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 $-5^\circ C$ to $+75^\circ C$.

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

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.

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**ABSOLUTE MAXIMUM RATINGS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rating</th>
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<tbody>
<tr>
<td>Supply Voltage, V+ to V–</td>
<td>±18V</td>
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<tr>
<td>Inputs</td>
<td>±18V</td>
</tr>
<tr>
<td>Input Current</td>
<td>±10mA</td>
</tr>
<tr>
<td>Output Short-Circuit Current</td>
<td>Continuous</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>–40°C to +85°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>–55°C to +125°C</td>
</tr>
<tr>
<td>Junction Temperature</td>
<td>+150°C</td>
</tr>
<tr>
<td>Lead Temperature (soldering, 10s)</td>
<td>+300°C</td>
</tr>
</tbody>
</table>

**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**

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>PACKAGE-LEAD</th>
<th>PACKAGE DESIGNATOR</th>
<th>PACKAGE MARKING</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOG112</td>
<td>SO-14</td>
<td>D</td>
<td>LOG112A</td>
</tr>
<tr>
<td>LOG2112</td>
<td>SO-16</td>
<td>DW</td>
<td>LOG2112A</td>
</tr>
</tbody>
</table>

**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.

**PIN CONFIGURATION**

```
Top View

LOG112

NC = No Internal Connection
```

```
1 I1
2 NC
3 +IN3
4 –IN3
5 VLOGOUT
6 V+
7 V03

14 I2
13 VCM-IN
12 NC
11 VREF-GND
10 GND
9 V-
8 VREF

LOG2112

16 I1B
15 I2B
14 +IN3B
13 –IN3B
12 VLOGOUTB
11 V-
10 V03B
9 VREF
```

Texas Instruments
www.ti.com

LOG112, 2112

SBOS246D
# ELECTRICAL CHARACTERISTICS

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

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

## PARAMETER CONDITION

<table>
<thead>
<tr>
<th>LOG112, LOG2112</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CORE LOG FUNCTION</strong></td>
<td>$V_{IN}/V_{OUT}$ Equation</td>
<td>$V_{LOGOUT} = (0.5V)\log (I_1/I_2)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LOG CONFORMANCE ERROR</strong>[1]</td>
<td>Initial</td>
<td>1nA to 100µA (5 decades)</td>
<td>0.01</td>
<td>0.2</td>
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<tr>
<td></td>
<td>100pA to 3.5mA (7.5 decades)</td>
<td>0.13</td>
<td></td>
<td>%</td>
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<tr>
<td></td>
<td>1nA to 100µA (5 decades)</td>
<td>0.0001</td>
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<td>%/°C</td>
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<tr>
<td></td>
<td>100pA to 3.5mA (7.5 decades)</td>
<td>0.005</td>
<td></td>
<td>%/°C</td>
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<td><strong>GAIN</strong>[2]</td>
<td>Initial Value</td>
<td>1nA to 100µA</td>
<td>0.5</td>
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<td></td>
<td>Gain Error</td>
<td>1nA to 100µA</td>
<td>±1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>vs Temperature</td>
<td>$T_{MIN}$ to $T_{MAX}$</td>
<td>0.003</td>
<td>0.01</td>
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<tr>
<td><strong>INPUT, A_{1A}, A_{1B}, A_{2A}, A_{2B}</strong></td>
<td>Offset Voltage vs Temperature</td>
<td>$T_{MIN}$ to $T_{MAX}$</td>
<td>±0.3</td>
<td>±1.5</td>
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<tr>
<td></td>
<td>vs Power Supply (PSRR)</td>
<td>$V_S = \pm 4.5\text{V}$ to $\pm 18\text{V}$</td>
<td>±2</td>
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<td></td>
<td>vs Temperature Voltage Noise</td>
<td>$T_{MIN}$ to $T_{MAX}$</td>
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<td>f = 10Hz to 10kHz</td>
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<td>f = 1kHz</td>
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<td>Current Noise</td>
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<td>Common-Mode Voltage Range (Positive)</td>
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<td>(V+) – 2</td>
<td>(V+) – 1.5</td>
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<td>Common-Mode Voltage Range (Negative)</td>
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<td>(V–) + 2</td>
<td>(V–) + 1.2</td>
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<td>Common-Mode Rejection Ratio (CMRR)</td>
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<td><strong>OUTPUT, $V_{LOG OUT}$</strong></td>
<td>Initial Value</td>
<td>$I_{1}$ or $I_{2} = 3.5\text{mA}$</td>
<td>±3</td>
<td>±15</td>
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<td>Full-Scale Output (FSO)</td>
<td>$V_S = \pm 5\text{V}$</td>
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<td>Output Offset, $V_{OSO}$</td>
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<td>$I_{1}$ or $I_{2} = 10\text{µA}$</td>
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<td>$I_{1}$ or $I_{2} = 350\text{pA}$</td>
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<td>Short-Circuit Current</td>
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</tr>
</tbody>
</table>

