Not Recommended For New Designs

SBOS211B – DECEMBER 2001– REVISED APRIL 2005

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.

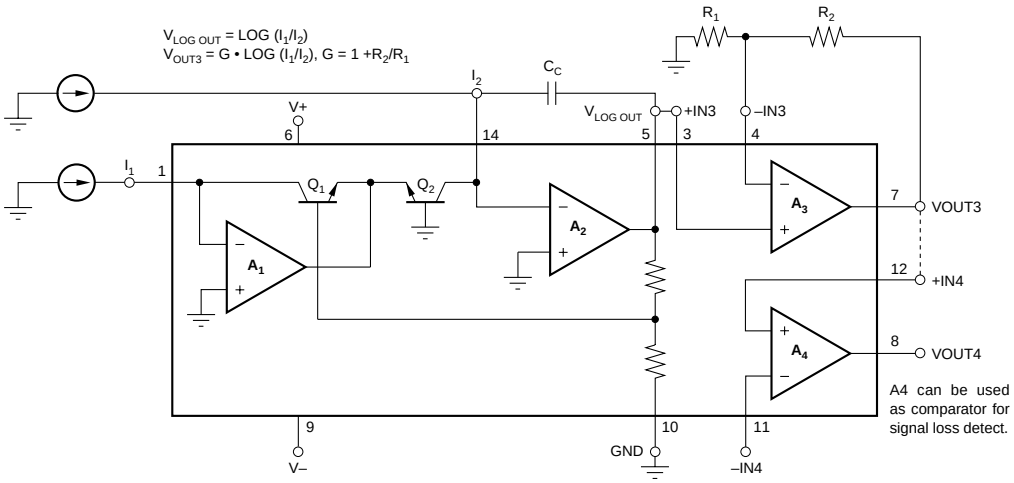
The LOG102 is tested over a wide dynamic range of input signals. In log ratio applications, a signal current can be generated by a photodiode, and a reference current from a resistor in series with a precision external voltage reference.

In the block diagram shown below, 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.



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.

All trademarks are the property of their respective owners.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

Copyright © 2001-2005, Texas Instruments Incorporated

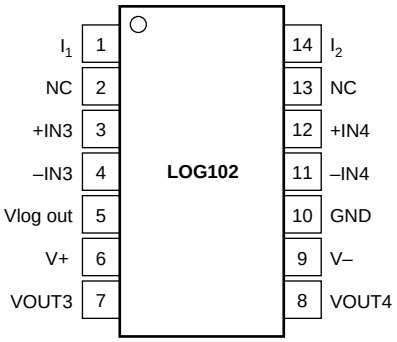
ABSOLUTE MAXIMUM RATINGS[1]

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.

PIN DESCRIPTION

Top View SO



NC = No Internal Connection

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[1]

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR	PACKAGE MARKING
LOG102AID	SO-14	D	LOG102A

NOTES: (1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website 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.

PARAMETER	CONDITION	LOG102AID MIN	LOG102AID TYP	LOG102AID 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**		**µV/°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**	**µV/°C**
Full-Scale Output (FSO)	V_S = ±5V Supplies	(V–) + 1.2		(V+) – 1.5	V
Short-Circuit Current			±18		mA

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.

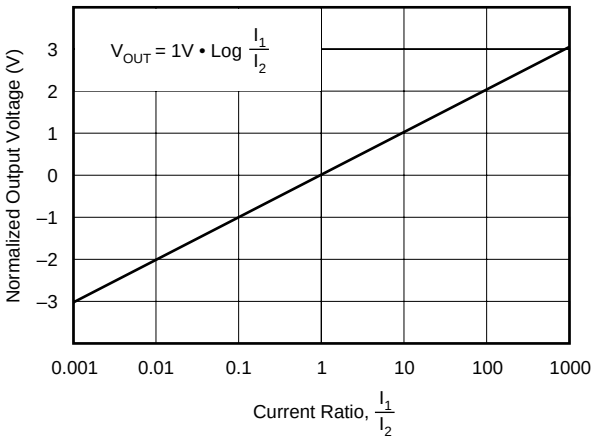
PARAMETER	CONDITION	LOG102AID MIN	LOG102AID TYP	LOG102AID MAX	UNITS
TOTAL ERROR[3][4]	I_1 or I_2 remains fixed while other varies				
Initial	min to max				
	I_1 or I_2 = 1mA			±55	mV
	I_1 or I_2 = 100µA			±30	mV
	I_1 or I_2 = 10µA			±25	mV
	I_1 or I_2 = 1µA			±20	mV
	I_1 or I_2 = 100nA			±25	mV
	I_1 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		μV_{PP}
f = 1kHz			28		$nV/\sqrt{Hz}$
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.

