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National Semiconductor

LM9044
Lambda Sensor Interface Amplifier

General Description

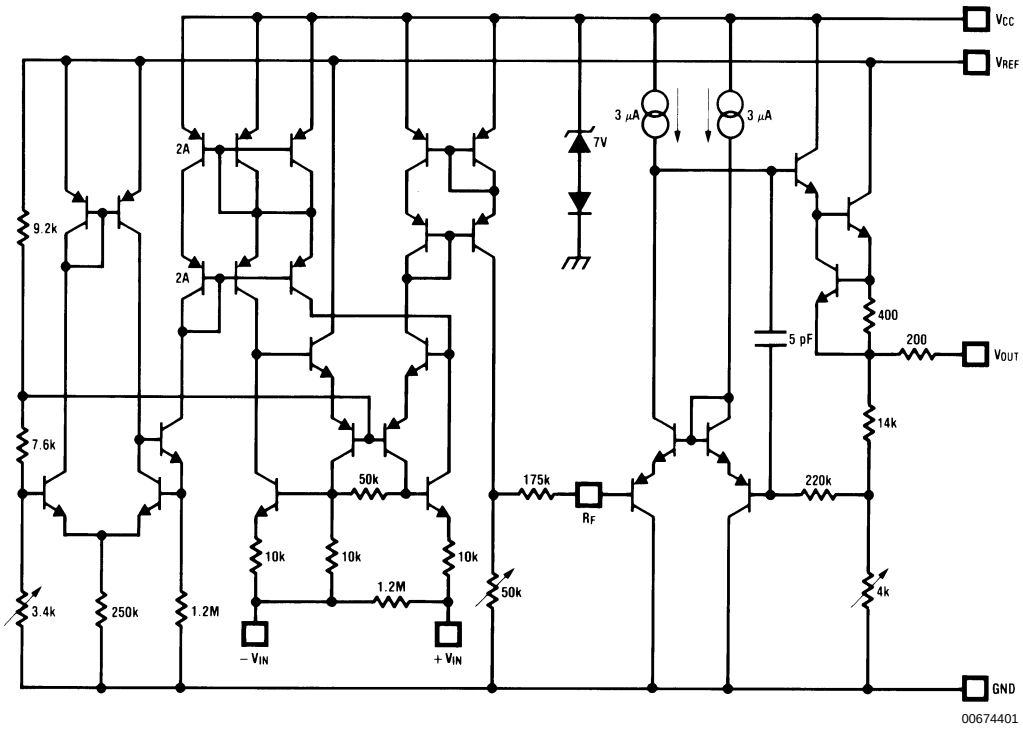
The LM9044 is a precision differential amplifier specifically designed for operation in the automotive environment. Gain accuracy is guaranteed over the entire automotive temperature range (−40˚C to +125˚C) and is factory trimmed after package assembly. The input circuitry has been specifically designed to reject common-mode signals as much as 3V below ground on a single positive power supply. This facilitates the use of sensors which are grounded at the engine block while the LM9044 itself is grounded at chassis potential. An external capacitor sets the maximum operating frequency of the amplifier, thereby filtering high frequency transients. Both inputs are protected against accidental shorting to the battery and against load dump transients. The input impedance is typically 1 MΩ.

The output op amp is capable of driving capacitive loads and is fully protected. Also, internal circuitry has been provided to detect open circuit conditions on either or both inputs and force the output to a “home” position (a ratio of the external reference voltage).

Features

- Normal circuit operation guaranteed with inputs up to 3V below ground on a single supply.
- Gain factory trimmed and guaranteed over temperature (±3% of full-scale from −40˚C to +125˚C)
- Low power consumption (typically 1 mA)
- Fully protected inputs
- Input open circuit detection
- Operation guaranteed over the entire automotive temperature range (−40˚C to +125˚C)
- Single supply operation

Schematic and Connection Diagrams



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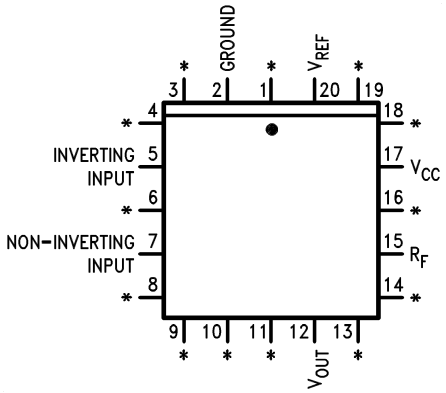
Schematic and Connection Diagrams (Continued)

Plastic Chip Carrier Package



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Top View
Order Number LM9044V
See NS Package Number V20A

*Pins 1, 3, 4, 6, 8, 9, 10, 11, 13, 14, 16, 18, 19 are trim pins and should be left floating.

