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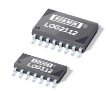


LOG112
LOG2112

SBOS246B – JUNE 2002 – REVISED NOVEMBER 2002

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: ±4.5V to ±18V**
- **PACKAGES: SO-14 (narrow) and SO-16**

APPLICATIONS

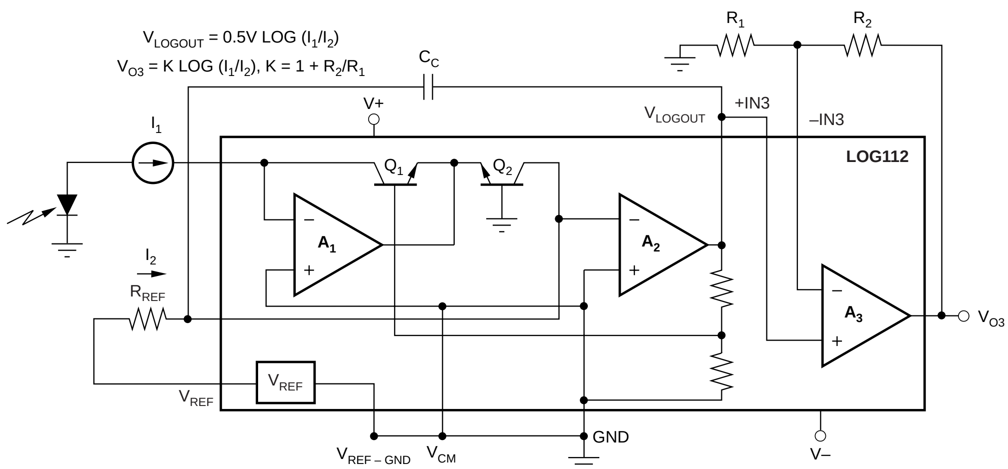
- **LOG, LOG RATIO: Communication, Analytical, Medical, Industrial, Test, General Instrumentation**
- **PHOTODIODE SIGNAL COMPRESSION AMP**
- **ANALOG SIGNAL COMPRESSION IN FRONT OF ANALOG-TO-DIGITAL (A/D) CONVERTER**
- **ABSORBANCE MEASUREMENT**
- **OPTICAL DENSITY MEASUREMENT**

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_{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°C to +75°C.



NOTE: R_1 and R_2 are metal resistors used to compensate gain change over temperature.

TEXAS INSTRUMENTS
www.ti.com

ABSOLUTE MAXIMUM RATINGS[1]

Supply Voltage, V+ to V–	±18V
Inputs	±18V
Input Current	±10mA
Output Short-Circuit Current[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) 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.

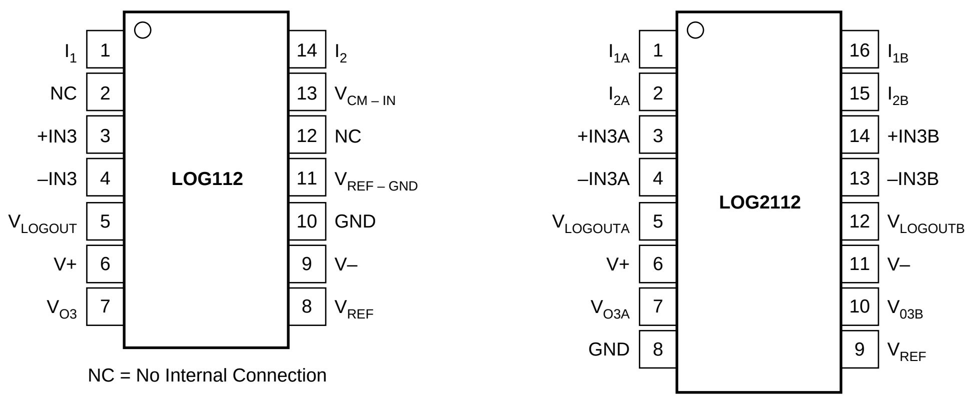
PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR[1]	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.

PIN CONFIGURATION

Top View **SO**



NC = No Internal Connection

ELECTRICAL CHARACTERISTICS

Boldface limits apply over the specified temperature range, **T_A = –5°C to +75°C.**

At T_A = +25°C, V_S = ±5V, and R_{OUT} = 10kΩ, unless otherwise noted.

PARAMETER	CONDITION	LOG112, LOG2112 MIN	TYP	MAX	UNITS
CORE LOG FUNCTION					
V_{IN}/V_{OUT} Equation			V_O = (0.5V)log (I_1/I_2)		V
LOG CONFORMITY ERROR(1)					
Initial	1nA to 100µA (5 decades)		0.01	0.2	%
	100pA to 3.5mA (7.5 decades)		0.13		%
over Temperature	**1nA to 100µA (5 decades)**		0.0001		**%/°C**
	100pA to 3.5mA (7.5 decades)		0.005		**%/°C**
GAIN(2)					
Initial Value	1nA to 100µA		0.5		V/decade
Gain Error	1nA to 100µA		0.10	±1	%
vs Temperature	**T_{MIN} to T_{MAX}**		**0.003**	**0.01**	**%/°C**
INPUT, A_{1A} and A_{1B}, A_{2A}, A_{2B}					
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	20	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
Common-Mode Rejection Ratio (CMRR)			105		dB
OUTPUT, ($V_{LOG\ OUT}$) A_{2A}, A_{2B}					
Output Offset, V_{OSO}, Initial			±3	±15	mV
vs Temperature	**T_{MIN} to T_{MAX}**		**±10**		**µV/°C**
Full-Scale Output (FSO)	V_S = ±5V	(V–) + 1.2		(V+) – 1.5	V
Short-Circuit Current			±18		mA
TOTAL ERROR(3)(4)	I_1 or I_2 remains fixed while other varies.				
Initial	Min to Max				
	I_1 or I_2 = 5mA ($V_S \geq$ ±6V)			±150	mV
	I_1 or I_2 = 3.5mA			±75	mV
	I_1 or I_2 = 1mA			±20	mV
	I_1 or I_2 = 100µA			±20	mV
	I_1 or I_2 = 10µA			±20	mV
	I_1 or I_2 = 1µA			±20	mV
	I_1 or I_2 = 100nA			±20	mV
	I_1 or I_2 = 10nA			±20	mV
	I_1 or I_2 = 1nA			±20	mV
	I_1 or I_2 = 350pA			±20	mV
	I_1 or I_2 = 100pA			±20	mV
vs Temperature	**I_1 or I_2 = 3.5mA**		**±1.2**		**mV/°C**
	I_1 or I_2 = 1mA		**±0.4**		**mV/°C**
	I_1 or I_2 = 100µA		**±0.1**		**mV/°C**
	I_1 or I_2 = 10µA		**±0.05**		**mV/°C**
	I_1 or I_2 = 1µA		**±0.05**		**mV/°C**
	I_1 or I_2 = 100nA		**±0.09**		**mV/°C**
	I_1 or I_2 = 10nA		**±0.2**		**mV/°C**
	I_1 or I_2 = 1nA		**±0.3**		**mV/°C**
	I_1 or I_2 = 350pA		**±0.1**		**mV/°C**
	I_1 or I_2 = 100pA		**±0.3**		**mV/°C**
vs Supply	I_1 or I_2 = 3.5mA		±3.0		mV/V
	I_1 or I_2 = 1mA		±0.1		mV/V
	I_1 or I_2 = 100µA		±0.1		mV/V
	I_1 or I_2 = 10µA		±0.1		mV/V
	I_1 or I_2 = 1µA		±0.1		mV/V
	I_1 or I_2 = 100nA		±0.1		mV/V
	I_1 or I_2 = 10nA		±0.1		mV/V
	I_1 or I_2 = 1nA		±0.25		mV/V
	I_1 or I_2 = 350pA		±0.1		mV/V
	I_1 or I_2 = 100pA		±0.1		mV/V