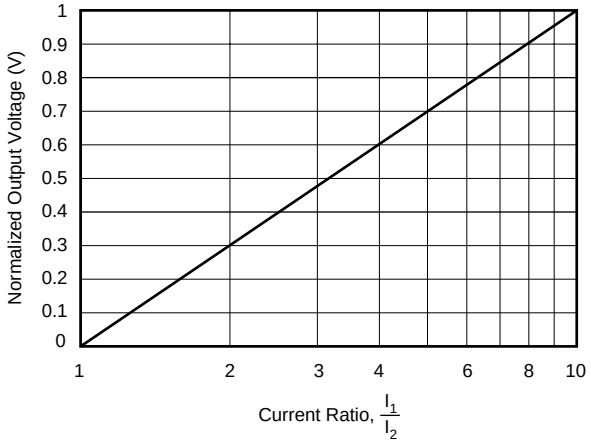
TYPICAL CHARACTERISTICS

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

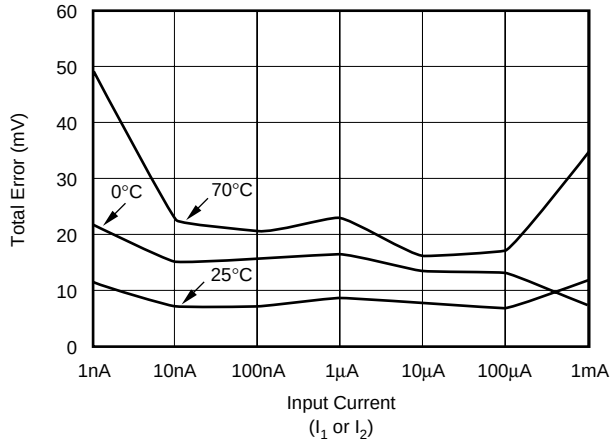
NORMALIZED TRANSFER FUNCTION



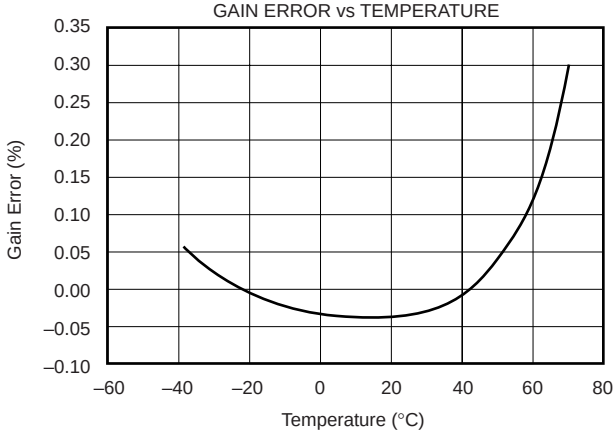
ONE CYCLE OF NORMALIZED TRANSFER FUNCTION



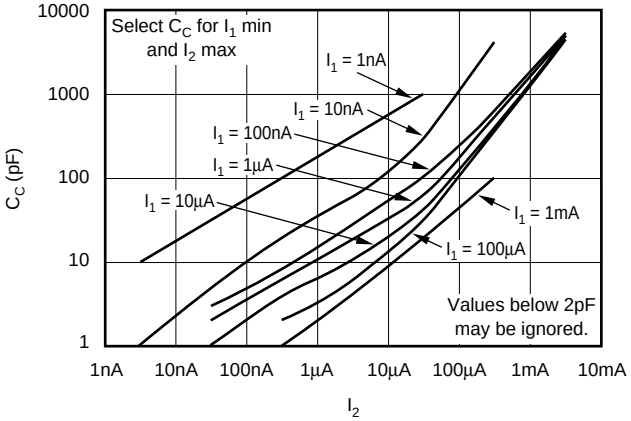
TOTAL ERROR vs INPUT CURRENT



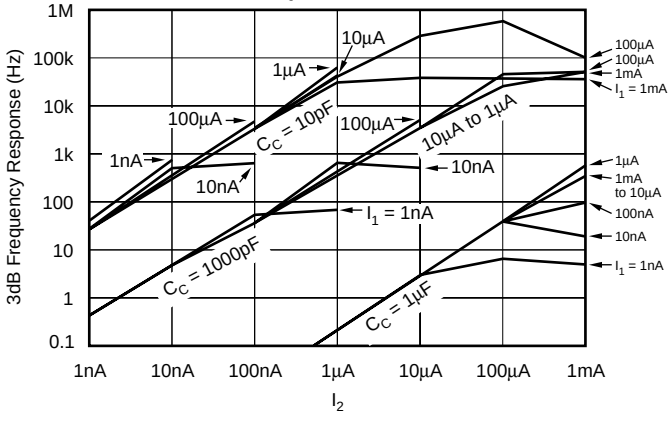
GAIN ERROR vs TEMPERATURE



MINIMUM VALUE OF COMPENSATION CAPACITOR



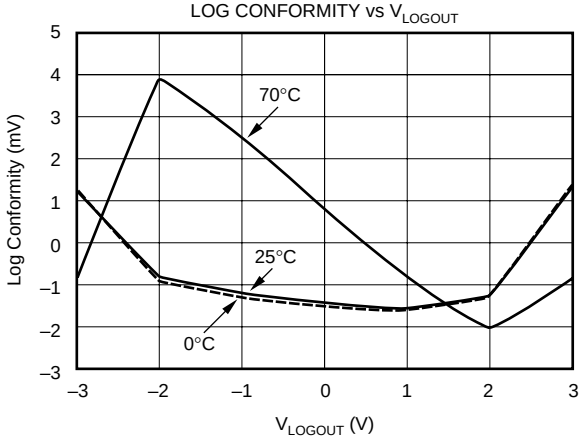
3dB FREQUENCY RESPONSE



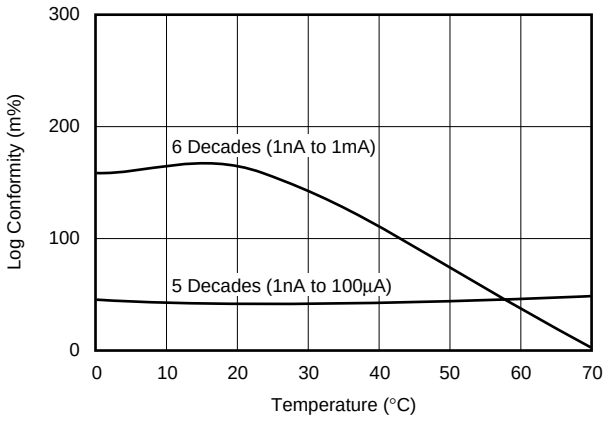
TYPICAL CHARACTERISTICS (Cont.)

