

## LM1964 Sensor Interface Amplifier

## General Description

The LM1964 is a precision differential amplifier specifically designed for operation in the automotive environment. Gain accuracy is guaranteed over the entire automotive temperature range ( $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ) and is factory trimmed prior to 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 LM1964 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 M $\Omega$ .

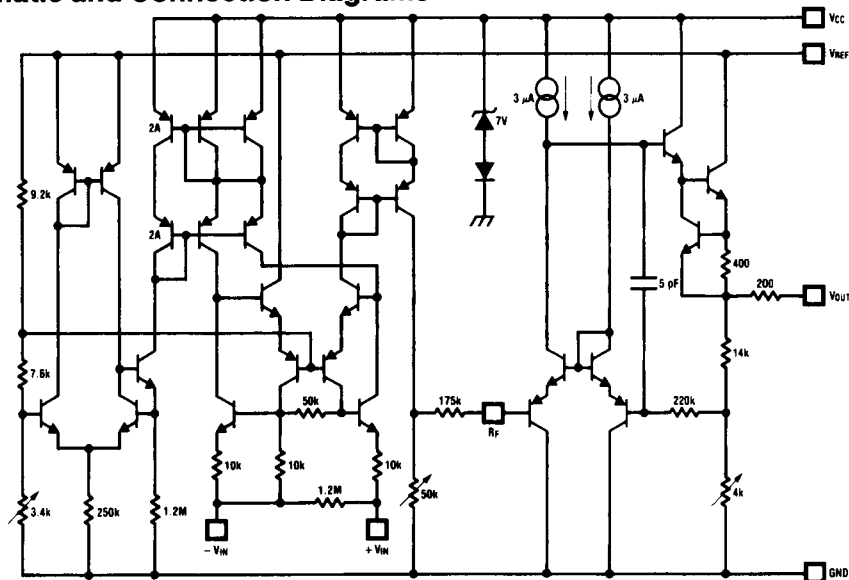
The output op amp is capable of driving capacitive loads and is fully protected. Also, internal circuitry has been pro-

vided 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

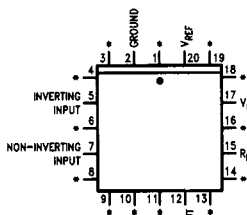
- Normal circuit operation guaranteed with inputs up to 3V below ground on a single supply
- Gain factory trimmed and guaranteed over temperature ( $\pm 3\%$  of full-scale from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ )
- Low power consumption (typically 1 mA)
- Fully protected inputs
- Input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

## Schematic and Connection Diagrams



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### Plastic Chip Carrier Package



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### Top View

**Order Number LM1964V**  
**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

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

|                                                           |              |
|-----------------------------------------------------------|--------------|
| V <sub>CC</sub> Supply Voltage (R <sub>VCC</sub> = 15 kΩ) | ±60V         |
| V <sub>REF</sub> Supply Voltage                           | −0.3V to +6V |
| DC Input Voltage (Either Input)                           | −3V to +16V  |
| Input Transients (Note 1)                                 | ±60V         |
| Power Dissipation (see Note 6)                            | 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 mount devices.

## Electrical Characteristics

V<sub>CC</sub> = 12V, V<sub>REF</sub> = 5V, T<sub>A</sub> = 25°C unless otherwise noted

