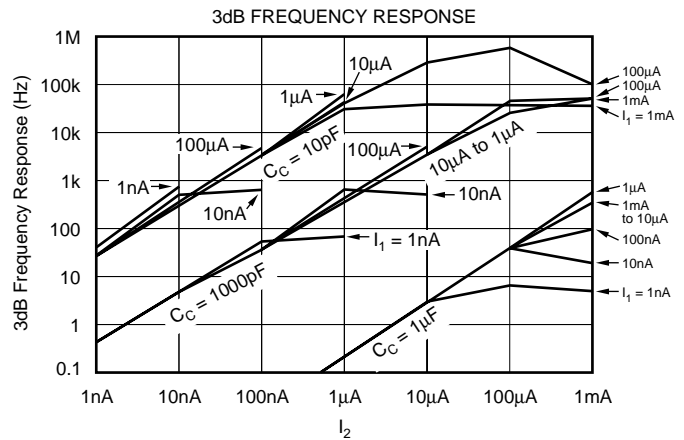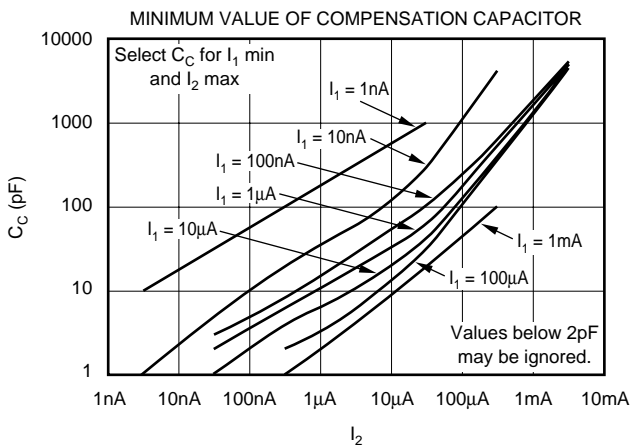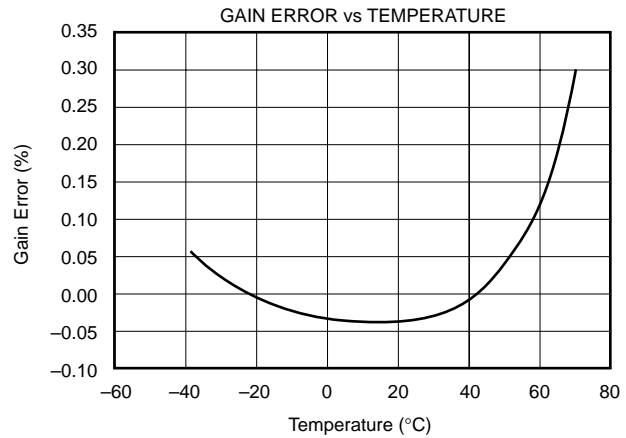At T_A = +25°C, V_S = ±5V, R_L = 10kΩ, unless otherwise noted.

		LOG102AID			
PARAMETER	CONDITION	MIN	TYP	MAX	UNITS
CORE LOG FUNCTION					
$I_{IN}/V_{LOG\ OUT}$ Equation			$V_O = \log (I_1/I_2)$		
LOG CONFORMITY ERROR[(1)]					
Initial	1nA to 100μA (5 decades)		0.04	±0.3	%
	1nA to 1mA (6 decades)		0.15		%
over Temperature	**1nA to 100μA (5 decades)**		**0.0002**		**%/°C**
	1nA to 1mA (6 decades)		**0.002**		**%/°C**
GAIN[(2)]					
Initial Value	1nA to 100μA (5 decades)		1		V/decade
Gain Error	1nA to 100μA (5 decades)		0.15	±1	%
vs Temperature	**T_{MIN} to T_{MAX}**		**0.025**	0.05	**%/°C**
INPUT, A1 and A2					
Offset Voltage			±0.3	±1.5	mV
vs Temperature	**T_{MIN} to T_{MAX}**		±**2**		μ**V/°C**
vs Power Supply (PSRR)	V_S = ±4.5V to ±18V		5	50	μV/V
Input Bias Current			±5		pA
vs Temperature	**T_{MIN} to T_{MAX}**		**Doubles Every 10°C**		
Voltage Noise	f = 10Hz to 10kHz		3		μVrms
	f = 1kHz		30		nV/√Hz
Current Noise	f = 1kHz		4		fA/√Hz
Common-Mode Voltage Range (Positive)		(V+) – 2	(V+) – 1.5		V
(Negative)		(V–) + 2	(V–) + 1.2		V
CMRR		90	105		dB
OUTPUT, A2 (V_{LOGOUT})					
Output Offset, V_{OSO}, Initial			±3	±55	mV
vs Temperature	**T_{MIN} to T_{MAX}**			**25**	μ**V/°C**
Full-Scale Output (FSO)	V_S = ±5V Supplies	(V–) + 1.2		(V+) – 1.5	V
Short-Circuit Current			±18		mA

⨺ TEXAS

ELECTRICAL CHARACTERISTICS (Cont.)

Boldface limits apply over the specified temperature range, $T_A = 0°C$ to $+70°C$.

At $T_A = +25°C$, $V_S = ±5V$, $R_L = 10kΩ$, unless otherwise noted.