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

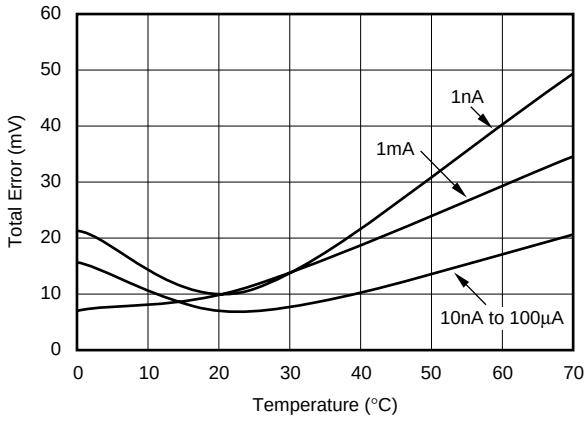
LOG CONFORMITY vs V_{LOGOUT}



LOG CONFORMITY vs TEMPERATURE



TOTAL ERROR vs TEMPERATURE



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.

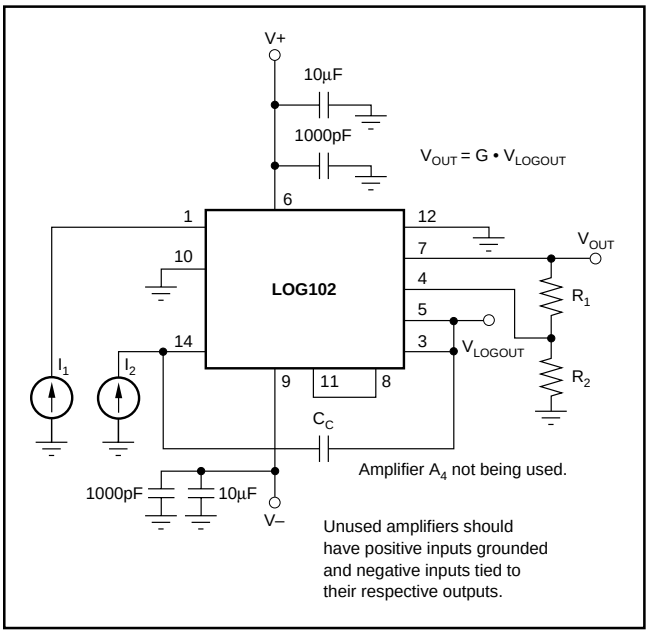


FIGURE 1. Basic Connections with Output Gain Factor of the LOG102.

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.

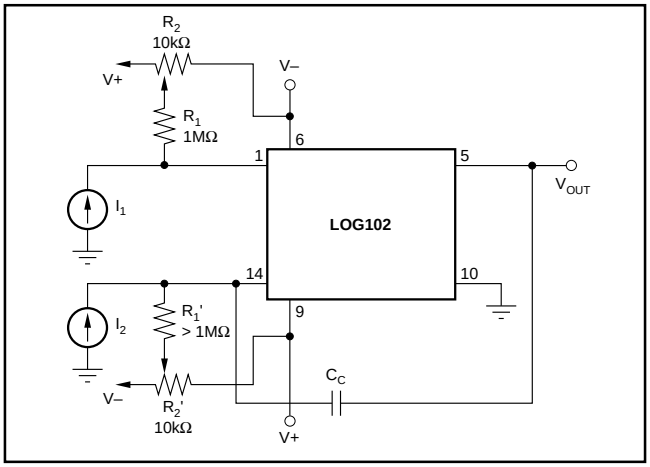


FIGURE 2. Bias Current Nulling.

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:

$$R_{REF} = 2.5V/10nA = 250M\Omega$$

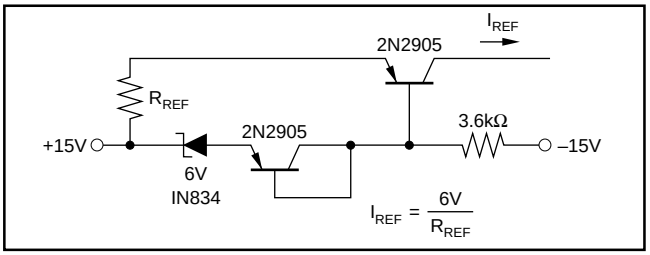


FIGURE 3. Temperature Compensated Current Source.

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.

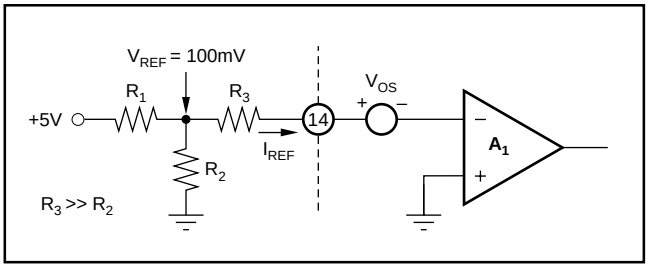


FIGURE 4. T Network for Reference Current.