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

V_{CC} Supply Voltage (RV_{CC} = 15 kΩ)	±60V
V_{REF} Supply Voltage	−0.3V to +6V
DC Input Voltage (Either input)	−3V to +6V
Input Transients (Note 2)	±60V
Power Dissipation see (Note 7)	1350 mW
Output Short Circuit Duration	Indefinite
Operating Temperature Range	−40˚C to +125˚C
Storage Temperature Range	−65˚C to +150˚C
Soldering Information	
Plastic Chip Carrier Package	
Vapor Phase (60 seconds)	215˚C
Infrared (15 seconds)	220˚C

See AN-450 “Surface Mounting Methods and Their Effect on Product Reliability” for other methods of soldering surface devices.

Electrical Characteristics V_{CC} = 12V, V_{REF} = 5V, −40˚C ≤ T_A ≤ 125˚C unless otherwise noted

Parameter	Conditions	(Note 3)			(Note 4)			Units
		Min	Typ	Max	Min	Typ	Max	
Differential Voltage Gain	V_{DIF} = 0.5, −1V ≤ V_{CM} ≤ +1V	4.41	4.50	4.59				V/V
	V_{DIF} = 0.5, −3V ≤ V_{CM} ≤ +1V				4.36	4.50	4.64	V/V
Gain Error (Note 6)	0 ≤ V_{DIF} ≤ 1V, −1V ≤ V_{CM} ≤ +1V	−2	0	2				%/FS
	0 ≤ V_{DIF} ≤ 1V, −3 ≤ V_{CM} ≤ +1V				−3	0	3	%/FS
Differential Input Resistance	0 ≤ V_{DIF} ≤ 1V, −1V ≤ V_{CM} ≤ +1V	0.95	1.20	3.00				MΩ
	0 ≤ V_{DIF} ≤ 1V, −3 ≤ V_{CM} ≤ +1V				0.70	1.20	4.00	MΩ
Non-Inverting Input Bias Current	0 ≤ V_{DIF} ≤ 1V, −1 ≤ V_{CM} ≤ +1V		±0.38	±0.65				µA
	0 ≤ V_{DIF} ≤ 1V, −3 ≤ V_{CM} ≤ +1V					±0.38	±1.5	µA
Inverting Input Bias Current	0 ≤ V_{DIF} ≤ 1V, −1 ≤ V_{CM} ≤ +1V	−25	−65	−100				µA
	0 ≤ V_{DIF} ≤ 1V, −3 ≤ V_{CM} ≤ +1V					−45	−150	µA
V_{CC} Supply Current	V_{CC} = 12V, RV_{CC} = 15k		300	500				µA
V_{RED} Supply Current	4.75V ≤ V_{REF} ≤ 5.5V		0.5	1.0				mA
Common-Mode Voltage Range (Note 5)		−1		1	−3		1	V
DC Common-Mode Rejection Ratio	Input Referred −1V ≤ V_{CM} ≤ +1V V_{DIF} = 0.5V	50	60					dB
Open Circuit Output Voltage	One or Both Inputs Open, −1V ≤ V_{CM} ≤ +1V	0.371	0.397	0.423				XV_{REF}
	−3V ≤ V_{CM} ≤ +1V				0.365	0.397	0.439	XV_{REF}
Short Circuit Output Current	Output Grounded	1.0	2.7	5.0				mA
V_{CC} Power Supply Rejection Ratio	V_{CC} = 12V, RV_{CC} = 15k V_{DIF} = 0.5V	50	65					dB
V_{REF} Power Supply Rejection Ratio	V_{REF} = 5 V_{DC} V_{DIF} = 0.5V	60	74					dB

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur.

Note 2: This test is performed with a 1000Ω source impedance.

Note 3: These parameters are guaranteed and 100% production tested.

Note 4: These parameters will be guaranteed but not 100% production tested.

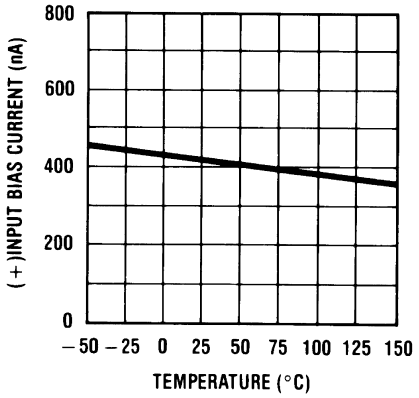
Note 5: The LM9044 has been designed to common-mode to −3V, but production testing is only performed at ±1V.