PARAMETER	CONDITION	LOG102AID MIN	LOG102AID TYP	LOG102AID MAX	UNITS
TOTAL ERROR[3][4]	I_1 or I_2 remains fixed while other varies				
Initial	min to max				
	I_1 or I_2 = 1mA			±55	mV
	I_1 or I_2 = 100µA			±30	mV
	I_1 or I_2 = 10µA			±25	mV
	I_1 or I_2 = 1µA			±20	mV
	I_1 or I_2 = 100nA			±25	mV
	I_1 or I_2 = 10nA			±30	mV
	I_1 or I_2 = 1nA			±37	mV
vs Temperature	**I_1 or I_2 = 1mA**		**±0.4**		**mV/°C**
	I_1 or I_2 = 100µA		**±0.07**		**mV/°C**
	I_1 or I_2 = 10µA		**±0.07**		**mV/°C**
	I_1 or I_2 = 1µA		**±0.07**		**mV/°C**
	I_1 or I_2 = 100nA		**±0.07**		**mV/°C**
	I_1 or I_2 = 10nA		**±0.07**		**mV/°C**
	I_1 or I_2 = 1nA		**±0.4**		**mV/°C**
vs Supply	I_1 or I_2 = 1mA		±0.15		mV/V
	I_1 or I_2 = 100µA		±0.15		mV/V
	I_1 or I_2 = 10µA		±0.25		mV/V
	I_1 or I_2 = 1µA		±0.2		mV/V
	I_1 or I_2 = 100nA		±0.2		mV/V
	I_1 or I_2 = 10nA		±0.15		mV/V
	I_1 or I_2 = 1nA		±0.25		mV/V
FREQUENCY RESPONSE, core log[5]					
BW, 3dB					
I_2 = 10nA	C_C = 4500pF		0.1		kHz
I_2 = 1µA	C_C = 150pF		38		kHz
I_2 = 10µA	C_C = 150pF		40		kHz
I_2 = 1mA	C_C = 50pF		45		kHz
Step Response					
Increasing					
I_2 = 1µA to 1mA (3 decade)	C_C = 150pF		11		µs
I_2 = 100nA to 1µA (1 decade)	C_C = 150pF		7		µs
I_2 = 10nA to 100nA (1 decade)	C_C = 150pF		110		µs
Decreasing					
I_2 = 1mA to 1µA (3 decade)	C_C = 150pF		45		µs
I_2 = 1µA to 100nA (1 decade)	C_C = 150pF		20		µs
I_2 = 100nA to 10nA (1 decade)	C_C = 150pF		550		µs
OP AMPS, A3 AND A4					
Input Offset Voltage			±175	±750	µV
vs Temperature	**T_{MIN} to T_{MAX}**		**±2**		**µV/°C**
vs Power Supply	V_S = ±4.5V to ±18V		10	50	µV/V
Input Bias Current[5]			−10		nA
Input Offset Current			±0.5		nA
Input Voltage Range		(V−)		(V+) − 1.5	V
Common-Mode Rejection			86		dB
Input Noise, f = 0.1Hz to 10Hz			1		µVp-p
f = 1kHz			28		nV/√Hz
Open Loop Voltage Gain			88		dB
Gain-Bandwidth Product			1.4		MHz
Slew Rate	G = 1, 2.5V step		0.5		V/µs
Settling Time, 0.01%	G = 1, 2.5V Step, C_L =100pF		16		µs
Rated Output	V_S = 5V, R_L = 10kΩ	(V−) + 1.5		(V+) − 0.9	V
Short-Circuit Current $-I_{SC}/+I_{SC}$			−36/+60		mA
POWER SUPPLY					
Operating Range	V_S	±4.5		±18	V
Quiescent Current	I_O = 0		1.25	2	mA
TEMPERATURE RANGE					
Specified Range, T_{MIN} to T_{MAX}		0		70	°C
Operating Range		−40		+85	°C
Storage Range		−40		+125	°C
Thermal Resistance, θ_{JA}					
SO-14			100		°C/W

NOTES: (1) Log Conformity Error is peak deviation from the best-fit straight line of V_O versus Log (I_1/I_2) curve expressed as a percent of peak-to-peak full-scale (2) Output core log function is trimmed to 1V output per decade change of input current. (3) Worst-case Total Error for any ratio of I_1/I_2, is the largest of the two errors, when I_1 and I_2 are considered separately. (4) Total $I_1 + I_2$ should be kept below 1.1mA on ±5V supply. (5) Bandwidth (3dB) and transient response are a function of both the compensation capacitor and the level of input current. (6) Positive conventional current flows into input terminals.

TEXAS

TYPICAL CHARACTERISTICS

At $T_A = +25°C$, $V_S = \pm5V$, $R_L = 10k\Omega$, unless otherwise noted.

NORMALIZED TRANSFER FUNCTION

$V_{OUT} = 1V \bullet Log \dfrac{I_1}{I_2}$

Normalized Output Voltage (V)

Current Ratio, $\dfrac{I_1}{I_2}$

ONE CYCLE OF NORMALIZED TRANSFER FUNCTION

Normalized Output Voltage (V)

Current Ratio, $\dfrac{I_1}{I_2}$

TOTAL ERROR vs INPUT CURRENT

Total Error (mV)

0°C
70°C
25°C

Input Current
(I_1 or I_2)

GAIN ERROR vs TEMPERATURE

Gain Error (%)

Temperature (°C)

MINIMUM VALUE OF COMPENSATION CAPACITOR

C_C (pF)

Select C_C for I_1 min
and I_2 max

$I_1 = 1nA$
$I_1 = 10nA$
$I_1 = 100nA$
$I_1 = 1\mu A$
$I_1 = 10\mu A$
$I_1 = 1mA$
$I_1 = 100\mu A$

Values below 2pF
may be ignored.

I_2

3dB FREQUENCY RESPONSE

3dB Frequency Response (Hz)

$10\mu A$
$1\mu A$
$100\mu A$
$100\mu A$
$10\mu A$ to $1\mu A$
$C_C = 10pF$
$1nA$
$10nA$
$10nA$
$I_1 = 1nA$
$C_C = 1000pF$
$C_C = 1\mu F$

$100\mu A$
$100\mu A$
$1mA$
$I_1 = 1mA$
$1\mu A$
$1mA$
to $10\mu A$
$100nA$
$10nA$
$I_1 = 1nA$

I_2

TYPICAL CHARACTERISTICS (Cont.)

At T_A = +25°C, V_S = ±5V, R_L = 10kΩ, unless otherwise noted.

LOG CONFORMITY vs V_{LOGOUT}

70°C

25°C

0°C

V_{LOGOUT} (V)

Log Conformity (mV)

LOG CONFORMITY vs TEMPERATURE

6 Decades (1nA to 1mA)

5 Decades (1nA to 100μA)

Temperature (°C)

Log Conformity (m%)

TOTAL ERROR vs TEMPERATURE

1nA

1mA

10nA to 100μA

Temperature (°C)

Total Error (mV)

APPLICATION INFORMATION

The LOG102 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. With two uncommitted on-chip operational amplifiers, the LOG102 provides design flexibility and simplicity.