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.

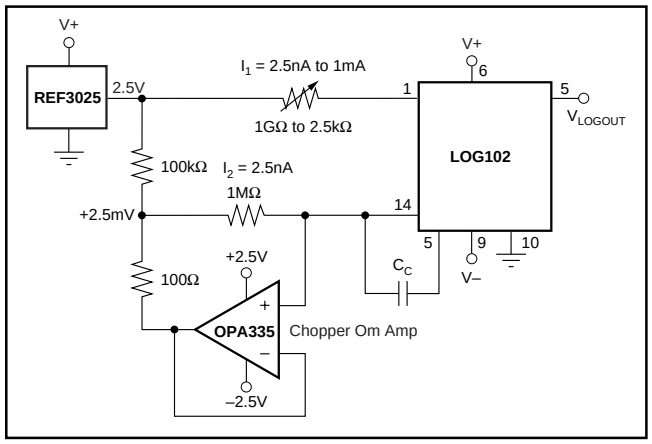


FIGURE 5. Current Source with Offset Compensation.

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.

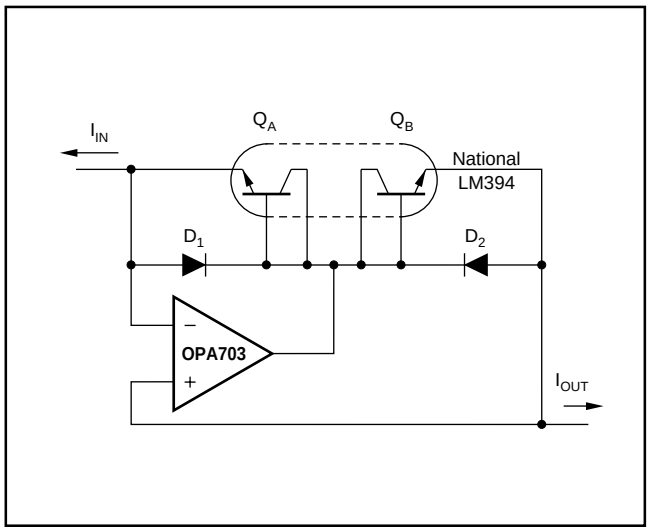


FIGURE 6. Current Inverter/Current Source.

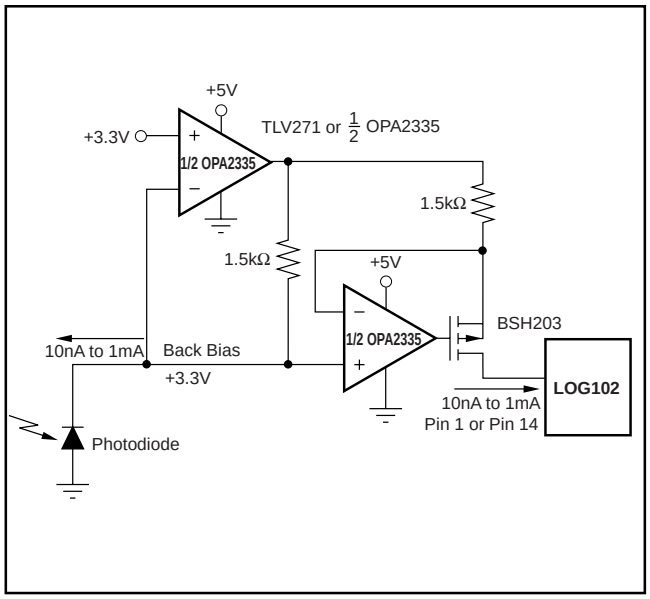


FIGURE 7. Precision Current Inverter/Current Source.

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.

