

LSP2961 Precision Log Ratio Amplifier

Features

- Seven decades (1 nA to 10 mA) typical input range
- Internal scale factor $K = 1 \pm 2\%$ (K externally adjustable):

$$\text{OUTPUT} = K \times \log \frac{I_{\text{REF}}}{I_{\text{IN}}} \quad (\text{eq. 1})$$

- Internal trimmed reference current ($I_{\text{REF}} = 1 \mu\text{A} \pm 5\%$, externally adjustable)
- Maximum ± 100 mV output offset (externally adjustable)
- Minimal external components
- ± 5 V power supply
- TSSOP small package

Applications

- Optical light density measurement
- Log, log ratio computation
- Data linearization

Description

The LSP2961 is a single-channel precision logarithm and log ratio integrated circuit powered by +5 V and -5 V power supplies. The voltage output of the amplifier is a logarithmic function of the ratio of a reference current (I_{REF}) over the input current (I_{IN}). The scale factor is set internally to 1 V/decade, and is further adjustable by adding an external resistor. The input dynamic range for the amplifier is a six-

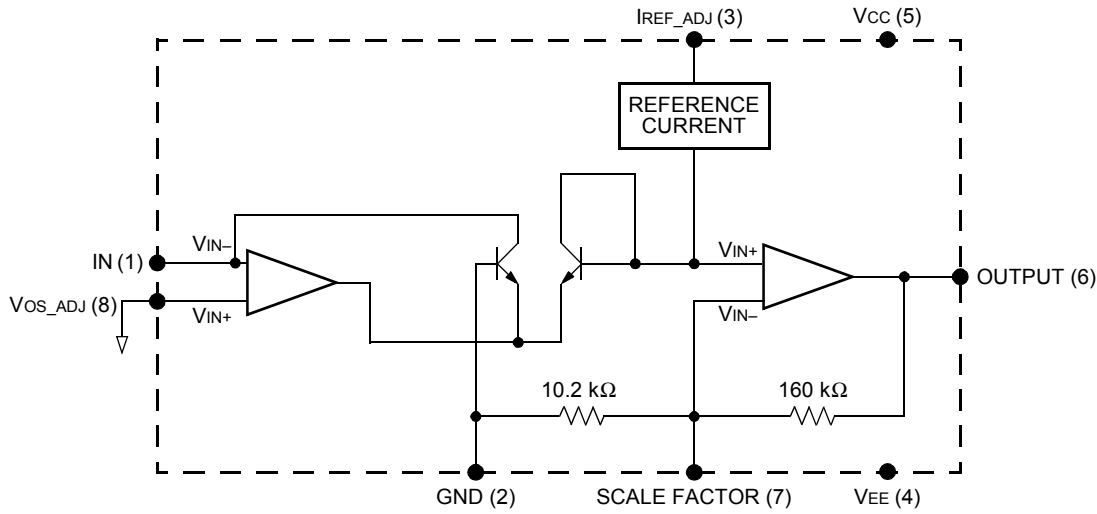
decade (1 nA to 1 mA) minimum, with seven-decade (1 nA to 10 mA) and eight-decade (100 pA to 10 mA) operation available with increased conformity error. The amplifier has an internal trimmed reference $1 \mu\text{A} \pm 5\%$ current source that is also externally adjustable using an external resistor. The output offset voltage is 100 mV maximum and can be nulled using an external potentiometer.

The input current is applied to the IN pin and the corresponding output is taken from the OUTPUT pin. For a 1 V/decade application in a stable temperature environment, no external components are required to obtain the specified performance. For an application that a scale factor other than 1 V/decade is required, an external resistor connecting the SCALE FACTOR pin to either the OUTPUT pin or GND will result in less or more than 1 V/decade for the scale factor. The amplifier's output can range from ($V_{\text{CC}} - 1$ V) to ($V_{\text{EE}} + 1$ V). This is ideal for the control in optical density measurements, and in other situations such as precision logarithm calculations. Each amplifier has an internally trimmed reference current of $1 \mu\text{A}$. This reference current can be changed using an external resistor connecting to the $I_{\text{REF_ADJ}}$ pin, and either V_{CC} or GND, depending on the need to increase or decrease the reference current. Additionally, the maximum output offset voltage is ± 100 mV. This can be nulled using an external potentiometer connected between the ± 5 V supplies and the wiper connected to the $V_{\text{OS_ADJ}}$ pin. The internal block diagram is shown in Figure 1.