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 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.

ELECTRICAL CHARACTERISTICS (Cont.)

Boldface limits apply over the specified temperature range, **T_A = –5°C to +75°C.**

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

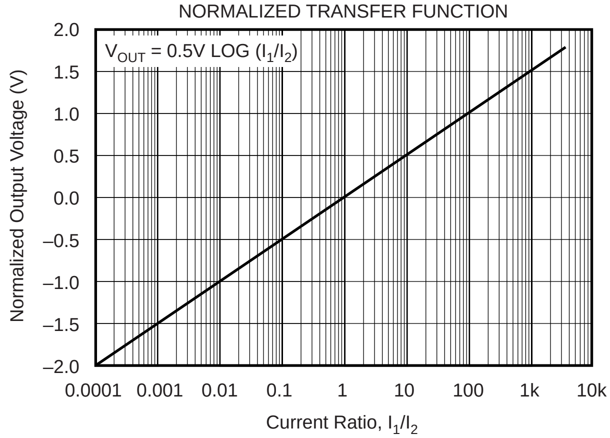
PARAMETER	CONDITION	LOG112, LOG2112			UNITS
		MIN	TYP	MAX	
FREQUENCY RESPONSE, CORE LOG(5)					
BW, 3dB					
I_2 = 10nA	C_C = 4500pF		0.1		kHz
I_2 = 1µA	C_C = 150pF		38		kHz
I_2 = 10µA	C_C = 150pF		40		kHz
I_2 = 1mA	C_C = 50pF		45		kHz
Step Response					
Increasing					
I_1 = 1µA to 1mA	C_C = 950pF, I_2 = 31.6µA		1.5		µs
I_1 = 100µA to 1µA	C_C = 375pF, I_2 = 10µA		1.6		µs
I_1 = 10nA to 100nA	C_C = 120pF, I_2 = 31.6nA		1.1		ms
Decreasing					
I_1 = 1mA to 1mA	C_C = 950pF, I_2 = 31.6µA		39		µs
I_1 = 1µA to 100nA	C_C = 375pF, I_2 = 10µA		31.2		µs
I_1 = 100µA to 10nA	C_C = 150pF, I_2 = 31.6nA		2.1		ms
I_2 = 1µA to 1nA	C_C = 10.5nF, I_1 = 31µA		1.2		ns
I_2 = 100µA to 1µA	C_C = 750pF, I_1 = 10µA		113		µs
I_2 = 10nA to 100nA	C_C = 125pF, I_1 = 31.6nA		2.6		ns
Decreasing					
I_2 = 1mA to 1µA	C_C = 10.5nF, I_1 = 31µA		13.3		µs
I_2 = 1µA to 100nA	C_C = 750pF, I_1 = 10µA		6.6		µs
I_2 = 100µA to 10nA	C_C = 125pF, I_1 = 31.6nA		629		µs
OP AMP, A3					
Input Offset Voltage			+250	±1000	µV
vs Temperature	**T_{MIN} to T_{MAX}**		**±2**		**µV/°C**
vs Supply	V_S = ±4.5V to ±18V		5	50	µV/V
Input Bias Current			–10		nA
Input Offset Current			±0.5		nA
Input Voltage Range		(V–)		(V+) – 1.5	V
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			0.5		V/µs
Settling Time, 0.01%	G = –1, 3V Step, C_L = 100pF		16		µs
Rated Output		(V–) + 1.5		(V+) – 0.9	V
Short-Circuit Current			±4		mA
VOLTAGE REFERENCE					
Bandgap Voltage			2.5		V
Error, Initial			±0.05	±0.5	%
vs Temperature	T_{MIN} to T_{MAX}		±25		ppm/°C
vs Supply	V_S = ±4.5V to ±18V		±10		ppm/V
vs Load	I_{LOAD} = 10mA		±600		ppm/mA
Short-Circuit Current			16		mA
POWER SUPPLY					
Operating Range	V_S	±4.5		±18	V
Quiescent Current	I_O = 0				
LOG112			±1.25	±1.75	mA
LOG2112			±2.5	±3.5	mA
TEMPERATURE RANGE					
Specified Range, T_{MIN} to T_{MAX}		–5		75	°C
Operating Range		–40		85	°C
Storage Range		–55		125	°C
Thermal Resistance, θ_{JA} SO-14			110		°C/W
SO-16			80		°C/W

NOTES: (1) Log Conformity Error is peak deviation from the best-fit-straight line of V_O vs 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.