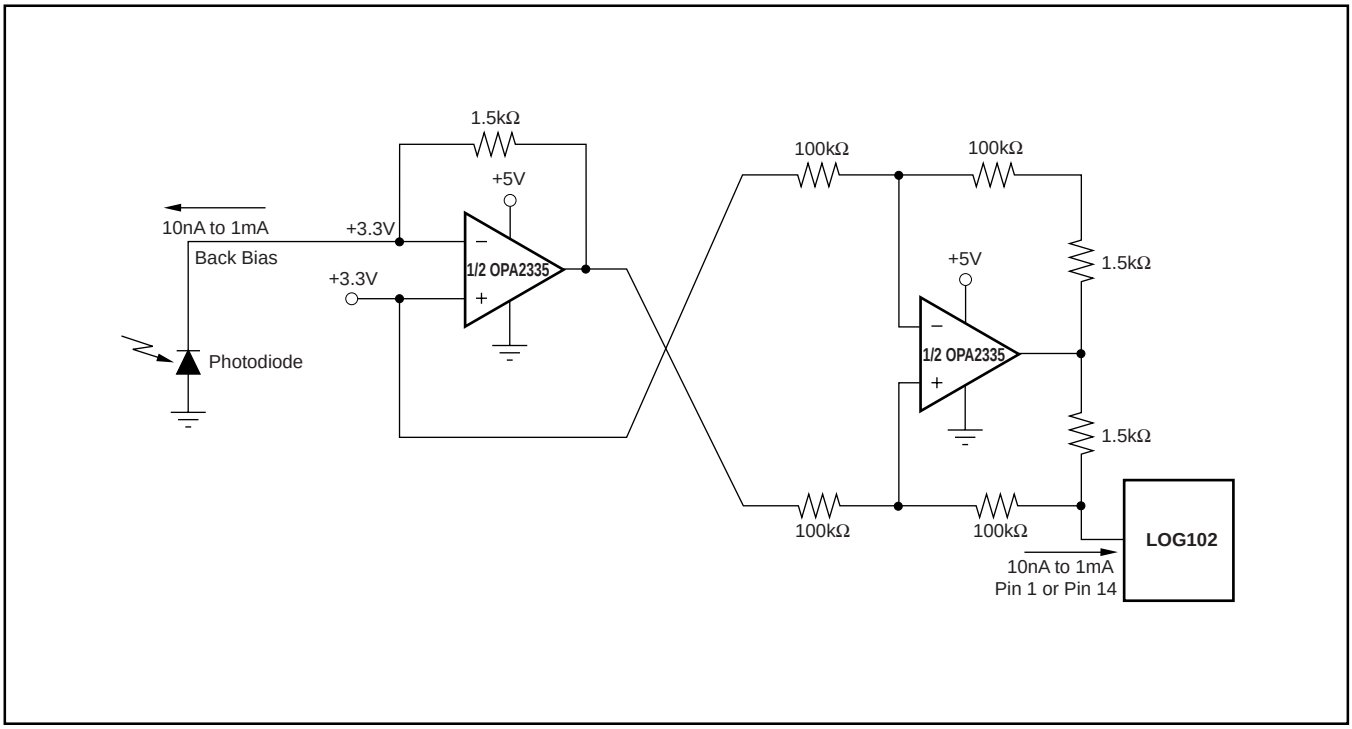
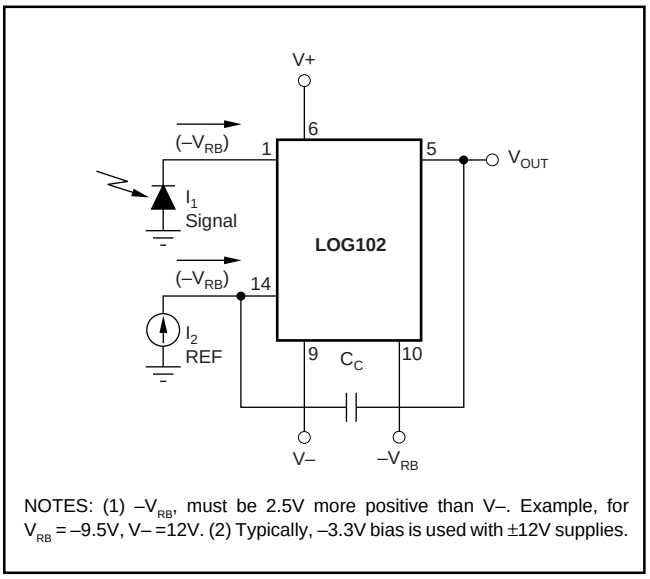


FIGURE 8. Precision Current Inverter/Current Source.



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.

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

If D_1 and D_2 are matched $A \propto (1V) \log I_1/I_2$ (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.

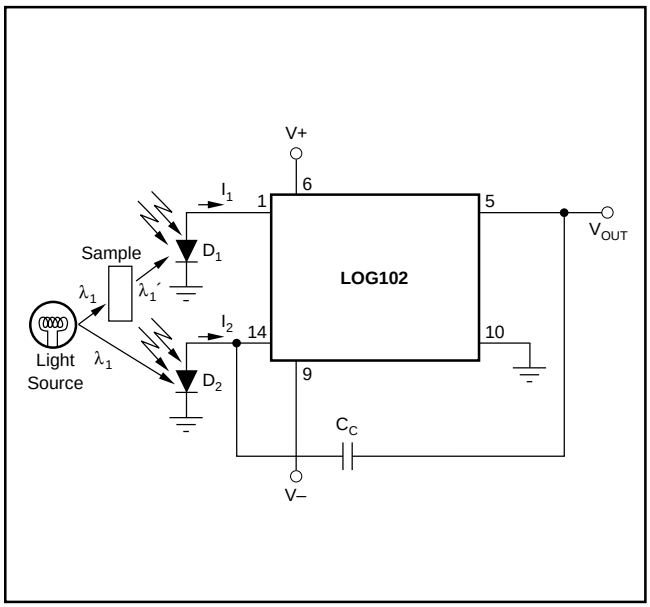


FIGURE 10. Absorbance Measurement.

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

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

k = Boltzmann's constant = 1.381 • 10^{-23}

T = Absolute temperature in degrees Kelvin

q = Electron charge = 1.602 • 10^{-19} Coulombs

I_C = Collector current

I_S = Reverse saturation current

From the circuit in Figure 11, we see that

$$V_L = V_{BE_1} - V_{BE_2} \tag{2}$$

Substituting (1) into (2) yields

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

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

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

$$V_L = V_T \ln \frac{I_1}{I_2} \text{ and since} \tag{5}$$

$$\ln x = 2.3 \log_{10} x \tag{6}$$

$$V_L = n V_T \log \frac{I_1}{I_2} \tag{7}$$

where n = 2.3 (8)

