# NCV952

# Operational Amplifier, Low Power, Rail-to-Rail

The NCV952 is a dual, low power, operational amplifier fully specified for 3 V, 5 V and 24 V operation. Rail−to−rail output performance over the supply range of 2.7 V to 26 V provides increased dynamic range in single−supply and split−supply applications. This device offers a gain−bandwidth of 3.5 MHz and a slew rate of 1 V/μs, with only 0.7 mA of quiescent current. The NCV952 is available in a space saving 8−pin TSSOP8 package.

### Features

- Rail−to−rail Input Common Mode Voltage Range
- Rail−to−rail Output Swing
- Wide Supply Range: 2.7 V to 26 V
- Excellent Gain−bandwidth and Speed: 3.5 MHz at 1 V/μs with 3 V Supply
- Low Quiescent Current: 0.7 mA at $V_S$ = 3 V per Channel
- PSRR: 105 dB Typical
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC−Q100 Qualified and PPAP Capable
- These Devices are Pb−free, Halogen Free/BFR Free and are RoHS Compliant

### Typical Applications

- General Purpose Operational Amplifier
- Active Filters
- Signal Conditioning Amplifiers/ADC Buffers
- Set−top Boxes
- Laptop/Notebook Computers
- Transformer/Line Drivers
- Personal Entertainment Systems
- Cell Phones and Other Portable Communications
- Portable Headphone Speaker Drivers
- Instrumentation and Sensoring

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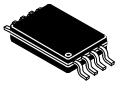
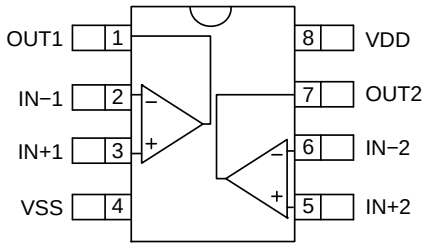


**TSSOP−8**
**CASE 948S**

### MARKING DIAGRAM


V52 = Specific Device Code
A = Assembly Location
Y = Year
WW = Work Week
▪ = Pb−Free Package

### PIN CONNECTIONS




### ORDERING INFORMATION

| Device | Package | Shipping† |
|---|---|---|
| NCV952DTBR2G | TSSOP−8 (Pb−Free) | 2500 / Tape & Reel |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

**Table 1. PIN DESCRIPTION**

| Pin | Name | Type | Description |
|---|---|---|---|
| 1 | OUT1 | Output | Output of opamp 1 |
| 2 | IN−1 | Input | Inverting input of opamp 1 |
| 3 | IN+1 | Input | Non−inverting input of opamp 1 |
| 4 | VSS | Power | Negative supply. A bypass capacitor of 0.1 μF to ground is recommended as close as possible to this pin. |
| 5 | IN+2 | Input | Non−inverting input of opamp 2 |
| 6 | IN−2 | Input | Inverting input of opamp 2 |
| 7 | OUT2 | Output | Output of opamp 2 |
| 8 | VDD | Power | Positive supply. A bypass capacitor of 0.1 μF to ground is recommended as close as possible to this pin. |

**Table 2. ABSOLUTE MAXIMUM RATINGS** (Over operating free−air temperature, unless otherwise stated)

| Parameter | Symbol | Limit | Unit |
|---|---|---|---|
| Supply Voltage ($V_{DD}$− $V_{SS}$) | $V_S$ | 28 | V |
| **INPUT AND OUTPUT PINS** | | | |
| Input Voltage | $V_{IN}$ | $V_{SS}$ – 0.3 to $V_{DD}$ + 0.3 | V |
| Differential Input Voltage (Note 1) | $V_{ID}$ | ±1 | V |
| **TEMPERATURE** | | | |
| Storage Temperature | $T_{STG}$ | −65 to +150 | °C |
| Junction Temperature | $T_J$ | +150 | °C |
| **ESD RATINGS** (Note 2) | | | |
| Human Body Model | HBM | 2500 | V |
| Machine Model | MM | 300 | V |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Input differential voltage is the non−inverting pin with respect to the inverting pin. If $V_{ID}$ > ±1 V, the maximum input current must not exceed ±1 mA; an input series resistor must be used to limit the input current.
2. This device series incorporates ESD protection and is tested by the following methods:
   ESD Human Body Model tested per AEC−Q100−002 (JEDEC standard: JESD22−A114)
   ESD Machine Model tested per AEC−Q100−003 (JEDEC standard: JESD22−A115)

**Table 3. THERMAL INFORMATION** (Note 3)

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Junction to Ambient (Note 4) | $\theta_{JA}$ | 140 | °C/W |
| Junction to Case Top (Note 4) | $\psi_{JT}$ | 34 | °C/W |

3. Short−circuits can cause excessive heating and destructive dissipation. Values are typical.
4. Multilayer board, 1 oz. copper, 400 $mm^2$ copper area, both junctions heated equally.