### NOTES:

1. Log Conformity Error is the 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.
### FREQUENCY RESPONSE, CORE LOG

**BW, 3dB**

- \( I_2 = 10nA \)  \( C_C = 450pF \)  \( f = 0.1kH \)  \( 0.1 \)  \( kHz \)
- \( I_2 = 1\mu A \)  \( C_C = 150pF \)  \( 38 \)  \( kHz \)
- \( I_2 = 10\mu A \)  \( C_C = 150pF \)  \( 40 \)  \( kHz \)
- \( I_2 = 1mA \)  \( C_C = 50pF \)  \( 45 \)  \( kHz \)

**Step Response**

- Increasing
  - \( I_1 = 10nA \)  \( C_C = 120pF, I_2 = 31.6nA \)  \( 1.1 \)  \( ms \)
  - \( I_1 = 1\mu A \)  \( C_C = 375pF, I_2 = 10\mu A \)  \( 31.2 \)  \( \mu s \)
  - \( I_1 = 1mA \)  \( C_C = 950pF, I_2 = 31.6\mu A \)  \( 1.2 \)  \( ms \)

- Decreasing
  - \( I_1 = 100nA \)  \( C_C = 120pF, I_2 = 31.6nA \)  \( 3.9 \)  \( ms \)
  - \( I_1 = 100\mu A \)  \( C_C = 375pF, I_2 = 10\mu A \)  \( 630 \)  \( \mu s \)
  - \( I_1 = 1mA \)  \( C_C = 950pF, I_2 = 31.6\mu A \)  \( 31.2 \)  \( \mu s \)

**OP AMP, A3**

- **Input Offset Voltage vs Temperature**
  - \( T_{MIN} \)  \( +250 \)  \( \mu V \)
  - \( T_{MAX} \)  \( +1000 \)  \( \mu V \)
- **Input Bias Current**
- **Input Offset Current**
- **Input Voltage Range** (V–)  \( -1.5 \)  \( V \)
- **Input Noise, f = 0.1Hz to 10Hz**
  - \( f = 1kHz \)  \( 1 \)  \( \mu V_{PP} \)
- **Open-Loop Voltage Gain**
  - \( G = -1, 3V \)  \( 88 \)  \( dB \)
- **Gain-Bandwidth Product**
  - \( 1.4 \)  \( MHz \)
- **Slew Rate**
  - \( 0.5 \)  \( \mu V/\mu s \)
- **Settling Time, 0.01%**
  - \( G = -1, 3V \)  \( 16 \)  \( \mu s \)
- **Rated Output**
  - \( (V–) + 1.5 \)  \( (V+) - 0.9 \)  \( V \)
- **Short-Circuit Current**
  - \( \pm 4 \)  \( mA \)

### VOLTAGE REFERENCE

- **Bandgap Voltage**
  - \( 2.5 \)  \( V \)
- **Error, Initial vs Temperature**
  - \( T_{MIN} \)  \( \pm 0.05 \)  \( \pm 0.5 \)  \( % \)
  - \( T_{MAX} \)  \( \pm 0.5 \)  \( \% \)
- **Gain-Bandwidth Product**
  - \( 1.4 \)  \( MHz \)
- **Slew Rate**
  - \( 0.5 \)  \( \mu V/\mu s \)
- **Settling Time, 0.01%**
  - \( G = -1, 3V \)  \( 16 \)  \( \mu s \)
- **Rated Output**
  - \( (V–) + 1.5 \)  \( (V+) - 0.9 \)  \( V \)
- **Short-Circuit Current**
  - \( \pm 4 \)  \( mA \)

### POWER SUPPLY

- **Operating Range**
  - \( V_S \)  \( \pm 5 \)  \( V \)
- **Quiescent Current**
  - \( I_Q = 0 \)  \( \pm 18 \)  \( mA \)
- **LOG112**
  - \( I_O = 0 \)  \( \pm 2.5 \)  \( mA \)
- **LOG2112**
  - \( I_O = 0 \)  \( \pm 1.25 \)  \( mA \)

### TEMPERATURE RANGE

- **Specified Range, \( T_{MIN} \) to \( T_{MAX} \)**
  - \( -5 \)  \( 75 \)  \( °C \)
- **Operating Range**
  - \( -40 \)  \( 85 \)  \( °C \)
- **Storage Range**
  - \( -55 \)  \( 125 \)  \( °C \)
- **Thermal Resistance, \( \theta_{JA} \)**
  - \( SO-14 \)  \( 110 \)  \( °C/W \)
  - \( SO-16 \)  \( 80 \)  \( °C/W \)

---

**NOTES:**
1. Log Conformity Error is the 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 $T_A = +25^\circ C$, $V_{C} = \pm 5V$, and $R_L = 10k\Omega$, unless otherwise noted.