also

$$V_{OUT} = V_L \frac{R_1 + R_2}{R1} \tag{9}$$

$$= \log \frac{I_1}{I_2} \tag{10}$$

or

$$V_{OUT} = \frac{R_1 + R_2}{R1} n V_T \log \frac{I_1}{I_2} \tag{11}$$

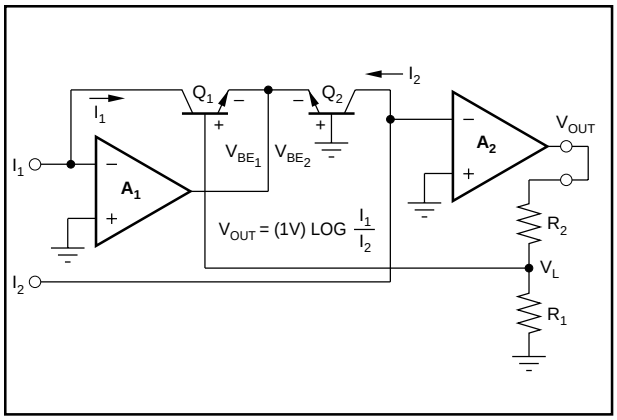


FIGURE 11. Simplified Model of Log Amplifier.

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).

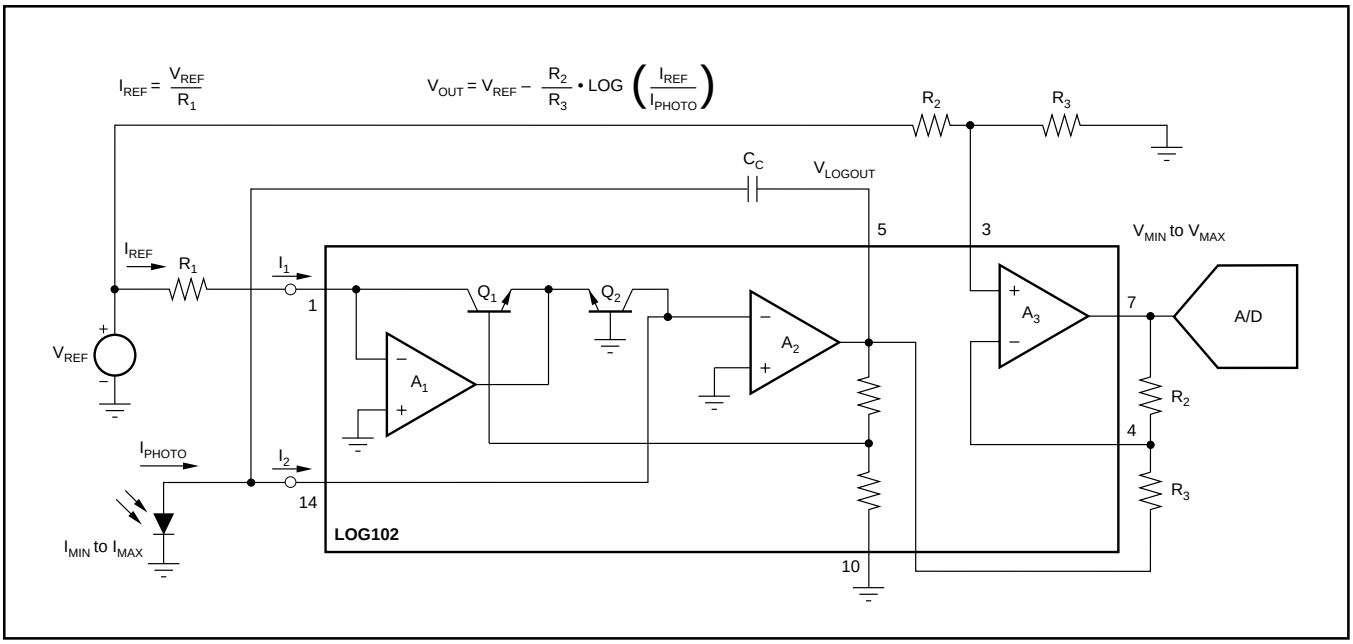
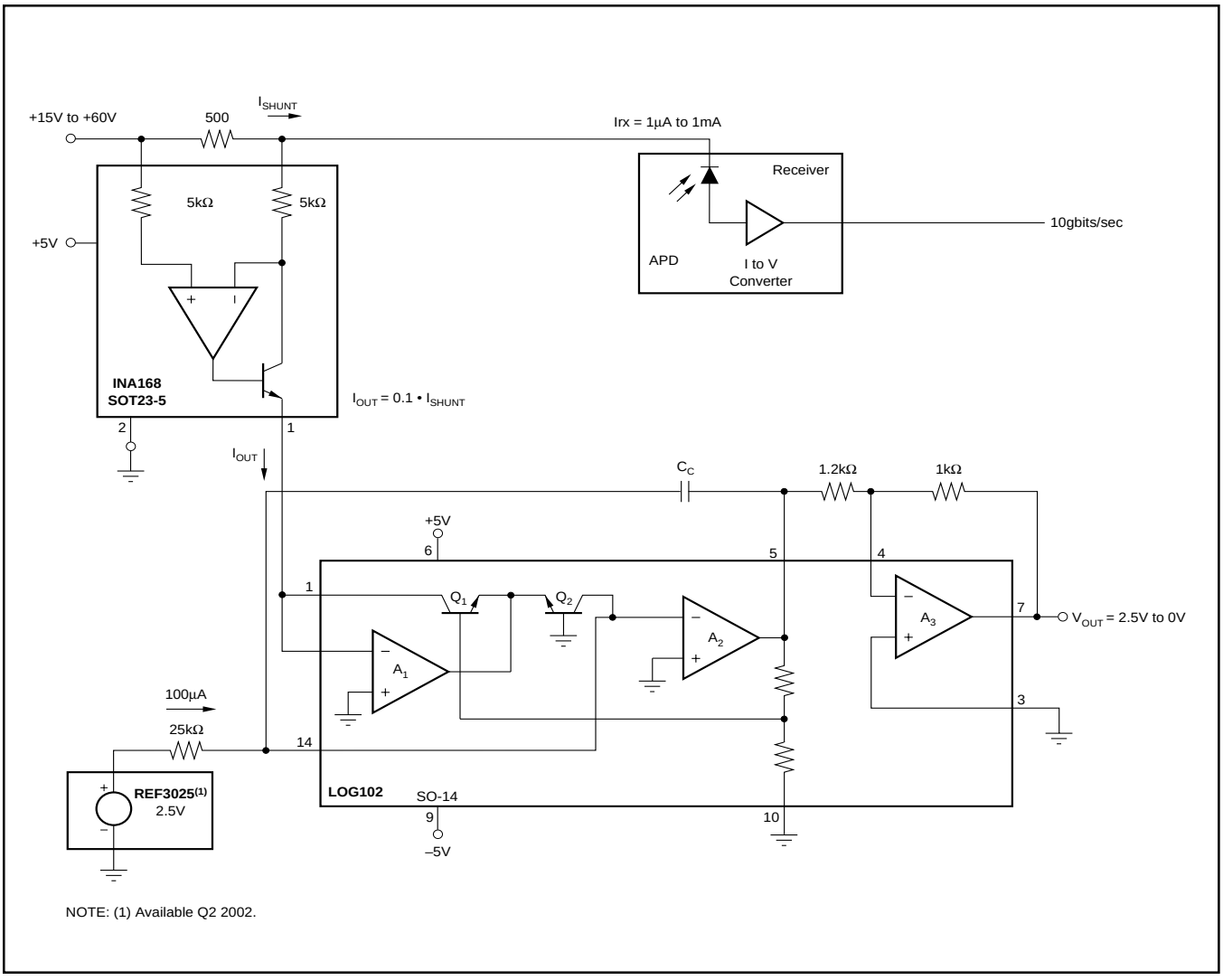