| Parameter                                     | Conditions                                                                                   | (Note 2) |       |       | (Note 3) |       |       | Units             |
|-----------------------------------------------|----------------------------------------------------------------------------------------------|----------|-------|-------|----------|-------|-------|-------------------|
|                                               |                                                                                              | Min      | Typ   | Max   | Min      | Typ   | Max   |                   |
| Differential Voltage Gain                     | V <sub>DIF</sub> = 0.5V<br>−1V ≤ V <sub>CM</sub> ≤ +1V                                       | 4.41     | 4.50  | 4.59  |          |       |       | V/V               |
|                                               | V <sub>DIF</sub> = 0.5V, −40°C ≤ T <sub>A</sub> ≤ 125°C<br>−3V ≤ V <sub>CM</sub> ≤ +1V       |          |       |       | 4.36     | 4.50  | 4.64  | V/V               |
| Gain Error (Note 5)                           | 0 ≤ V <sub>DIF</sub> ≤ 1V<br>−1V ≤ V <sub>CM</sub> ≤ +1V                                     | −2       | 0     | 2     |          |       |       | %/FS              |
|                                               | 0 ≤ V <sub>DIF</sub> ≤ 1V<br>−3V ≤ V <sub>CM</sub> ≤ +1V<br>−40°C ≤ T <sub>A</sub> ≤ +125°C  |          |       |       | −3       | 0     | 3     | %/FS              |
| Differential Input Resistance                 | 0 ≤ V <sub>DIF</sub> ≤ 1V<br>−1V ≤ V <sub>CM</sub> ≤ +1V                                     | 1.00     | 1.20  |       |          |       |       | MΩ                |
|                                               | 0 ≤ V <sub>DIF</sub> ≤ 1V<br>−3V ≤ V <sub>CM</sub> ≤ +1V<br>−40°C ≤ T <sub>A</sub> ≤ +125°C  |          |       |       | 0.70     | 1.20  |       | MΩ                |
| Non-Inverting Input Bias Current              | 0 ≤ V <sub>DIF</sub> ≤ 1V<br>−1V ≤ V <sub>CM</sub> ≤ +1V                                     |          | 0.3   | 1.0   |          |       |       | μA                |
|                                               | 0 ≤ V <sub>DIF</sub> ≤ 1V<br>−3V ≤ V <sub>CM</sub> ≤ +1V<br>−40°C ≤ T <sub>A</sub> ≤ +125°C  |          |       |       | 0.3      | 1.5   |       | μA                |
| Inverting Input Bias Current                  | 0 ≤ V <sub>DIF</sub> ≤ 1V<br>−1V ≤ V <sub>CM</sub> ≤ +1V                                     |          | 45    | 100   |          |       |       | μA                |
|                                               | 0V ≤ V <sub>DIF</sub> ≤ 1V<br>−3V ≤ V <sub>CM</sub> ≤ +1V<br>−40°C ≤ T <sub>A</sub> ≤ +125°C |          |       |       | 45       | 150   |       | μA                |
| V <sub>CC</sub> Supply Current                | V <sub>CC</sub> = 12V, R <sub>VCC</sub> = 15k                                                |          | 300   | 500   |          |       |       | μA                |
| V <sub>REF</sub> Supply Current               | 4.75V ≤ V <sub>REF</sub> ≤ 5.5V                                                              |          | 0.5   | 1.0   |          |       |       | mA                |
| Common-Mode Voltage Range (Note 4)            | −40°C ≤ T <sub>A</sub> ≤ +125°C                                                              | −1       |       | 1     | −3       |       | 1     | V                 |
| DC Common-Mode Rejection Ratio                | Input Referred<br>−1V ≤ V <sub>CM</sub> ≤ +1V<br>V <sub>DIF</sub> = 0.5V                     | 50       | 60    |       |          |       |       | dB                |
| Open Circuit Output Voltage                   | One or Both Inputs<br>Open, −1V ≤ V <sub>CM</sub> ≤ +1V                                      | 0.371    | 0.397 | 0.423 |          |       |       | XV <sub>REF</sub> |
|                                               | −3V ≤ V <sub>CM</sub> ≤ +1V<br>−40°C ≤ T <sub>A</sub> ≤ +125°C                               |          |       |       | 0.365    | 0.397 | 0.429 | XV <sub>REF</sub> |
| Short Circuit Output Current                  | Output Grounded                                                                              | 1.0      | 2.7   | 5.0   |          |       |       | mA                |
| V <sub>CC</sub> Power Supply Rejection Ratio  | V <sub>CC</sub> = 12V, R <sub>VCC</sub> = 15K<br>V <sub>DIF</sub> = 0.5V                     | 50       | 65    |       |          |       |       | dB                |
| V <sub>REF</sub> Power Supply Rejection Ratio | V <sub>REF</sub> = 5 V <sub>DC</sub><br>V <sub>DIF</sub> = 0.5V                              | 60       | 74    |       |          |       |       | dB                |