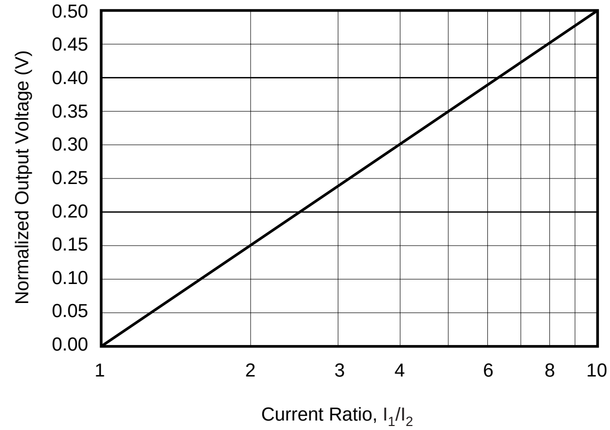
TYPICAL CHARACTERISTICS

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

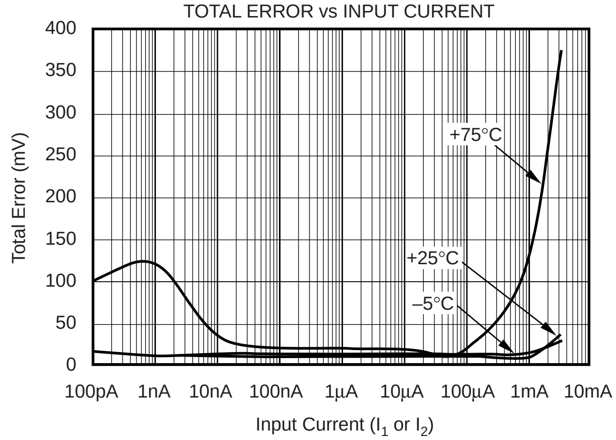
NORMALIZED TRANSFER FUNCTION



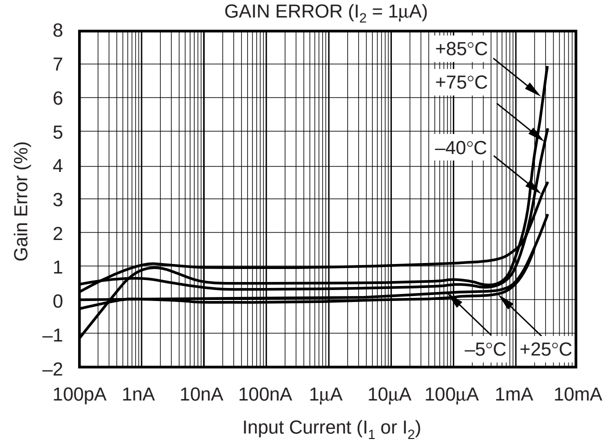
ONE CYCLE OF NORMALIZED TRANSFER FUNCTION



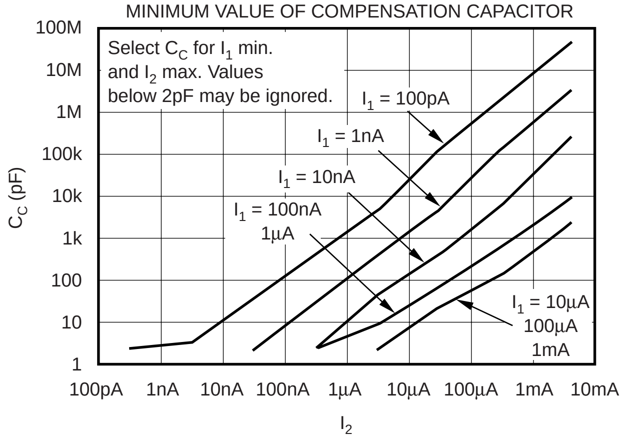
TOTAL ERROR vs INPUT CURRENT



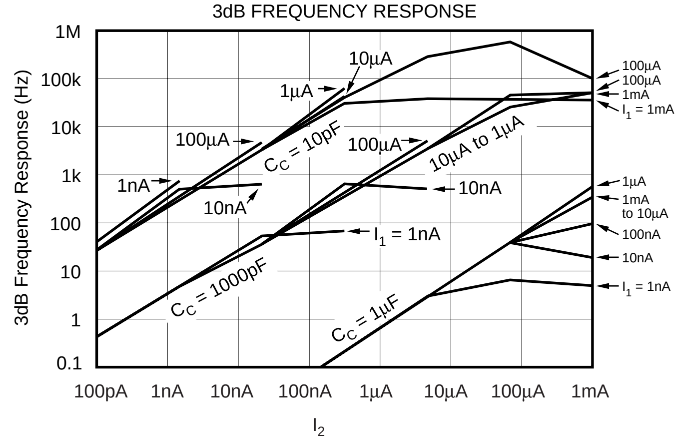
GAIN ERROR ($I_2 = 1µA$)