FIGURE 12. Technique for Using Full-Scale Reference Current such that V_{OUT} Increases with Increasing Photodiode Current.



NOTE: (1) Available Q2 2002.

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

DEFINITION OF TERMS

TRANSFER FUNCTION

The ideal transfer function is:

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

Figure 14 shows the graphical representation of the transfer over valid operating range for the LOG102.

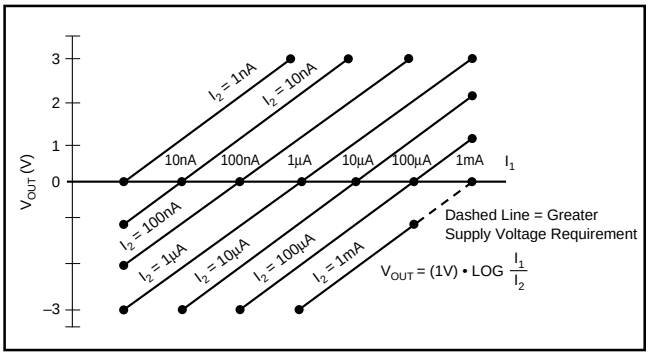


FIGURE 14. Transfer Function with Varying I_2 and I_1.

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,

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

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; this case 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:

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

where N is the log conformity error, in percent.

INDIVIDUAL ERROR COMPONENTS

The ideal transfer function with current input is:

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

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

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

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

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

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

$$= 1.003\ (1) + 0.004 + 0.0003 \quad (11)$$

$$= 1.0073V \quad (12)$$

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

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

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

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

(15)

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

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LOG102AID	OBSOLETE	SOIC	D	14		TBD	Call TI	Call TI	0 to 70	LOG102A	
LOG102AIDG4	OBSOLETE	SOIC	D	14		TBD	Call TI	Call TI	0 to 70	LOG102A	
LOG102AIDR	OBSOLETE	SOIC	D	14		TBD	Call TI	Call TI	0 to 70	LOG102A	

(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.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