**NORMALIZED TRANSFER FUNCTION**

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

**ONE CYCLE OF NORMALIZED TRANSFER FUNCTION**

**TOTAL ERROR ($-5^\circ C$)**

**TOTAL ERROR ($25^\circ C$)**

**TOTAL ERROR ($70^\circ C$)**

**GAIN ERROR ($I_2 = 1\mu A$)**
TYPICAL CHARACTERISTICS (Cont.)

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

MINIMUM VALUE OF COMPENSATION CAPACITOR

- Select $C_C$ for $I_1$ min.
- and $I_2$ max. Values below 2pF may be ignored.

$C_C$ (pF) vs $I_2$

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

$C_C$ Frequency Response (Hz)

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

LOG CONFORMANCE vs INPUT CURRENT

- $+85^\circ C$
- $+75^\circ C$
- $-40^\circ C$ to $+25^\circ C$

LOG CONFORMANCE vs TEMPERATURE

- 7.5 Decade
- 7 Decade
- 6 Decade
- 5 Decade

Input Current ($I_1$ or $I_2$) vs Log Conformity (mV)

- Log Conformity (mV) vs Temperature (°C)
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 10 μF tantalum capacitor in parallel with a 1000 pF 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.

INPUT CURRENT RANGE

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

On ±5 V supplies, the total input current (I1 + I2) is limited to 4.5 mA. 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 I1 or I2 can be held constant to become the reference current to which the other is compared.

V_LOGOUT is expressed as:

\[
V_{\text{LOGOUT}} = (0.5V) \log\left(\frac{I_2}{I_{\text{REF}}}\right) \tag{1}
\]

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

\[
R_{\text{REF}} = \frac{2.5V}{10nA} = 250M\Omega \tag{2}
\]

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 A1 has a maximum value of 1.5 mV, making V_REF a suggested value of 100 mV.

FIGURE 3. Temperature Compensated Current Source.

V_REF = 100 mV

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.

**FREQUENCY COMPENSATION**

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

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

**NEGATIVE INPUT CURRENTS**

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

---

**FIGURE 5. Current Source with Offset Compensation.**

**FREQUENCY RESPONSE**

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

The 3dB frequency response of the LOG112 and LOG2112 are a function of the magnitude of the input current levels and of the value of the frequency compensation capacitor. See Typical Characteristic curve, *3dB Frequency Response* for details.

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

**FIGURE 6. Current Inverter/Current Source.**

**FIGURE 7. Precision Current Inverter/Current Source.**

---

NOTE: (1) +3.3V bias is an arbitrary ac level < 5V that also appears on the −IN through the op amp where it applies a reverse bias to the photodiode.
VOLTAGE INPUTS
The LOG112 and LOG2112 give the best performances with current inputs. Voltage inputs may be handled directly with series resistors, but the dynamic input range is limited to approximately three decades of input voltage by voltage noise and offsets. The transfer function of Equation 13 applies to this configuration.

ACHIEVING HIGHER ACCURACY WITH HIGHER INPUT CURRENTS
As input current to the LOG112 increases, output accuracy degrades. For a 4.5mA input current on ±5V supplies and a 10mA input current on ±12V supplies, total output error can be between 15% and 25%. Applying a common-mode voltage to $V_{CM}$ of at least +1V and up to 2.5V, brings the log transistors out of saturation and reduces output error to approximately 10%. To avoid forward biasing a photodiode, return the cathode to the $V_{CM}$ pin, as shown in Figure 9. To reverse bias the photodiode, apply a more positive voltage to the cathode than the anode.

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

Absorbance of the sample is $A = \log \frac{\lambda_2}{\lambda_1}$  (3)
If $D_1$ and $D_2$ are matched $A \propto (0.5V) \log I_1/I_2$  (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 11 shows the LOG112 and LOG2112 configured for operation with a single +5V supply.