Figure 1 shows the basic connections required for operation of the LOG102 with a gain factor. 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. Connecting the capacitors as close to the LOG102 as possible will contribute to noise reduction as well.
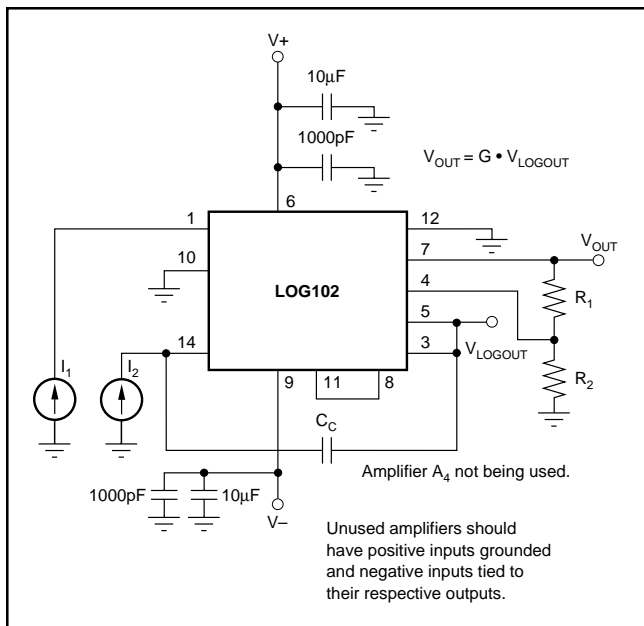
FIGURE 1. Basic Connections with Output Gain Factor of the LOG102.

INPUT CURRENT RANGE

To maintain specified accuracy, the input current range of the LOG102 should be limited from 1nA to 1mA. Input currents outside of this range may compromise LOG102 performance. Input currents larger than 1mA result in increased nonlinearity. An absolute maximum input current rating of 10mA is included to prevent excessive power dissipation that may damage the logging transistor.

On ±5V supplies the total input current $(I_1 + I_2)$ is limited to 1.1mA. Due to compliance issues internal to the LOG102, to accommodate larger total input currents, supplies should be increased.

Currents smaller than 1nA will result in increased errors due the input bias currents of op amps A_1 and A_2 (typically 5pA). The input bias currents may be compensated for, as shown in Figure 2. The input stages of the amplifiers have FET inputs, with input bias current doubling every 10°C, which makes the nulling technique shown practical only where the temperature is fairly stable.
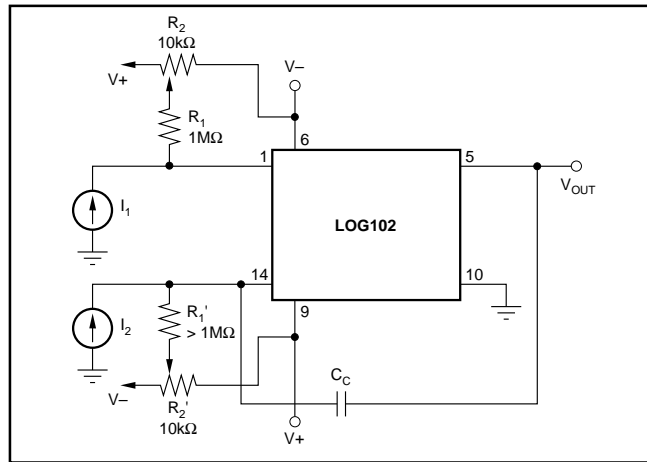
FIGURE 2. Bias Current Nulling.

SETTING THE REFERENCE CURRENT

When the LOG102 is used to compute logarithms, either I_1 or I_2 can be held constant and becomes the reference current to which the other is compared.

V_{LOGOUT} is expressed as:

$$V_{LOGOUT} = (1V) \bullet \log (I_1/I_2) \qquad (1)$$

I_{REF} can be derived from an external current source (such as 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:
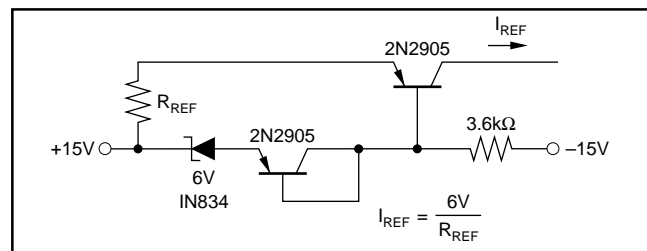
$$R_{REF} = 2.5V/10nA = 250M\Omega$$

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.
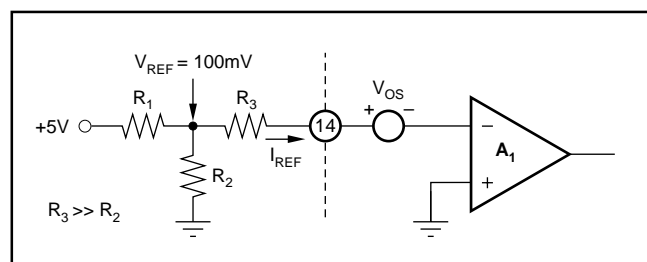

FIGURE 4. T Network for Reference Current.

Figure 5 shows a low-level current source using a series resistor. The low offset op-amp reduces the effect of the LOG102's input offset voltage.
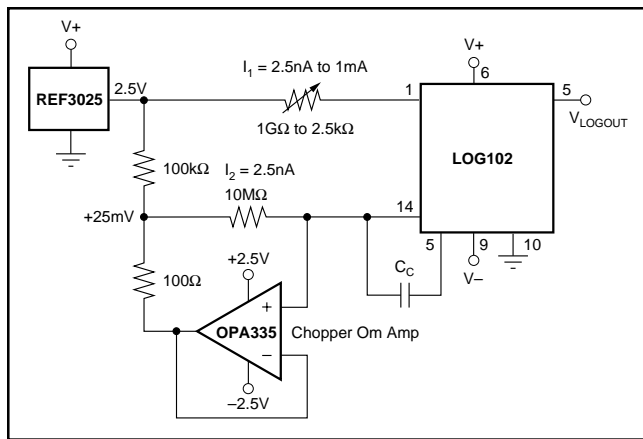

FIGURE 5. Current Source with Offset Compensation.