The LSP2961 is available in a 3 mm x 3 mm TSSOP package. The 8-pin LSP2961 requires one negative 5 V power supply (V_{EE}) and one positive 5 V power supply (V_{CC}). Refer to Table 1 for detailed pin information. Figure 3 references the external pin connections.

Description (continued)

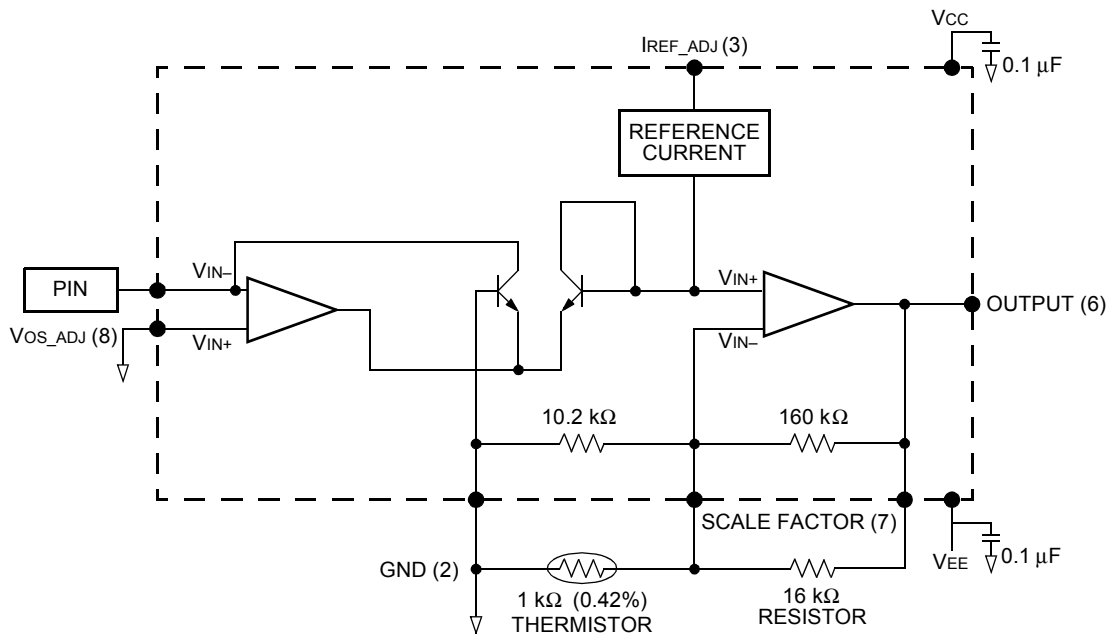
Block Diagram



2352.a(F)

Figure 1. LSP2961 Internal Block Diagram

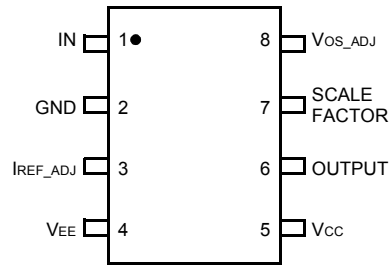
Typical Application Circuit



2353.b(F)

Figure 2. Typical Application Circuit with External Temperature Compensation

Pin Information



2311(F)

Figure 3. External Connections

Table 1. LSP2961 Pin Description

Pin Number	Pin Name	Function	Pin Total Counts	Description
1	IN	Input	1	Input current.
2	GND	Ground	1	Analog ground.
3	IREF_ADJ	Sets the Reference Current to Other than 1 μ A	1	Used to set reference current with an external resistor to GND or VCC.
4	VEE	Power Supply	1	-5 V power supply.
5	VCC	Power Supply	1	5 V power supply.
6	OUTPUT	Output Voltage	1	Output voltage.
7	SCALE FACTOR	Sets the Scale Factor to Other than 1 V/decade	1	Used to change the scale factor to other than 1 V/decade (either less than or greater than) with an external resistor connecting to the OUTPUT pin or GND.
8	VOS_ADJ	Offset Voltage Adjustment	1	Used to null offset voltage by connecting to the wiper of an external potentiometer between VCC and VEE.

Absolute Maximum Ratings

Stresses in excess of the absolute maximum ratings can cause permanent damage to the device. These are absolute stress ratings only. Functional operation of the device is not implied at these or any other conditions in excess of those given in the operational sections of the data sheet. Exposure to absolute maximum ratings for extended periods can adversely affect device reliability.