**Table 4. RECOMMENDED OPERATING CONDITIONS**

| Parameter | Symbol | Limit | Unit |
|---|---|---|---|
| Operating Supply Voltage | $V_S$ | 2.7 to 26 | V |
| Specified Operating Range | $T_A$ | −40 to +125 | °C |

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

**Table 5. ELECTRICAL CHARACTERISTICS AT $V_S$ = 3.0 V**
At $T_A$ = +25°C, $R_L$ = 10 kΩ connected to mid−supply, $V_{CM}$ = $V_{OUT}$ = midsupply, unless otherwise noted.
**Boldface** limits apply over the specified temperature range, $T_A$ = –40°C to +125°C, guaranteed by characterization and/or design.

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **INPUT CHARACTERISTICS** | | | | | | |
| Offset Voltage | $V_{OS}$ | | | 0.6 | 6.0 | mV |
| | | | | | **8.0** | mV |
| Offset Voltage Drift | ΔV/ΔT | | | 2.0 | | μV/°C |
| Input Bias Current | $I_{IB}$ | | | 55 | 100 | nA |
| | | | | | **200** | nA |
| Input Offset Current | $I_{OS}$ | | | 1.0 | 30 | nA |
| | | | | | **80** | nA |
| Input Common Mode Range | $V_{CM}$ | | $V_{SS}$ – 0.2 | | $V_{DD}$ + 0.2 | V |
| Common Mode Rejection Ratio | CMRR | $V_{SS}$ + 0.15 < $V_{CM}$ < $V_{DD}$ − 0.15 | 50 | 80 | | dB |
| **OUTPUT CHARACTERISTICS** | | | | | | |
| Output Voltage High | $V_{OH}$ | $R_L$ = 600 Ω | $V_{DD}$ − 0.2 | $V_{DD}$ − 0.08 | | V |
| Output Voltage Low | $V_{OL}$ | $R_L$ = 600 Ω | | $V_{SS}$ + 0.10 | $V_{SS}$ + 0.25 | V |
| Short Circuit Current | $I_{SC}$ | | 10 | | | mA |
| **NOISE PERFORMANCE** | | | | | | |
| Voltage Noise Density | $e_N$ | f = 1 kHz, no load | | 25 | | nV/√Hz |
| **DYNAMIC PERFORMANCE** | | | | | | |
| Open Loop Voltage Gain | $A_{VOL}$ | $V_O$ = 2 Vpp, $R_L$ = 600 Ω | | 88 | | dB |
| Gain Bandwidth Product | GBWP | $R_L$ = 2 kΩ | | 3.5 | | MHz |
| Gain Margin | $A_M$ | $R_L$ = 600 Ω, $C_L$ = 100 pF | | 8 | | dB |
| Phase Margin | $\psi_M$ | $R_L$ = 600 Ω, $C_L$ = 100 pF | | 56 | | ° |
| Slew Rate | SR | $R_L$ = 10 kΩ | | 1.0 | | V/μS |
| Total Harmonic Distortion + Noise | THD+N | $V_{OUT}$ = 2 Vpp, $f_{IN}$ = 10 kHz, $A_V$ = 2, $R_L$ = 10 kΩ | | 0.008 | | % |
| **POWER SUPPLY** | | | | | | |
| Power Supply Rejection Ratio | PSRR | $V_S$ = 2.7 V to 26 V | 60 | 105 | | dB |
| Quiescent Current | $I_{DD}$ | No load, $V_{CM}$ = $V_S$/2, per channel | | 0.7 | 1.3 | mA |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

**Table 6. ELECTRICAL CHARACTERISTICS AT $V_S$ = 5.0 V**
At $T_A$ = +25°C, $R_L$ = 10 kΩ connected to mid−supply, $V_{CM}$ = $V_{OUT}$ = midsupply, unless otherwise noted.
**Boldface** limits apply over the specified temperature range, $T_A$ = –40°C to +125°C, guaranteed by characterization and/or design.