FREQUENCY RESPONSE

The 3dB frequency response of the LOG102 is a function of the magnitude of the input current levels and of the value of the frequency compensation capacitor. See Typical Characteristic Curves for details.

The frequency response curves are shown for constant DC I_1 and I_2 with a small signal AC current on one of them.

The transient response of the LOG102 is 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 LOG102.

FREQUENCY COMPENSATION

Frequency compensation for the LOG102 is obtained by connecting a capacitor between pins 5 and 14. 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 will make the LOG102 more stable, but will 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.

As seen on front page diagram, the voltage output of V_{LOGOUT} can be scaled by increasing or decreasing the resistor ratio connected to pins 4 and 7. The gain, G, can be set according to the following equation:

$$G = 1 + R_2/R_1 \qquad (2)$$

NEGATIVE INPUT CURRENTS

The LOG102 will function only with positive input currents (conventional current flow into pins 1 and 14). In situations where negative input currents are needed, the circuits in Figures 6, 7, 8, and 9, may be used.
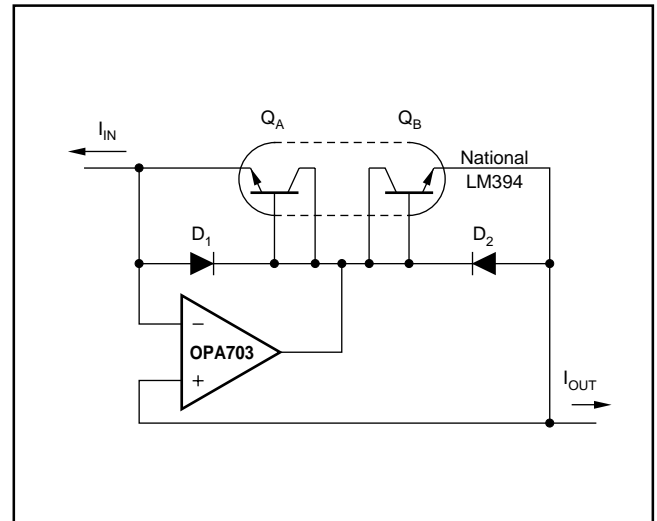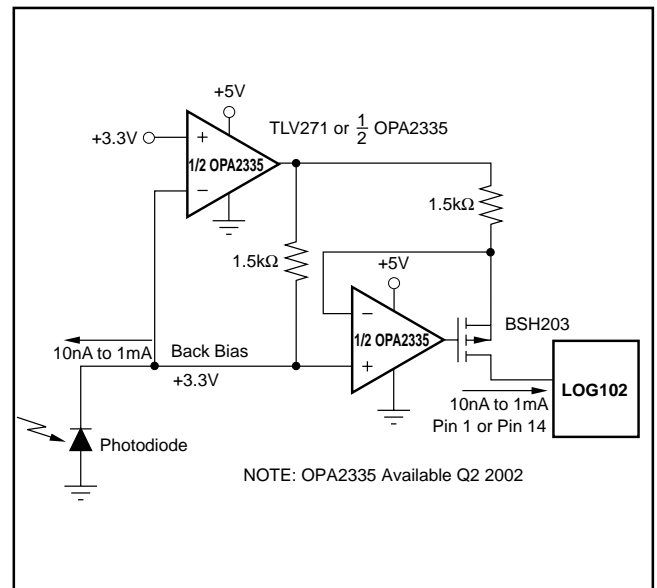

FIGURE 6. Current Inverter/Current Source.

FIGURE 7. Precision Current Inverter/Current Source.