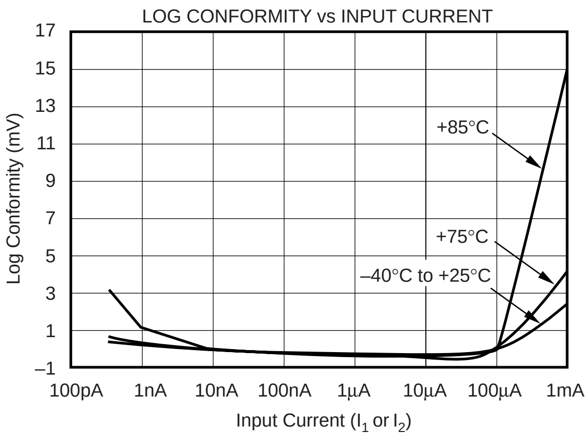
MINIMUM VALUE OF COMPENSATION CAPACITOR

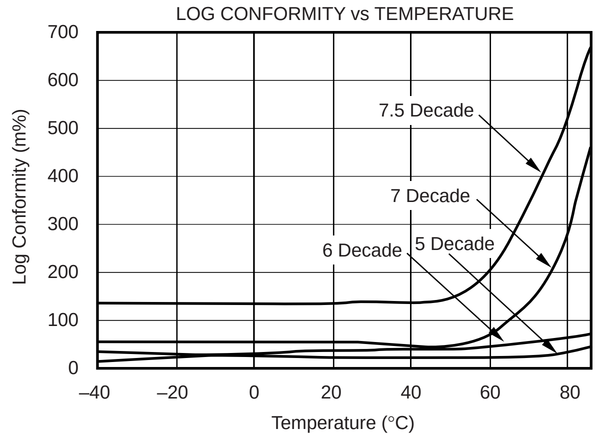


3dB FREQUENCY RESPONSE



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

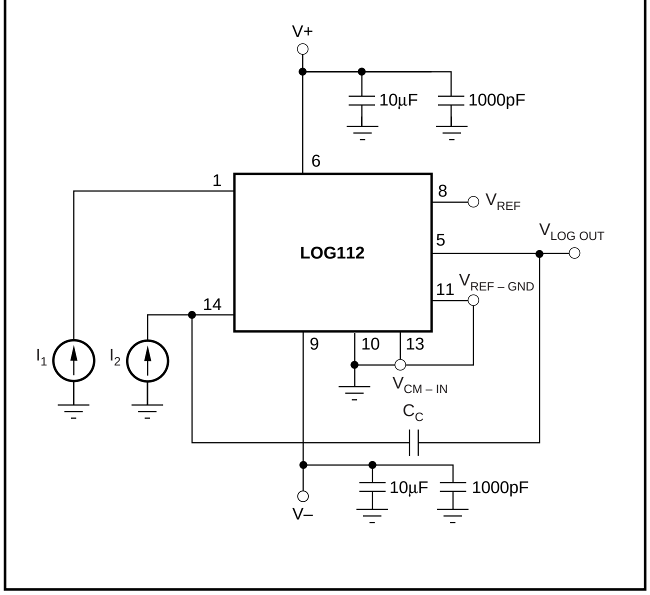


FIGURE 1. Basic Connections of the LOG112.

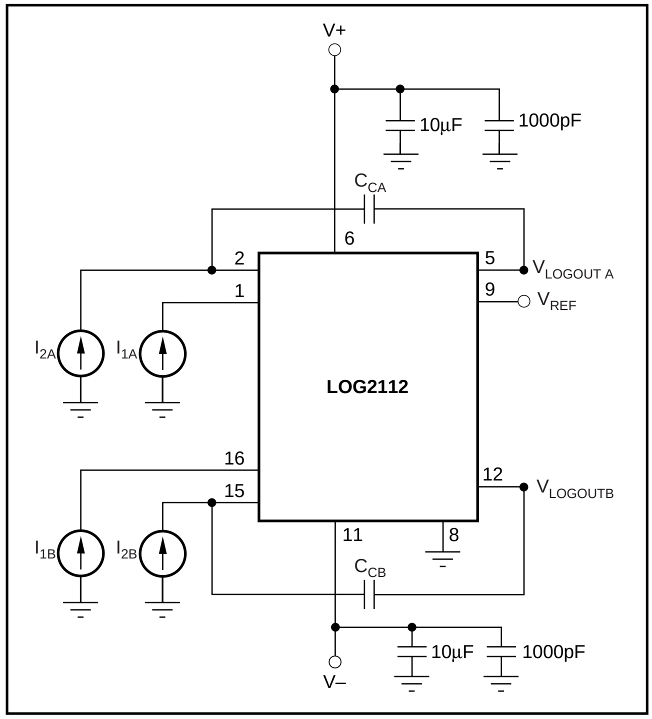


FIGURE 2. Basic Connections of the LOG2112.

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 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:

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

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:

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

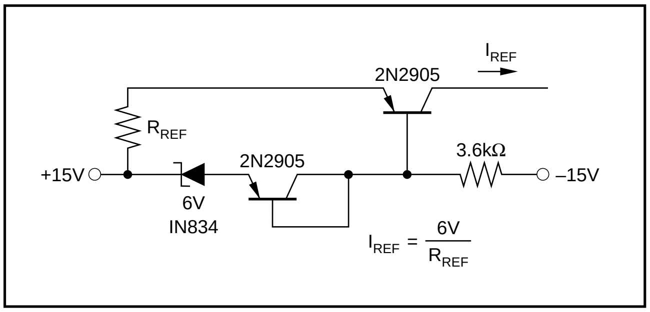


FIGURE 3. Temperature Compensated Current Source.

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.

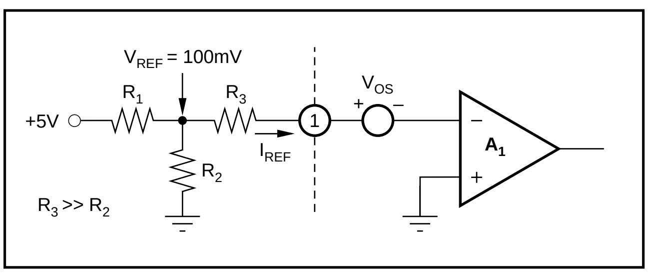


FIGURE 4. T Network for Reference Current.

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.

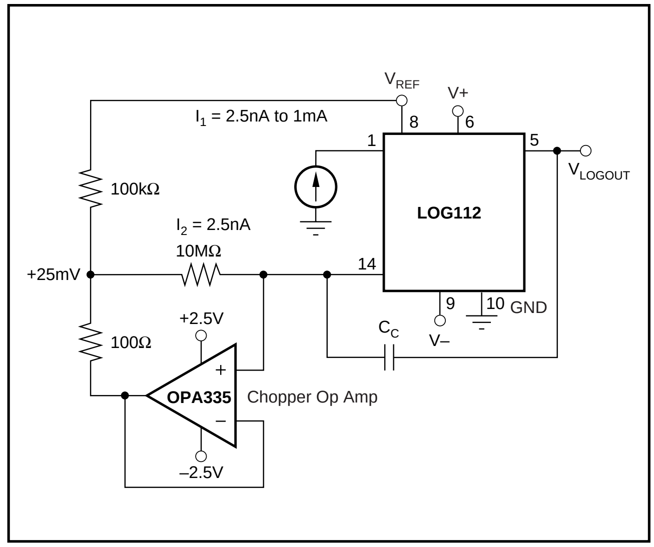


FIGURE 5. Current Source with Offset Compensation.