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **INPUT CHARACTERISTICS** | | | | | | |
| Offset Voltage | $V_{OS}$ | | | 0.6 | 6.0 | mV |
| | | | | | **8.0** | mV |
| Offset Voltage Drift | ΔV/ΔT | | | 2.0 | | μV/°C |
| Input Bias Current | $I_{IB}$ | | | 55 | 100 | nA |
| | | | | | **200** | nA |
| Input Offset Current | $I_{OS}$ | | | 1.0 | 30 | nA |
| | | | | | **80** | nA |
| Input Common Mode Range | $V_{CM}$ | | $V_{SS}$ – 0.2 | | $V_{DD}$+0.2 | V |
| Common Mode Rejection Ratio | CMRR | $V_{SS}$ + 0.15 < $V_{CM}$ < $V_{DD}$ − 0.15 | 50 | 85 | | dB |
| **OUTPUT CHARACTERISTICS** | | | | | | |
| Output Voltage High | $V_{OH}$ | $R_L$ = 600 Ω | $V_{DD}$−0.30 | $V_{DD}$−0.10 | | V |
| Output Voltage Low | $V_{OL}$ | $R_L$ = 600 Ω | | $V_{SS}$+0.14 | $V_{SS}$+0.30 | V |
| Short Circuit Current | $I_{SC}$ | | 10 | | | mA |
| **NOISE PERFORMANCE** | | | | | | |
| Voltage Noise Density | $e_N$ | f = 1 kHz, no load | | 25 | | nV/√Hz |
| **DYNAMIC PERFORMANCE** | | | | | | |
| Open Loop Voltage Gain | $A_{VOL}$ | $V_O$ = 2 Vpp, $R_L$ = 600 Ω | | 88 | | dB |
| Gain Bandwidth Product | GBWP | $R_L$ = 2 kΩ | | 3.6 | | MHz |
| Gain Margin | $A_M$ | $R_L$ = 600 Ω, $C_L$ = 100 pF | | 9 | | dB |
| Phase Margin | $\psi_M$ | $R_L$ = 600 Ω, $C_L$ = 100 pF | | 60 | | ° |
| Slew Rate | SR | $R_L$ = 10 kΩ | | 1.0 | | V/μS |
| Total Harmonic Distortion + Noise | THD+N | $V_{OUT}$ = 4 Vpp, $f_{IN}$ = 10 kHz, $A_V$ = 2, $R_L$ = 10 kΩ | | 0.008 | | % |
| **POWER SUPPLY** | | | | | | |
| Power Supply Rejection Ratio | PSRR | $V_S$ = 2.7 V to 26 V | 60 | 105 | | dB |
| Quiescent Current | $I_{CC}$ | No load, $V_{CM}$ = $V_S$/2, per channel | | 0.75 | 1.4 | mA |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

**Table 7. ELECTRICAL CHARACTERISTICS AT $V_S$ = 24 V**
At $T_A$ = +25°C, $R_L$ = 10 kΩ connected to mid−supply, $V_{CM}$ = $V_{OUT}$ = midsupply, unless otherwise noted.
**Boldface** limits apply over the specified temperature range, $T_A$ = –40°C to +125°C, guaranteed by characterization and/or design.

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **INPUT CHARACTERISTICS** | | | | | | |
| Offset Voltage | $V_{OS}$ | | | 0.6 | 6.0 | mV |
| | | | | | **8.0** | mV |
| Offset Voltage Drift | ΔV/ΔT | | | 4.5 | | μV/°C |
| Input Bias Current | $I_{IB}$ | | | 55 | 100 | nA |
| | | | | | **200** | nA |
| Input Offset Current | $I_{OS}$ | | | 1.0 | 30 | nA |
| | | | | | **80** | nA |
| Input Common Mode Range | $V_{CM}$ | | $V_{SS}$ – 0.2 | | $V_{DD}$+0.2 | V |
| Common Mode Rejection Ratio | CMRR | $V_{SS}$ + 0.15 < $V_{CM}$ < $V_{DD}$ − 0.15 | 50 | 100 | | dB |
| **OUTPUT CHARACTERISTICS** | | | | | | |
| Output Voltage High | $V_{OH}$ | $R_L$ = 2 kΩ | $V_{DD}$−0.30 | $V_{DD}$−0.10 | | V |
| Output Voltage Low | $V_{OL}$ | $R_L$ = 2 kΩ | | $V_{SS}$+0.14 | $V_{SS}$+0.30 | V |
| Short Circuit Current | $I_{SC}$ | | 10 | | | mA |
| **NOISE PERFORMANCE** | | | | | | |
| Voltage Noise Density | $e_N$ | f = 1 kHz, no load | | 25 | | nV/√Hz |
| **DYNAMIC PERFORMANCE** | | | | | | |
| Open Loop Voltage Gain | $A_{VOL}$ | $V_O$ = 2 Vpp, $R_L$ = 2 kΩ | | 88 | | dB |
| Gain Bandwidth Product | GBWP | $R_L$ = 10 kΩ | | 3.0 | | MHz |
| Gain Margin | $A_M$ | $R_L$ = 10 kΩ, $C_L$ = 100 pF | | 9.0 | | dB |
| Phase Margin | $\psi_M$ | $R_L$ = 10 kΩ, $C_L$ = 100 pF | | 70 | | ° |
| Slew Rate | SR | $R_L$ = 10 kΩ | | 1.0 | | V/μS |
| Total Harmonic Distortion + Noise | THD+N | $V_{OUT}$ = 10 Vpp, $f_{IN}$ = 10 kHz, $A_V$ = 2, $R_L$ = 10 kΩ | | 0.013 | | % |
| **POWER SUPPLY** | | | | | | |
| Power Supply Rejection Ratio | PSRR | $V_S$ = 2.7 V to 26 V | 60 | 105 | | dB |
| Quiescent Current | $I_{CC}$ | No load, $V_{CM}$ = $V_S$/2, per channel | | 0.95 | 1.4 | mA |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