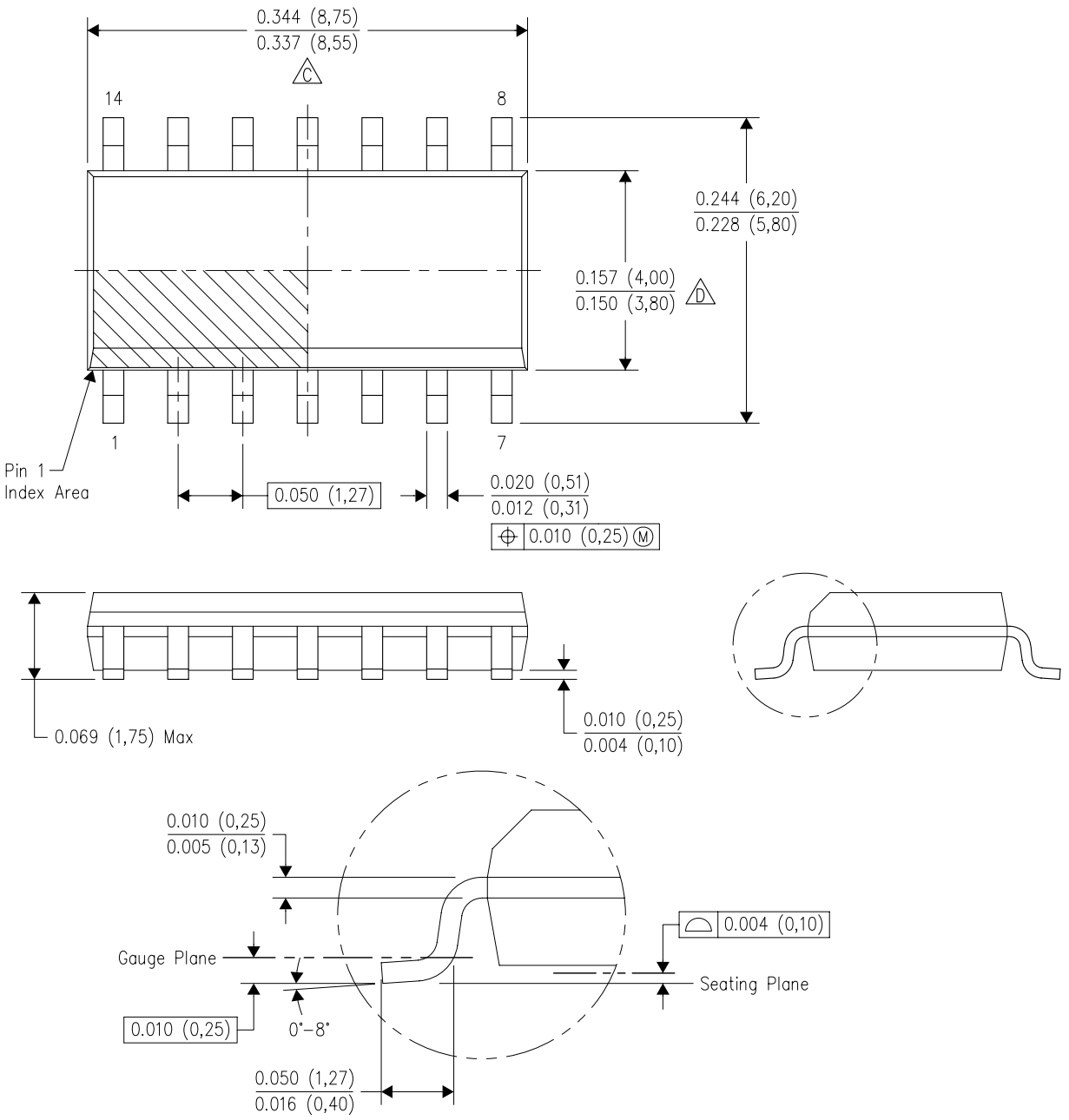
(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

D (R–PDSO–G14) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS–012 variation AB.

IMPORTANT NOTICE

Texas Instruments Incorporated (TI) reserves the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete.

TI's published terms of sale for semiconductor products (http://www.ti.com/sc/docs/stdterms.htm) apply to the sale of packaged integrated circuit products that TI has qualified and released to market. Additional terms may apply to the use or sale of other types of TI products and services.

Reproduction of significant portions of TI information in TI data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such reproduced documentation. Information of third parties may be subject to additional restrictions. 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.

Buyers and others who are developing systems that incorporate TI products (collectively, "Designers") understand and agree that Designers remain responsible for using their independent analysis, evaluation and judgment in designing their applications and that Designers have full and exclusive responsibility to assure the safety of Designers' applications and compliance of their applications (and of all TI products used in or for Designers' applications) with all applicable regulations, laws and other applicable requirements. Designer represents that, with respect to their applications, Designer has all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. Designer agrees that prior to using or distributing any applications that include TI products, Designer will thoroughly test such applications and the functionality of such TI products as used in such applications.

TI's provision of technical, application or other design advice, quality characterization, reliability data or other services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using TI Resources in any way, Designer (individually or, if Designer is acting on behalf of a company, Designer's company) agrees to use any particular TI Resource solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

Designer is authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources 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.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS. TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY DESIGNER AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

Unless TI has explicitly designated an individual product as meeting the requirements of a particular industry standard (e.g., ISO/TS 16949 and ISO 26262), TI is not responsible for any failure to meet such industry standard requirements.

Where TI specifically promotes products as facilitating functional safety or as compliant with industry functional safety standards, such products are intended to help enable customers to design and create their own applications that meet applicable functional safety standards and requirements. Using products in an application does not by itself establish any safety features in the application. Designers must ensure compliance with safety-related requirements and standards applicable to their applications. Designer may not use any TI products in life-critical medical equipment unless authorized officers of the parties have executed a special contract specifically governing such use. Life-critical medical equipment is medical equipment where failure of such equipment would cause serious bodily injury or death (e.g., life support, pacemakers, defibrillators, heart pumps, neurostimulators, and implantables). Such equipment includes, without limitation, all medical devices identified by the U.S. Food and Drug Administration as Class III devices and equivalent classifications outside the U.S.

TI may expressly designate certain products as completing a particular qualification (e.g., Q100, Military Grade, or Enhanced Product). Designers agree that it has the necessary expertise to select the product with the appropriate qualification designation for their applications and that proper product selection is at Designers' own risk. Designers are solely responsible for compliance with all legal and regulatory requirements in connection with such selection.

Designer will fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of Designer's non-compliance with the terms and provisions of this Notice.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2017, Texas Instruments Incorporated