VOLTAGE INPUTS

The LOG102 gives the best performance 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 (14) applies to this configuration.
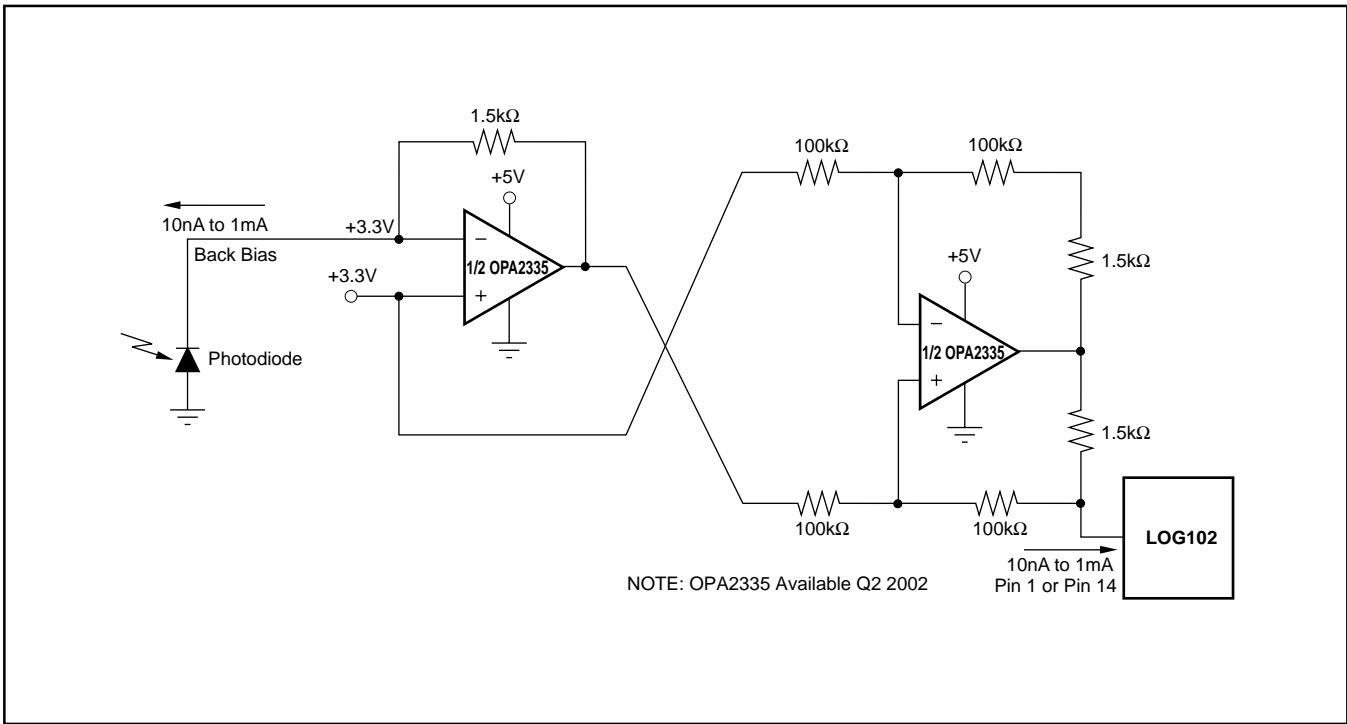
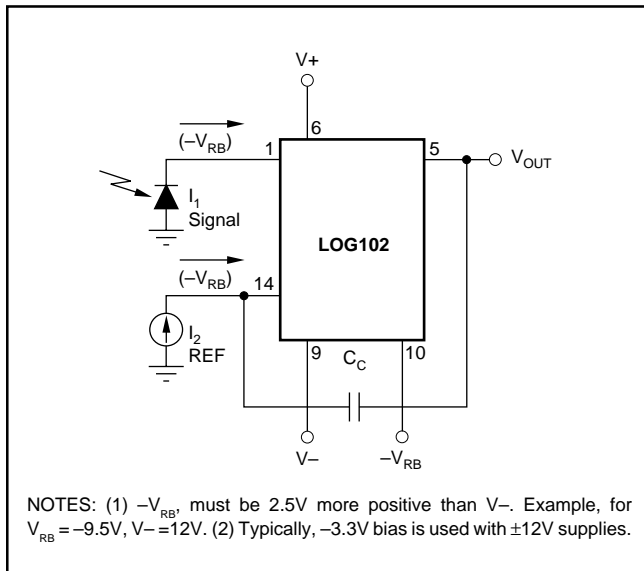FIGURE 8. Precision Current Inverter/Current Source.

NOTES: (1) $-V_{RB}$, must be 2.5V more positive than V−. Example, for $V_{RB} = -9.5V$, V− =12V. (2) Typically, −3.3V bias is used with ±12V supplies.

FIGURE 9. Reverse Biased Photodiode Using Pin 10 on LOG102.

APPLICATION CIRCUITS

LOG RATIO

One of the more common uses of log ratio amplifiers is to measure absorbance. A typical application is shown in Figure 10.

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

$$\text{If } D_1 \text{ and } D_2 \text{ are matched } A \propto (1V) \log I_1 / I_2 \quad (4)$$

DATA COMPRESSION

In many applications the compressive effects of the logarithmic transfer function are useful. For example, a LOG102 preceding a 12-bit Analog-to-Digital (A/D) converter can produce the dynamic range equivalent to a 20-bit converter.
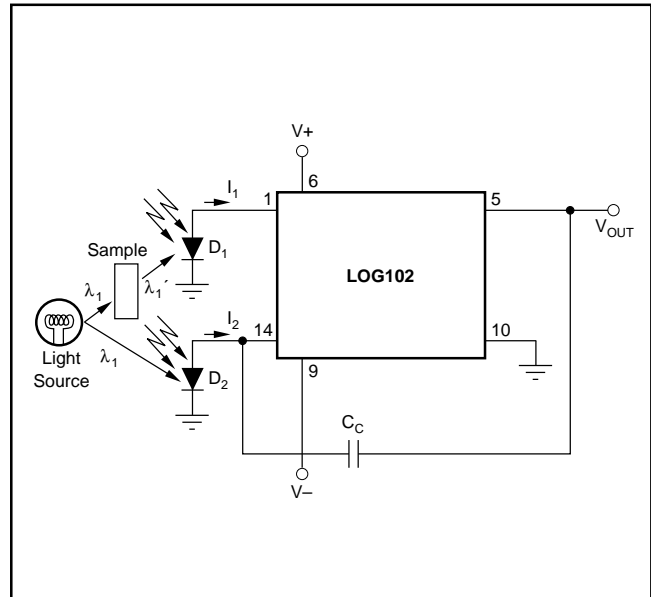
FIGURE 10. Absorbance Measurement.

INSIDE THE LOG102

Using the base-emitter voltage relationship of matched bipolar transistors, the LOG102 establishes a logarithmic function of input current ratios. Beginning with the base-emitter voltage defined as

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

   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 11, we see that

$$V_L = V_{BE_1} - V_{BE_2} \qquad (2)$$

Substituting (1) into (2) yields

$$V_L = V_{T_1} \ln \frac{I_1}{I_{S_1}} - V_{T_2} \ln \frac{I_2}{I_{S_2}} \qquad (3)$$

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

$$V_L = V_{T_1} \left[\ln \frac{I_1}{I_S} - \ln \frac{I_2}{I_S} \right] \qquad (4)$$

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

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

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

where n = 2.3   (8)

also

$$V_{OUT} = V_L \frac{R_1 + R_2}{R1} \qquad (9)$$

$$= \log \frac{I_1}{I_2} \qquad (10)$$

or
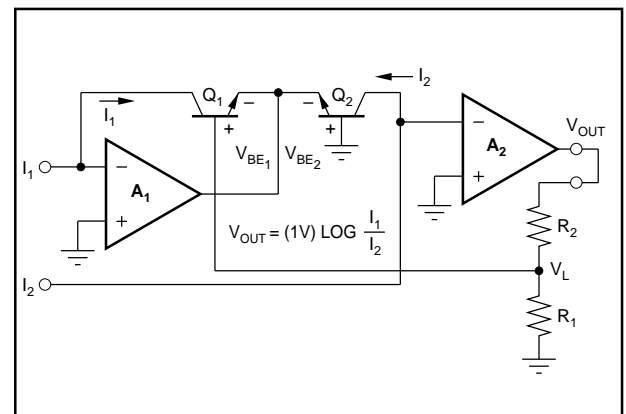$$V_{OUT} = \frac{R_1 + R_2}{R1} n V_T \log \frac{I_1}{I_2} \qquad (11)$$

FIGURE 11. Simplified Model of Log Amplifier.