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

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

- \( k \) = Boltzmann's constant = \( 1.381 \times 10^{-23} \)
- \( T \) = Absolute temperature in degrees Kelvin
- \( q \) = Electron charge = \( 1.602 \times 10^{-19} \) Coulombs
- \( I_C \) = Collector current
- \( I_S \) = Reverse saturation current

From the circuit in Figure 12:

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

Substituting (1) into (2) yields:

\[ V_L = V_T \left[ \ln \frac{I_1}{I_{S1}} - \ln \frac{I_2}{I_{S2}} \right] \quad (3) \]

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

\[ V_L = V_T \left[ \ln \frac{I_1}{I_{S}} - \ln \frac{I_2}{I_{S}} \right] \quad (4) \]

\[ V_L = V_T \ln \frac{I_1}{I_2} \quad \text{and since} \quad \ln x = 2.3 \log_{10} x \quad (5) \]

\[ V_L = n V_T \log_{10} \frac{I_1}{I_2} \quad (6) \]

where \( n = 2.3 \) (8)

**DEFINITION OF TERMS**

**TRANSFER FUNCTION**

The ideal transfer function is:

\[ V_{LOGOUT} = (0.5V) \log \left( I_1/I_2 \right) \]

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

**ACCURACY**

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

**TOTAL ERROR**

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

\[ V_{LOGOUT(REAL)} = V_{LOGOUT(Ideal)} \pm \text{Total Error} \quad (6) \]

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.

**NOTE:** \( R_t \) is a metal resistor used to compensate for gain over temperature.
ERRORS RTO AND RTI

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

LOG CONFORMITY

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

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

\[
V_{\text{LOGOUT (NONLIN)}} = 0.5V/\text{dec} \cdot 2NmV \tag{7}
\]

where \( N \) is the log conformity error, in percent.

INDIVIDUAL ERROR COMPONENTS

The ideal transfer function with current input is:

\[
V_{\text{LOGOUT}} = (0.5V) \log \left( \frac{l_1}{l_2} \right) \tag{8}
\]

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

\[
V_{\text{LOGOUT}} = (0.5V)(1 \pm \Delta K) \log \left( \frac{l_1 - l_{b1}}{l_2 - l_{b2}} \right) \pm Nm \pm V_{\text{OSO}} \tag{9}
\]

The individual component of error is:

\[
\Delta K = \text{gain error (0.10%, typ), as specified in the specification table.}
\]

\[
l_{b1} = \text{bias current of } A_1 \text{ (5pA, typ)}
\]

\[
l_{b2} = \text{bias current of } A_2 \text{ (5pA, typ)}
\]

\[
N = \text{log conformity error (0.01%, 0.13%, typ)}
\]

\[
0.01\% \text{ for } m = 5, \ 0.13\% \text{ for } m = 7.5
\]

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

\[
m = \text{number of decades over which } N \text{ is specified}
\]

For example, what is the error when:

\[
l_1 = 1\mu\text{A and } l_2 = 100\text{nA} \tag{10}
\]

\[
V_{\text{LOGOUT}} = (0.5\pm 0.001)\log \left( \frac{10^{-6} - 5 \times 10^{-12}}{10^{-7} - 5 \times 10^{-12}} \right) \pm (2)(0.0001)5 \pm 3.0\text{mV} \tag{11}
\]

\[
= 0.505\text{V}
\]

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

\[
\% \text{ error} = \frac{0.505\text{V}}{0.5} \times 100\% = 1.01\% \tag{12}
\]

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

\[
V_{\text{LOGOUT}} = (0.5V)(1\pm \Delta K)\log \left( \frac{V_1 - l_{b1} \pm E_{\text{OS1}}}{V_2 - l_{b2} \pm E_{\text{OS2}}} \right) \pm Nm \pm V_{\text{OSO}} \tag{13}
\]

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

<table>
<thead>
<tr>
<th>Orderable Device</th>
<th>Status</th>
<th>Package Type</th>
<th>Package Drawing</th>
<th>Pins</th>
<th>Package Qty</th>
<th>Eco Plan</th>
<th>Lead/Ball Finish</th>
<th>MSL Peak Temp</th>
<th>Op Temp (°C)</th>
<th>Device Marking</th>
<th>Samples</th>
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<td>ACTIVE</td>
<td>SOIC</td>
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<td>LOG2112A</td>
<td>Samples</td>
</tr>
</tbody>
</table>

(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.

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(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.
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## TAPE AND REEL INFORMATION

### REEL DIMENSIONS

![Reel Diagram](image)

### TAPE DIMENSIONS

- **A0**: Dimension designed to accommodate the component width
- **B0**: Dimension designed to accommodate the component length
- **K0**: Dimension designed to accommodate the component thickness
- **W**: Overall width of the carrier tape
- **P1**: Pitch between successive cavity centers

### TAPE AND REEL INFORMATION

*All dimensions are nominal*

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<th>Device</th>
<th>Package Type</th>
<th>Package Drawing</th>
<th>Pins</th>
<th>SPQ</th>
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<th>Reel Width W1 (mm)</th>
<th>A0 (mm)</th>
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<td>38.0</td>
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</table>

*All dimensions are nominal*
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.

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C. Publication IPC-7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.
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