Note 6: Gain error is given as a percent of full-scale. Full-scale is defined as 1V at the input and 4.5V at the output.

Note 7: For operation in ambient temperatures above 25˚C the device must be derated based on a maximum junction temperature of 150˚C and a thermal resistance of 93˚C/W junction to ambient.

Typical Performance Characteristics

Non-Inverting Input Bias Current vs Temperature



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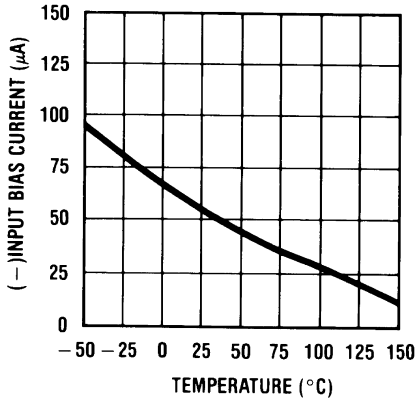
Inverting Input Bias Current vs Temperature



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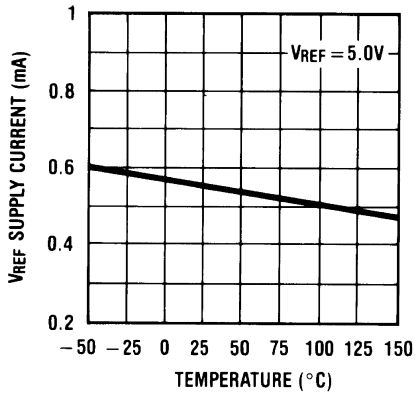
V_{REF} Supply Current vs Temperature



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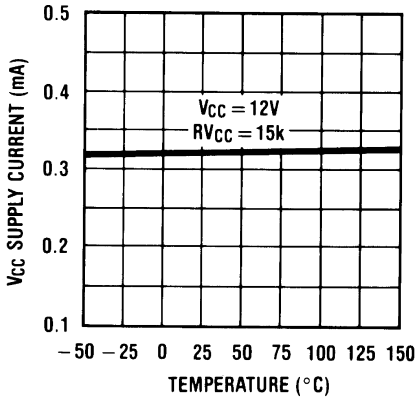
V_{CC} Supply Current vs Temperature



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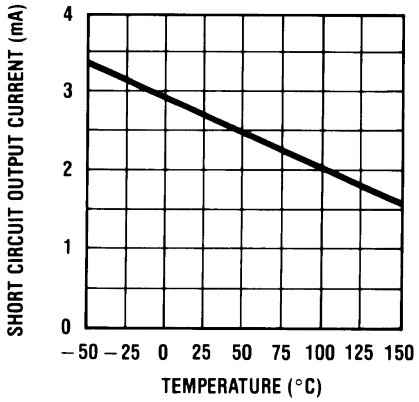
Short Circuit Output Current vs Temperature



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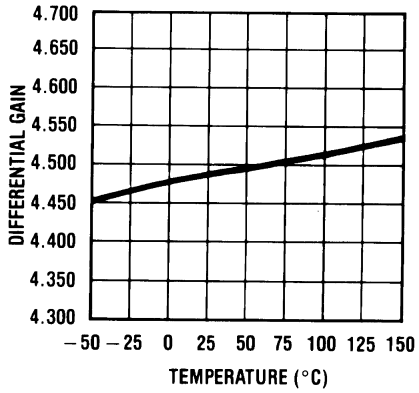
Differential Gain vs Temperature



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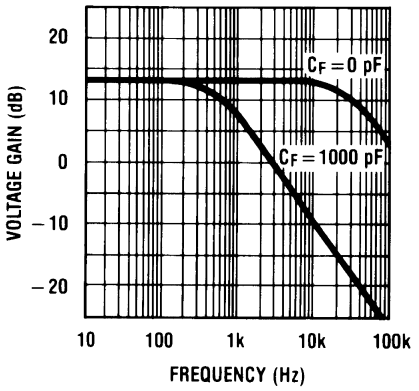
Typical Performance Characteristics (Continued)

Voltage Gain vs Frequency



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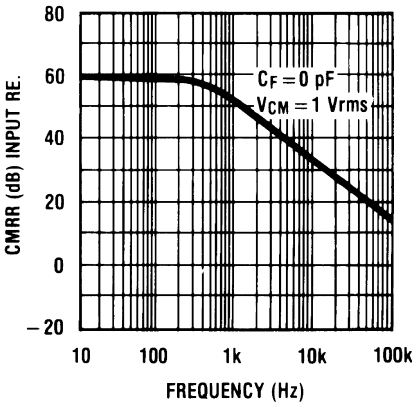
CMRR vs Frequency