It should be noted that the temperature dependance associated with $V_T = kT/q$ is internally compensated on the LOG102 by making R_1 a temperature sensitive resistor with the required positive temperature coefficient.

USING A LARGER REFERENCE VOLTAGE REDUCES OFFSET ERRORS

Using a larger reference voltage to create the reference current minimizes errors due to the LOG102's input offset voltage. Maintaining an increasing output voltage as a function of increasing photodiode current is also important in many optical sensing applications. All zeros from the A/D converter output represent zero or low scale photodiode current. Inputting the reference current into I_1, and designing

I_{REF} such that it is as large or larger than the expected maximum photodiode current is accomplished using this requirement. The LOG102 configured with the reference current connecting I_1 and the photodiode current connecting to I_2 is shown in Figure 12. A_3 is configured as a level shifter with inverting gain and is used to scale the photodiode current directly into the A/D input voltage range.

The wide dynamic range of the LOG102 is useful for measuring avalanche photodiode current (APD) (see Figure 13).
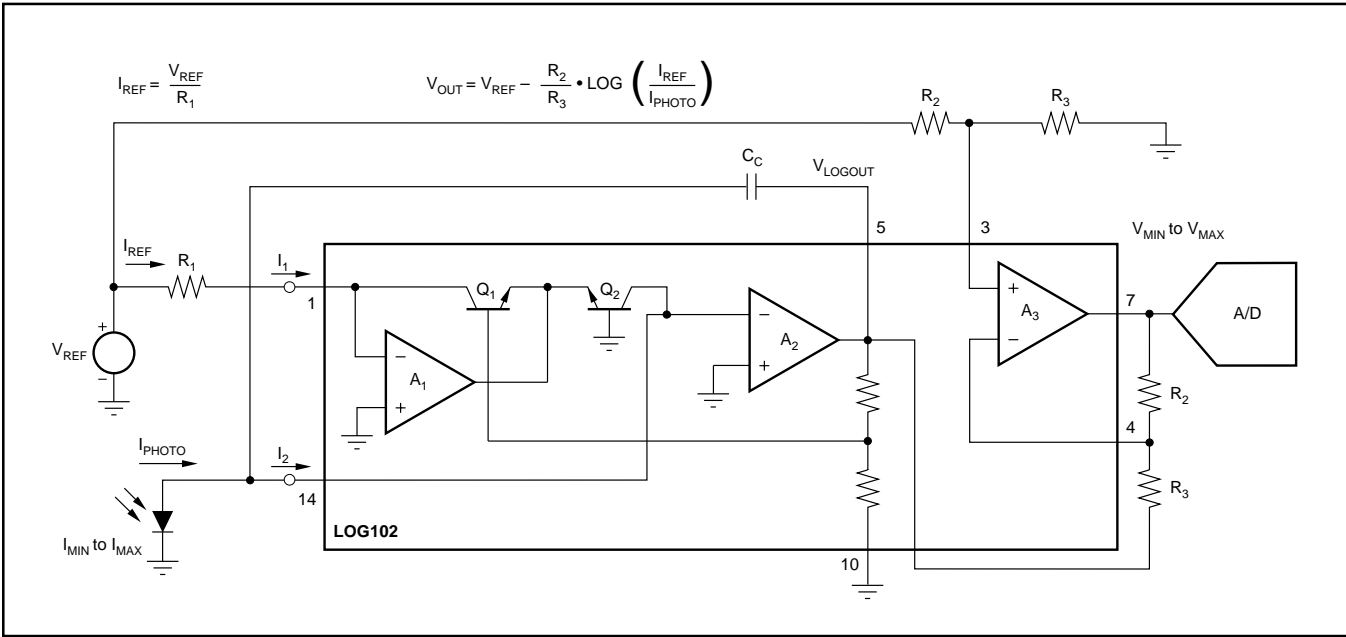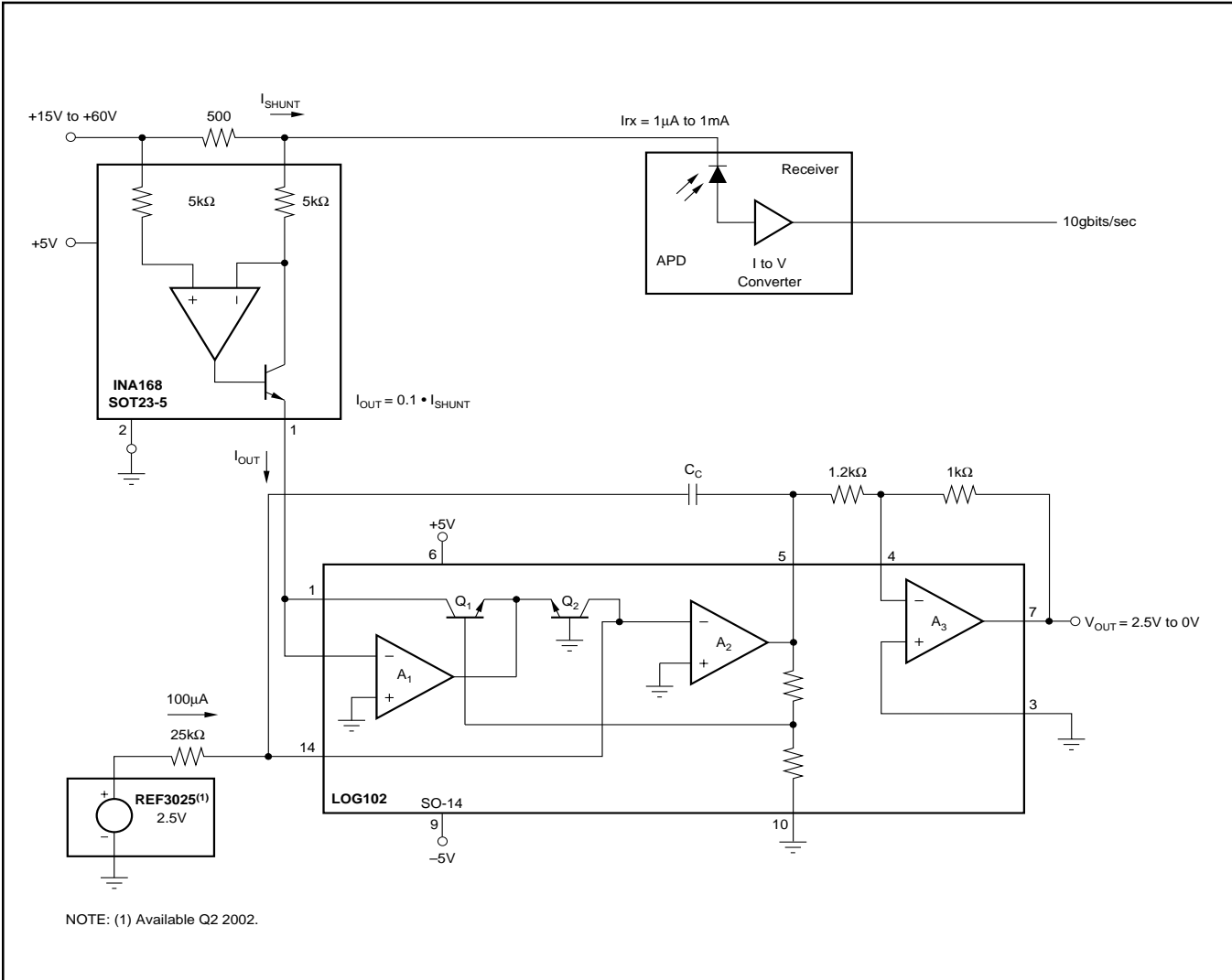
FIGURE 12. Technique for Using Full-Scale Reference Current Such that V_{OUT} Increases with Increasing Photodiode Current.