FREQUENCY RESPONSE

The frequency response curves seen in the Typical Characteristics 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 will make the LOG112 and LOG2112 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.

NEGATIVE INPUT CURRENTS

The LOG112 and LOG2112 will 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.

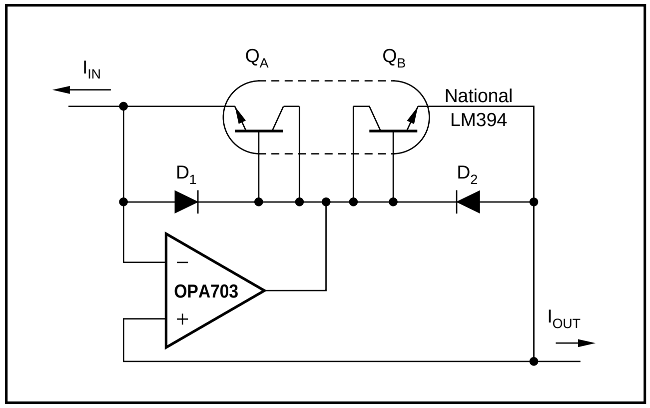


FIGURE 6. Current Inverter/Current Source.

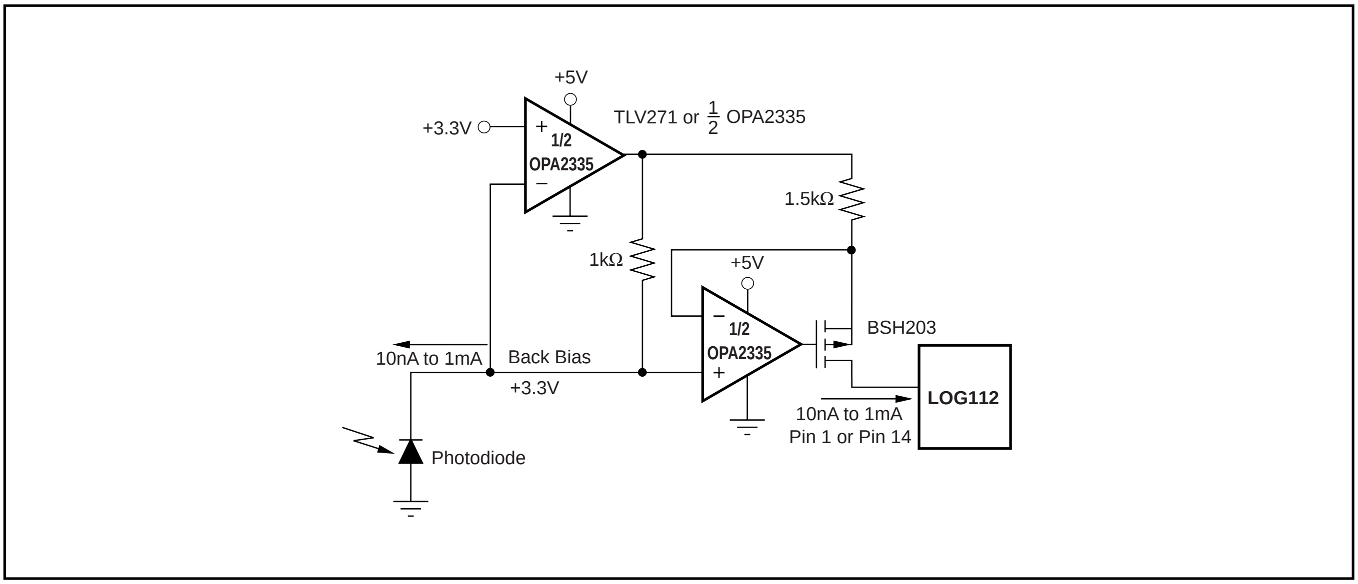


FIGURE 7. Precision Current Inverter/Current Source.

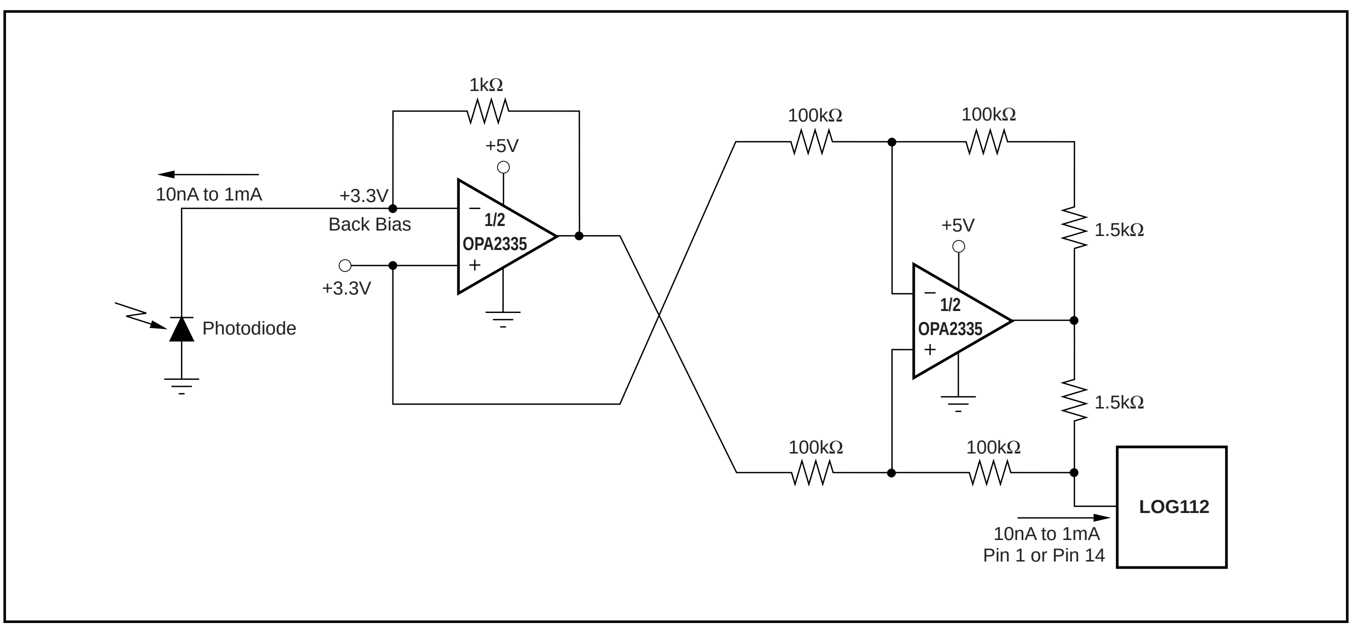


FIGURE 8. Precision Current Inverter/Current Source.