Table 2. Absolute Maximum Ratings

Parameter	Min	Typ	Max	Unit
Power Supply				
VCC	4.0	5.0	6.0	V
VEE	-6.0	-5.0	-4.0	V
Operating Temperature (TA)	-40	25	85	°C
Storage Temperature	-65	25	150	°C
Lead Temperature (soldering 10 seconds)	—	—	300	°C

Handling Precautions

Although protection circuitry has been designed into this device, proper precautions should be taken to avoid exposure to electrostatic discharge (ESD) during handling and mounting. Agere Systems employs a human-body model (HBM) and charged-device model (CDM) for ESD-susceptibility testing and protection design evaluation. ESD voltage thresholds are dependent on the circuit parameters used in the defined model. No industrywide standard has been adopted for the CDM. However, a standard HBM (resistance = 1500 Ω , capacitance = 100 pF) is widely used and, therefore, can be used for comparison purposes. The HBM ESD threshold (>1500 V) presented here was obtained by using these circuit parameters.

Application Considerations

A typical application is shown in Figure 2 for optical light intensity detection with temperature compensation by using a thermistor with positive temperature coefficient of 0.42%.

Electrical Characteristics

Table 3. Electrical Characteristics

$T_A = 25\text{ }^\circ\text{C}$, $V_{CC} = 5\text{ V}$, $V_{EE} = -5\text{ V}$, no external components for performance adjustment.