$$I_{REF} = \frac{V_{REF}}{R_1}$$

$$V_{OUT} = V_{REF} - \frac{R_2}{R_3} \cdot LOG\left(\frac{I_{REF}}{I_{PHOTO}}\right)$$

NOTE: (1) Available Q2 2002.

FIGURE 13. High Side Shunt for Avalanche Photodiode (APD) Measures 3-Decades of APD Current.

$I_{OUT} = 0.1 \cdot I_{SHUNT}$

TEXAS

DEFINITION OF TERMS

TRANSFER FUNCTION

The ideal transfer function is:

$$V_{OUT} = 1V \bullet \log I_1/I_2 \qquad (5)$$

Figure 14 shows the graphical representation of the transfer over valid operating range for the LOG102.
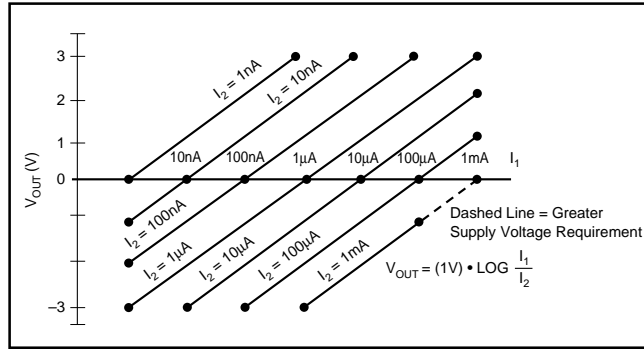
FIGURE 14. Transfer Function with Varying I_2 and I_1.

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 $V_{OUT} = 1V \bullet \log(I_1/I_2)$.

Thus,

$$V_{OUT\ (ACTUAL)} = V_{OUT\ (IDEAL)} \pm \text{Total Error.} \qquad (5)$$

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; and is shown in Table I. Temperature can affect total error.

I_2 (maximum error)[1]	I_1 (maximum error)[1]		
	10nA (30mV)	100nA (25mV)	1μA (20mV)
100nA (25mV)	30mV	25mV	25mV
1μA (20mV)	30mV	25mV	20mV
10μA (25mV)	30mV	25mV	25mV

NOTE: (1) Maximum errors are in parenthesis.

TABLE I. I_1/I_2 and Maximum Errors.

ERRORS RTO AND RTI

As with any transfer function, errors generated by the function itself 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 LOG102, 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 (1pA compared to input currents of 1nA 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_{OUT} 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:

$$V_{OUT\ (NONLIN)} = 1V/dec \bullet 2Nm \ V \qquad (6)$$

where N is the log conformity error, in percent.

INDIVIDUAL ERROR COMPONENTS

The ideal transfer function with current input is:

$$V_{OUT} = (1V) \bullet \log \frac{I_1}{I_2} \qquad (7)$$

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

$$V_{OUT} = (1V)\,(1 \pm \Delta K)\log \frac{I_1 - I_{B1}}{I_2 - I_{B2}} \pm 2Nm \pm V_{OS\ OUT} \qquad (8)$$

The individual component of error is:

ΔK = gain accuracy (0.3%, typ), as specified in specification table.