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.

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 9.

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

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

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 10 shows the LOG112 and LOG2112 configured for operation with a single +5V supply.

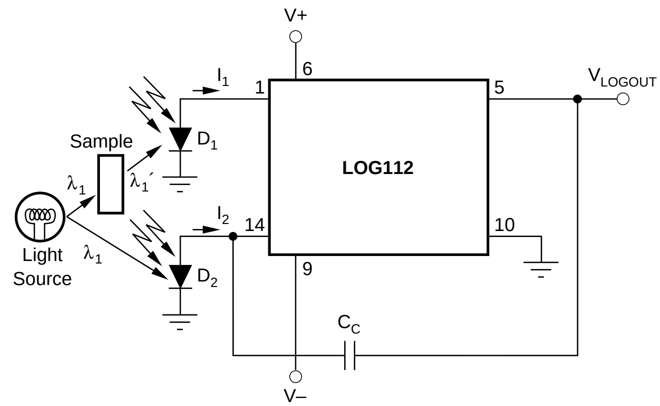


FIGURE 9. Absorbance Measurement.

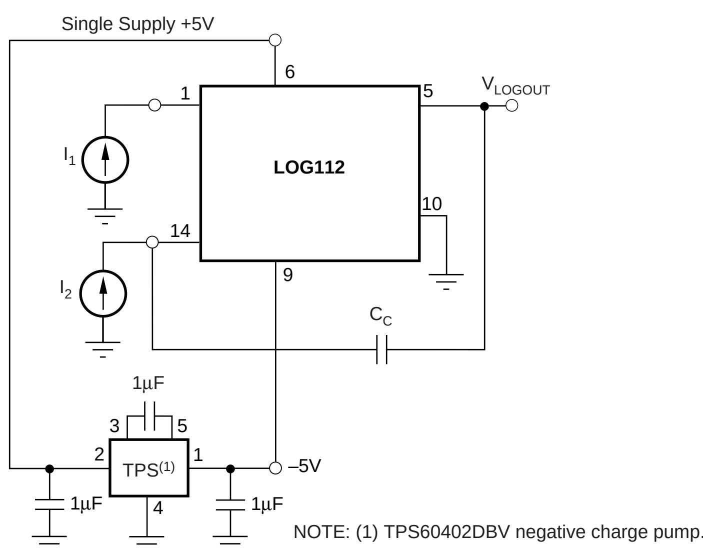


FIGURE 10. Single +5V Power-Supply Operation.

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:

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

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

T = Absolute temperature in degrees Kelvin

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

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

$$V_{OUT} = \frac{R_1 + R_2}{R_1} n\, V_T \log \frac{I_1}{I_2} \tag{10}$$

or

$$V_{OUT} = 0.5V \bullet \log \frac{I_1}{I_2} \tag{11}$$

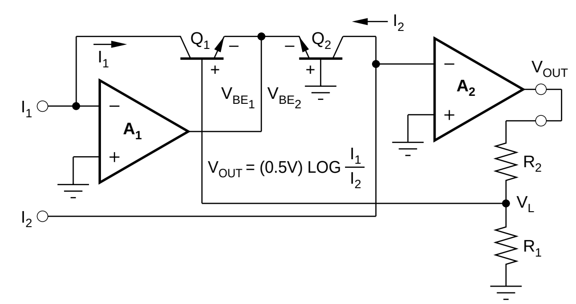


FIGURE 11. Simplified Model of a Log Amplifier.

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

DEFINITION OF TERMS

TRANSFER FUNCTION

The ideal transfer function is:

$$V_{LOGOUT} = 0.5V \bullet \log I_1/I_2 \tag{5}$$

Figure 12 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.

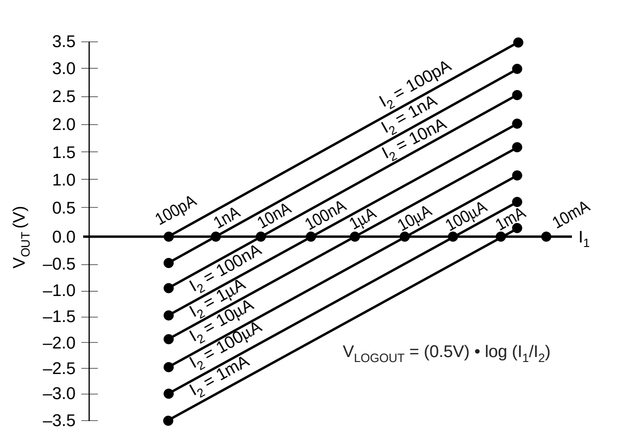


FIGURE 12. Transfer Function with Varying I_2 and I_1.

TOTAL ERROR

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

Thus,

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

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 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.

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 13.

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_{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:

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

where N is the log conformity error, in percent.