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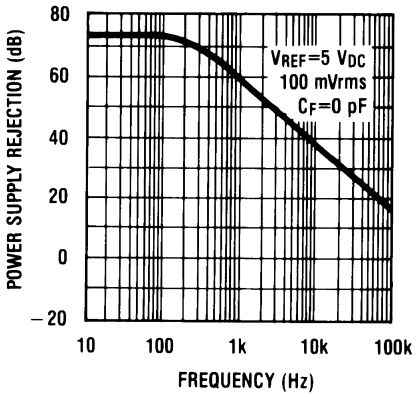
V_{REF} Power Supply Rejection



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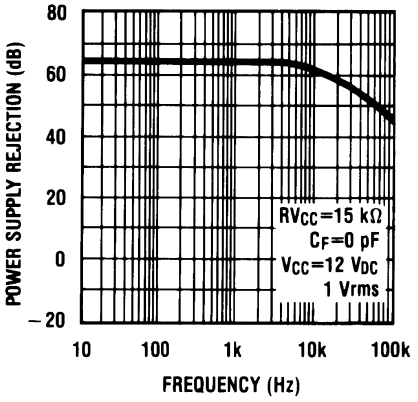
V_{CC} Power Supply Rejection



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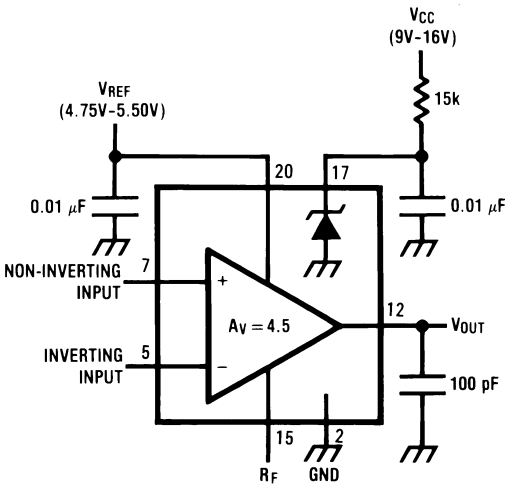
Test Circuit



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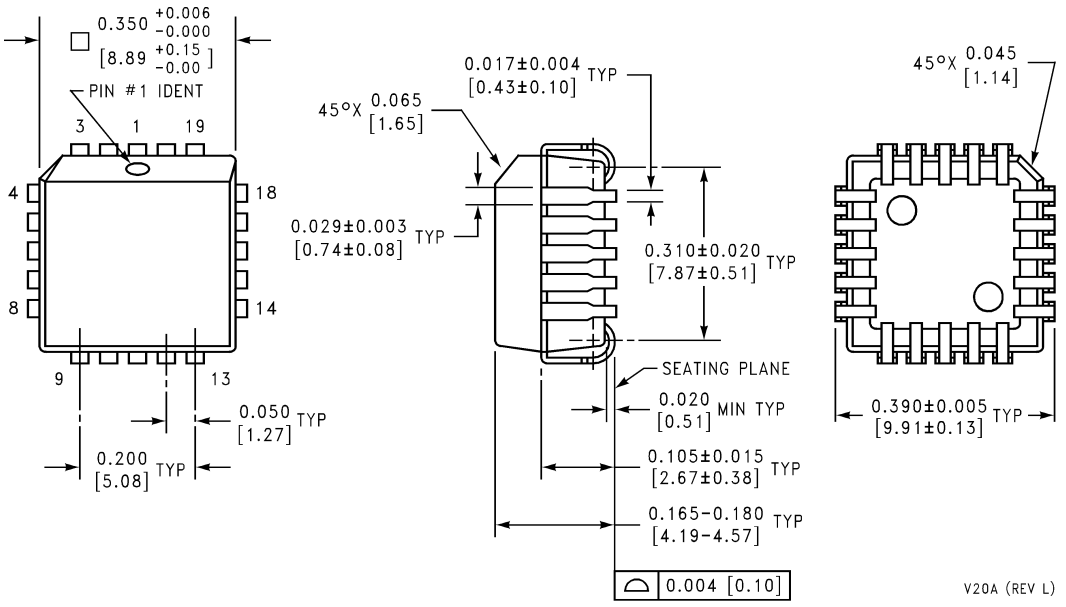
Physical Dimensions inches (millimeters) unless otherwise noted



Plastic Chip Carrier Package
Order Number LM9044V
NS Package Number V20A

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