I_{B1} = bias current of A_1 (5pA, typ)
I_{B2} = bias current of A_2 (5pA, typ)

N = log conformity error (0.04%, 0.15%, typ)

0.04% for n = 5, 0.15% for n = 6

$V_{OS\ OUT}$ = output offset voltage (1mV, typ)

n = number of decades over which N is specified:

Example: what is the error when

$$I_1 = 1\mu A \text{ and } I_2 = 100nA \qquad (9)$$

$$V_{OUT} = (1 \pm 0.003)\log \frac{10^{-6} - 5 \bullet 10^{-12}}{10^{-7} - 5 \bullet 10^{-12}} \pm (2)(0.0004)5 \pm 0.3mV$$

$$\approx 1.003 \log \frac{10^{-6}}{10^{-7}} + 0.004 + 0.003 \qquad (10)$$

$$= 1.003\,(1) + 0.004 + 0.0003 \qquad (11)$$

$$= 1.0073\text{V} \qquad (12)$$

Since the ideal output is 1.000V, the error as a percent of reading is

$$\% \text{ error} = \frac{0.0073}{1} \bullet 100\% = 0.73\% \qquad (13)$$

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

$$V_{OUT} = (1V)(1 \pm \Delta K)\log \frac{\dfrac{V_1}{R_1} - I_{B_1} \pm \dfrac{E_{OS_1}}{R_1}}{\dfrac{V_2}{R_2} - I_{B_2} \pm \dfrac{E_{OS_2}}{R_2}} \pm 2Nn \pm V_{OS\,OUT} \qquad (14)$$

$$(15)$$

Where $\dfrac{E_{OS1}}{R_1}$ and $\dfrac{E_{OS2}}{R_2}$ are considered to be zero for large values of resistance from external input current sources.
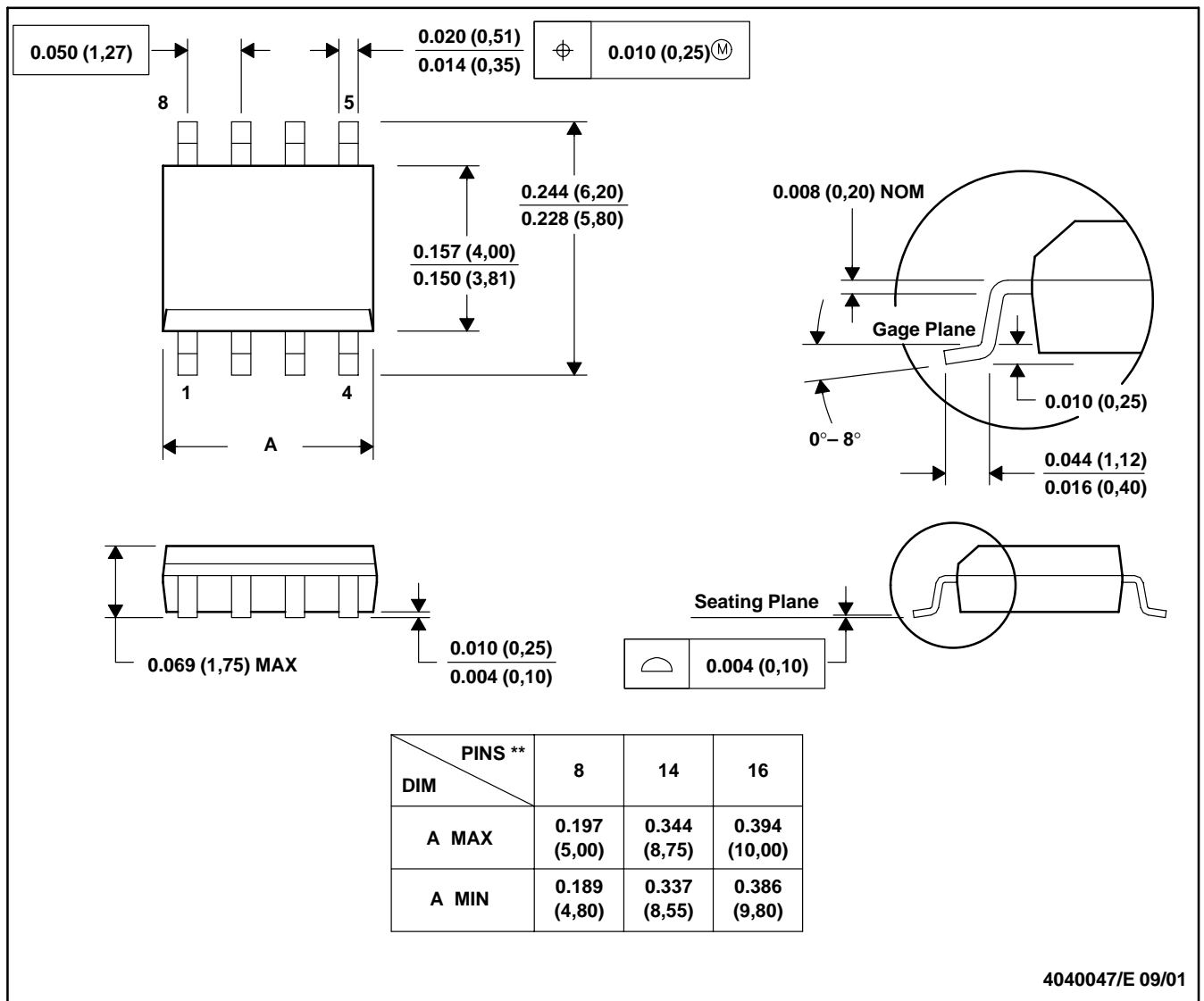
D (R-PDSO-G**)   **PLASTIC SMALL-OUTLINE PACKAGE**

8 PINS SHOWN

0.050 (1,27)

$\dfrac{0.020\ (0,51)}{0.014\ (0,35)}$

0.010 (0,25) Ⓜ

$\dfrac{0.244\ (6,20)}{0.228\ (5,80)}$

$\dfrac{0.157\ (4,00)}{0.150\ (3,81)}$

A

0.008 (0,20) NOM

Gage Plane

0°– 8°

0.010 (0,25)

$\dfrac{0.044\ (1,12)}{0.016\ (0,40)}$

0.069 (1,75) MAX

$\dfrac{0.010\ (0,25)}{0.004\ (0,10)}$

Seating Plane

0.004 (0,10)

DIM \ PINS **	8	14	16
A MAX	0.197 (5,00)	0.344 (8,75)	0.394 (10,00)
A MIN	0.189 (4,80)	0.337 (8,55)	0.386 (9,80)

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

Texas

PACKAGE OPTION ADDENDUM

PACKAGING INFORMATION

ORDERABLE DEVICE	STATUS(1)	PACKAGE TYPE	PACKAGE DRAWING	PINS	PACKAGE QTY
LOG102AID	ACTIVE	SOIC	D	14	58
LOG102AIDR	ACTIVE	SOIC	D	14	2500

(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:

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

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