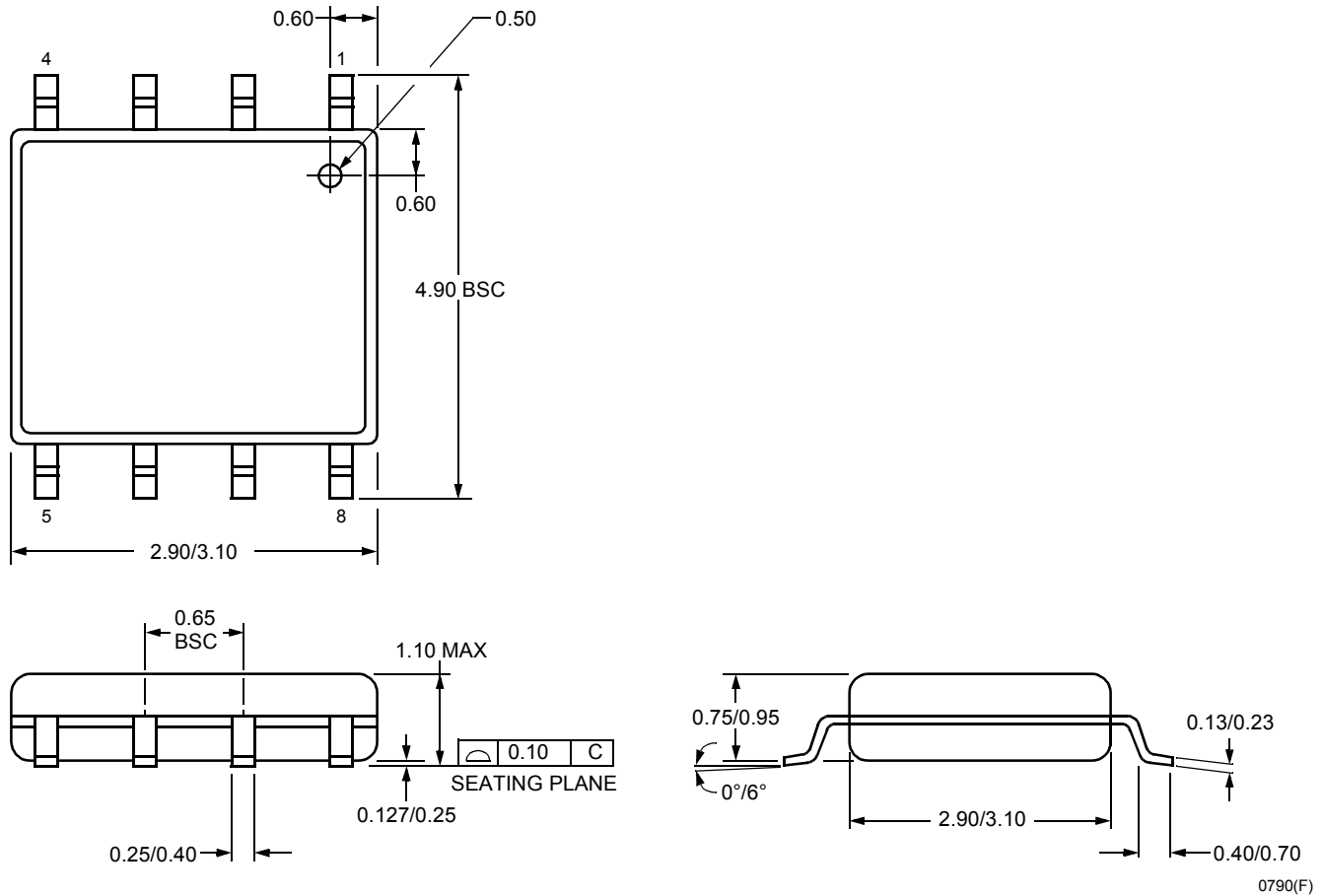
Parameter	Symbol	Conditions	Min	Typ	Max	Unit	
Total Conformity Error	$\left[\frac{K \times \log \frac{I_{REF}}{I_{IN}} - V_{OUT}}{V_{FULLSCALE}} \right] \times 100\%$	$T_A = 25\text{ }^\circ\text{C}$ $I_N = 1\text{ nA to } 1\text{ mA}$	—	1	TBD	%	
		$T_A = 25\text{ }^\circ\text{C}$ $I_N = 1\text{ nA to } 10\text{ mA}$	—	TBD	—		
		$T_A = 25\text{ }^\circ\text{C}$ $I_N = 100\text{ pA to } 10\text{ mA}$	—	TBD	—		
Temperature Coefficient ^{1, 2}	—	$-5\text{ }^\circ\text{C to } 70\text{ }^\circ\text{C}^2$	—	0.34	—	%/ $^\circ\text{C}$	
Scale Factor ³	Scale Factor	K	$T_A = 25\text{ }^\circ\text{C}$ $I_N = 1\text{ nA to } 1\text{ mA}$	0.98	1	1.02	V/decade
	Temperature Coefficient ²	—	$-5\text{ }^\circ\text{C to } 70\text{ }^\circ\text{C}^1$	—	0.34	—	%/ $^\circ\text{C}$
Reference Accuracy ³	Reference Accuracy	—	$T_A = 25\text{ }^\circ\text{C}$ $I_N = 1\text{ nA to } 1\text{ mA}$	0.95	1	1.05	μA
	Temperature Coefficient ²	—	$-5\text{ }^\circ\text{C to } 70\text{ }^\circ\text{C}^1$	—	0.02	—	%/ $^\circ\text{C}$
Output Offset Voltage ⁴	—	V_{OS}	$T_A = 25\text{ }^\circ\text{C}$ $I_N = 1\text{ nA to } 1\text{ mA}$	-100	-10	100	mV
	Temperature Coefficient ²	—	$-5\text{ }^\circ\text{C to } 70\text{ }^\circ\text{C}$	—	0.20	—	%/ $^\circ\text{C}$
3 dB Bandwidth ^{5, 6}	f _{3dB}	$C = 10\text{ pF}$, $I_N = 1\text{ }\mu\text{A}$	—	100	—	kHz	
Output Voltage Range	—	—	$V_{EE} + 1$	—	$V_{CC} - 1$	V	
Supply Current ⁷	—	$R_{LOAD} > 1\text{ M}\Omega$ $I_N = 1\text{ nA to } 1\text{ mA}$ $-5\text{ }^\circ\text{C to } 70\text{ }^\circ\text{C}^1$	0.2	0.3	1.3	mA	
			$I_N \leq 1\text{ }\mu\text{A}^8$	0.18	0.24		0.3
Power Supply Operation Range ²	V_{CC}	—	4.5	5.0	5.5	V	
	V_{EE}	—	-4.5	-5.0	-5.5		

1. Can be externally compensated using a thermistor and a resistor.
2. Guaranteed by design.
3. Externally adjustable using a resistor.
4. Can be nulled using an external potentiometer.
5. Transimpedance bandwidth.
6. Tested by limited samples.
7. Supply current at $1\text{ nA} < I_N < 1\text{ mA}$.
8. Supply current at $I_N \leq 1\text{ }\mu\text{A}$.

Note: Terms used for the specification of the analog log amplifier:

- Total conformity error—this is used to describe the log linearity of the log amplifier, which is the maximum deviation from the best-fit straight line of logarithm, **allowing for offset error**.

LSP2961 Package Diagram



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