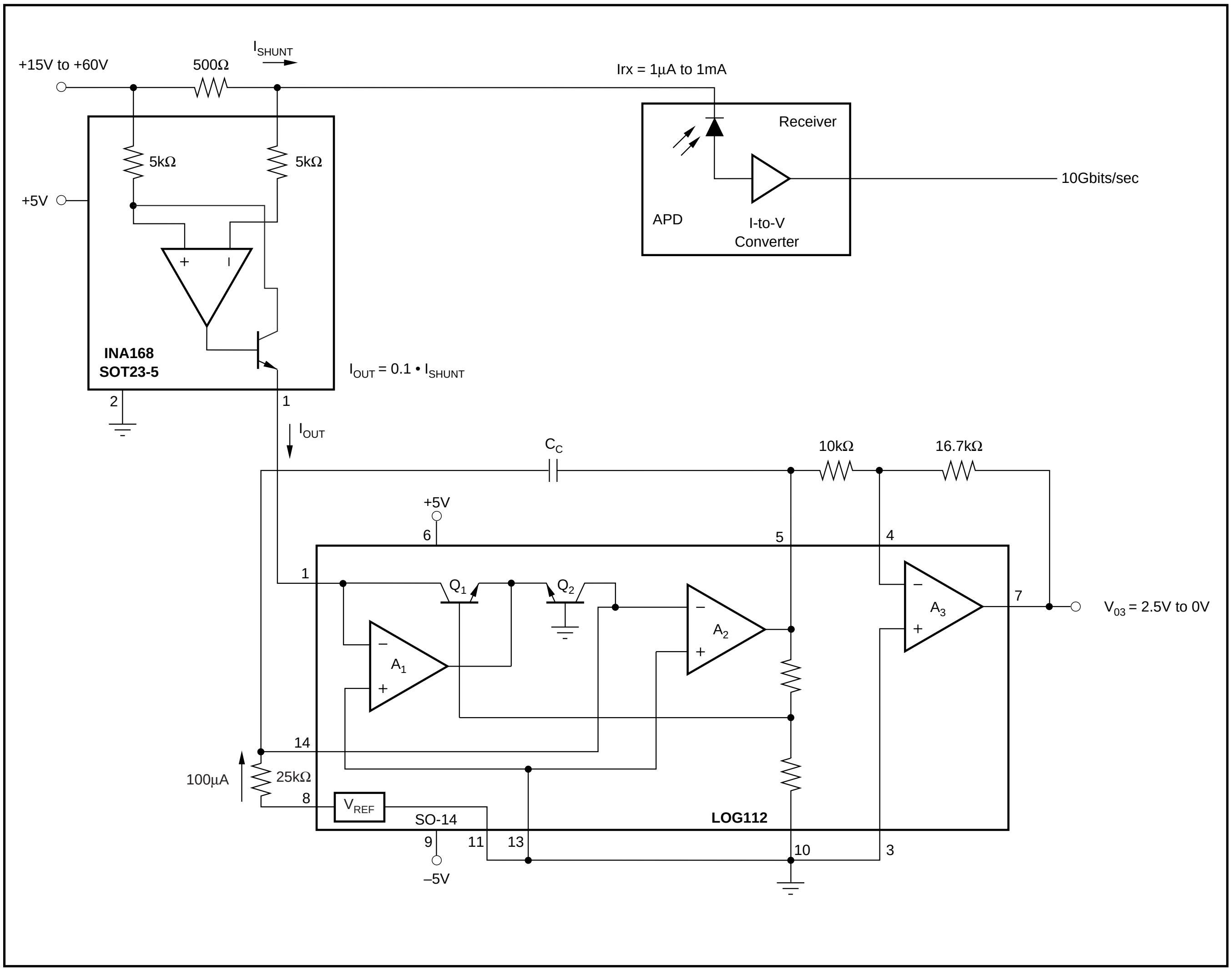


FIGURE 13. High-Side Shunt for Avalanche Photodiode (APD) Measures 3 Decades of APD Current.

INDIVIDUAL ERROR COMPONENTS

The ideal transfer function with current input is:

$$V_{LOGOUT} = (0.5V) \bullet \log \frac{I_1}{I_2} \quad (8)$$

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

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

The individual component of error is:

ΔK = gain error (0.10%, 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 (0.01%, 0.13%, typ)

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

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

m = number of decades over which N is specified:

Example: what is the error when

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

$$V_{LOGOUT} = (0.5 \pm 0.001)\log \frac{10^{-6} - 5 \bullet 10^{-12}}{10^{-7} - 5 \bullet 10^{-12}} \pm (2)(0.0001)5 \pm 3.0mV \quad (11)$$
$$= 0.505V$$

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

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

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

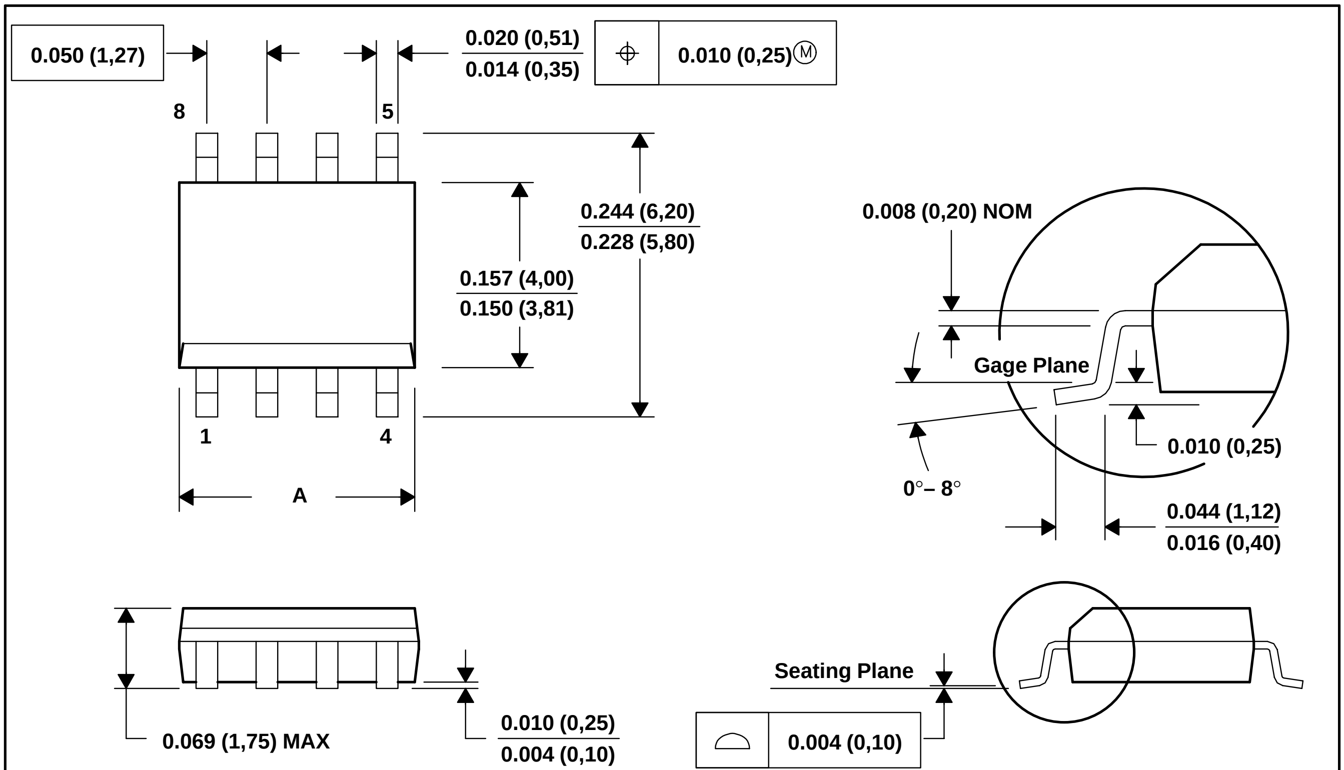
$$V_{LOGOUT} = (0.5V)(1 \pm \Delta K) \log \frac{\frac{V_1}{R_1} - I_{B_1} \pm \frac{E_{OS_1}}{R_1}}{\frac{V_2}{R_2} - I_{B_2} \pm \frac{E_{OS_2}}{R_2}} \pm Nm \pm V_{OSO} \quad (13)$$