**Note 1:** This test is performed with a 1000Ω source impedance.

**Note 2:** These parameters are guaranteed and 100% production tested.

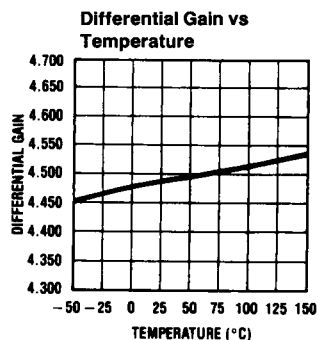
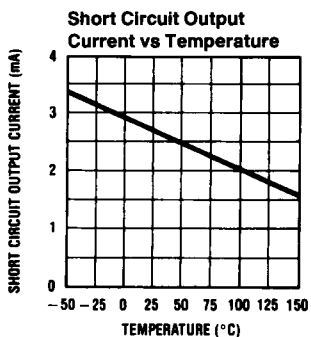
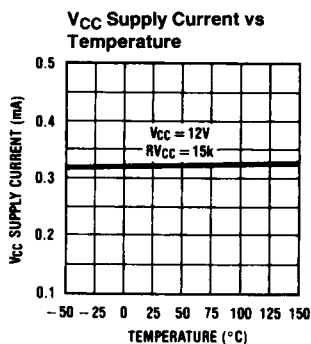
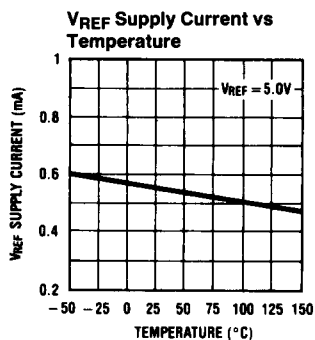
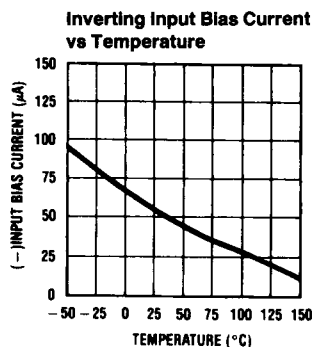
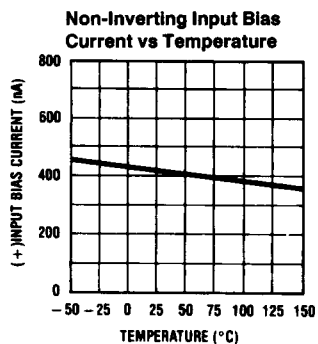
**Note 3:** These parameters will be guaranteed but not 100% production tested.

**Note 4:** The LM1964 has been designed to common-mode to −3V, but production testing is only performed at ±1V.

**Note 5:** 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.

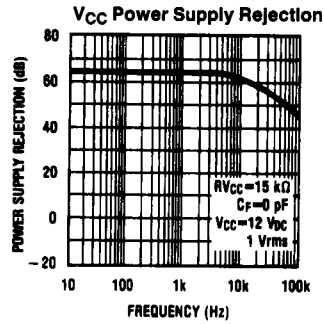
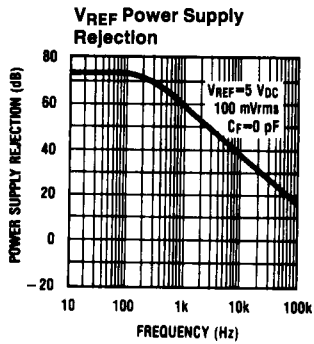
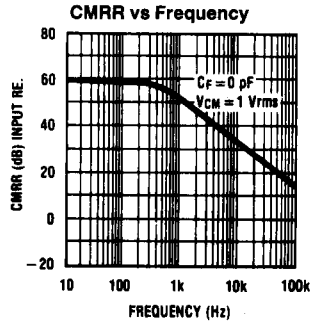
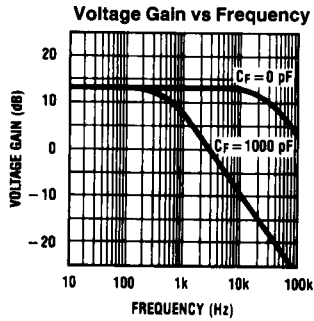
**Note 6:** For operation in ambient temperatures above 25°C the device must be derated based on a maximum junction temperature of 150°C and a thermal resistance of 93°C/W junction to ambient.

# Typical Performance Characteristics



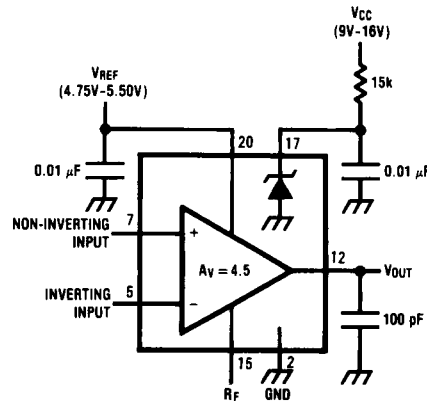
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# Typical Performance Characteristics (Continued)



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## Test Circuit



TL/H/6744-5