Where $\frac{E_{OS1}}{R_1}$ and $\frac{E_{OS2}}{R_2}$ (offset error) 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



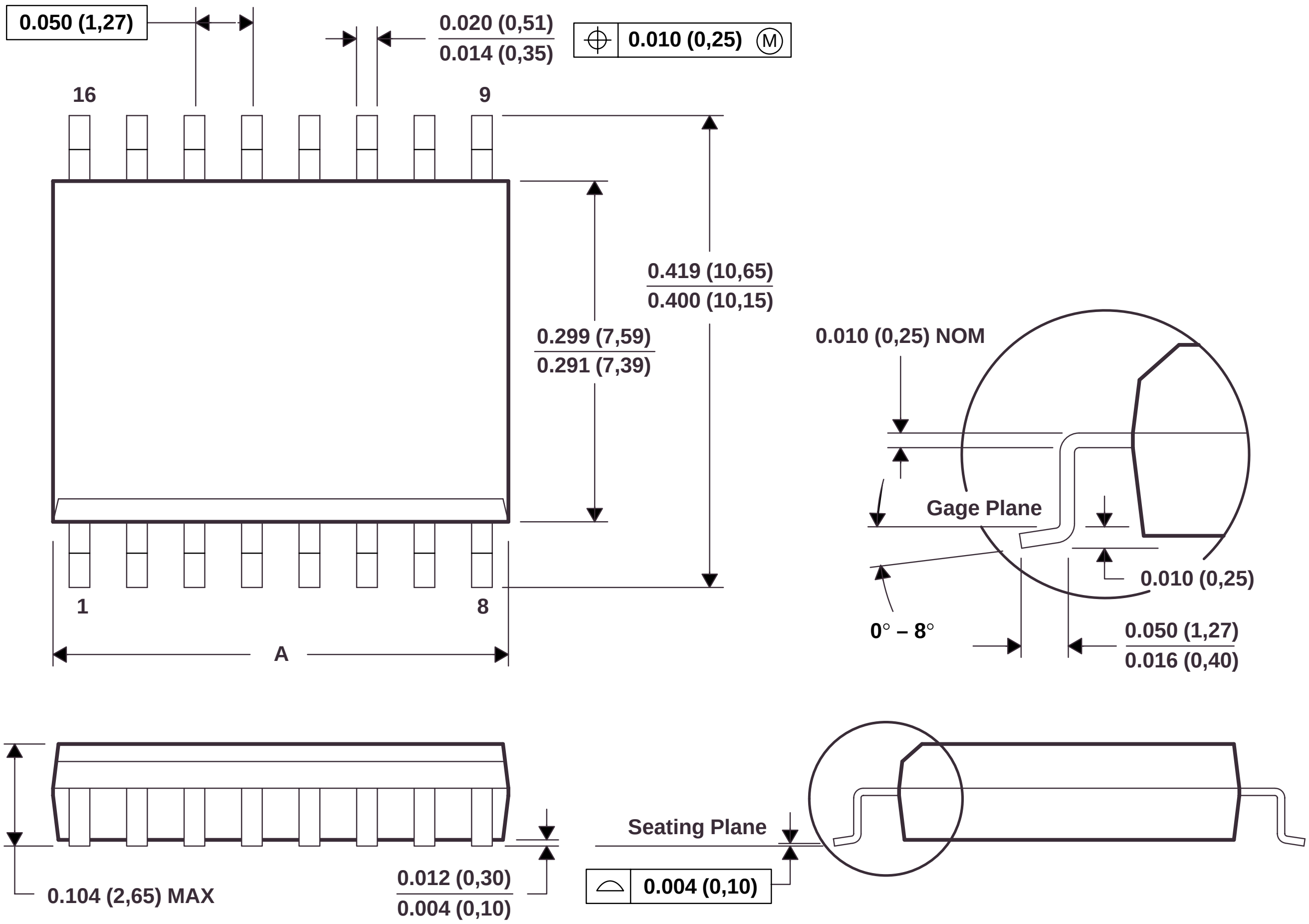
PINS ** / DIM	8	14	16
A MAX	0.197 (5,00)	0.344 (8,75)	0.394 (10,00)
A MIN	0.189 (4,80)	0.337 (8,55)	0.386 (9,80)

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

DW (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

16 PINS SHOWN



DIM \ PINS **	16	18	20	24	28
A MAX	0.410 (10,41)	0.462 (11,73)	0.510 (12,95)	0.610 (15,49)	0.710 (18,03)
A MIN	0.400 (10,16)	0.453 (11,51)	0.500 (12,70)	0.600 (15,24)	0.700 (17,78)

4040000 / E 08/01

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-013

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