## TYPICAL CHARACTERISTICS

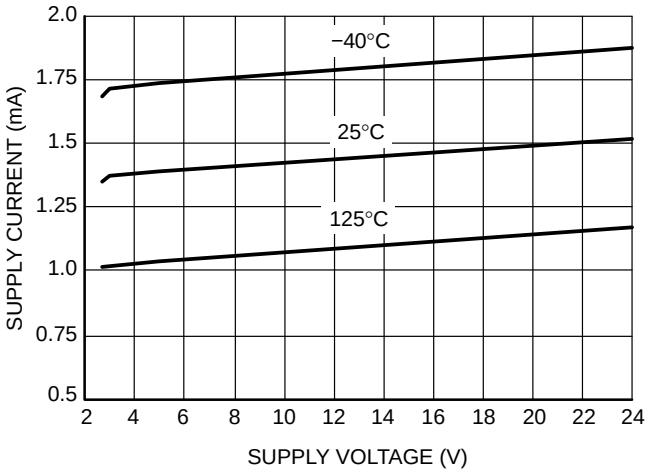



**Figure 1. Supply Current vs. Supply Voltage**

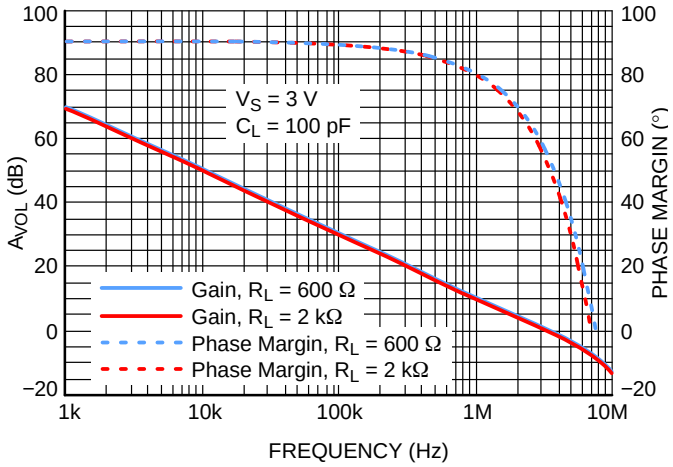



**Figure 2. Open Loop Gain and Phase Margin vs. Frequency**

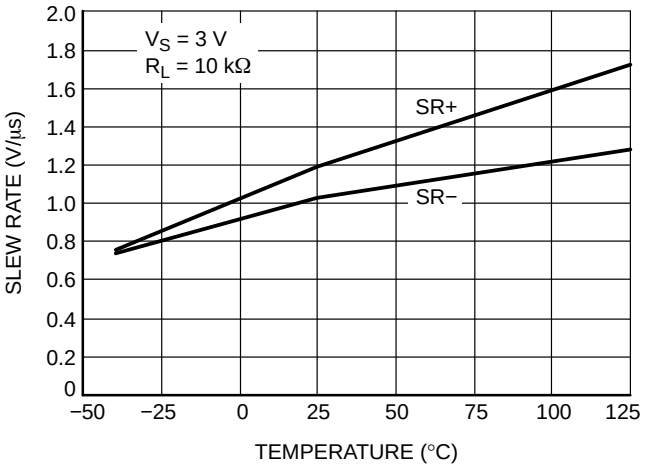



**Figure 3. Slew Rate vs. Temperature**

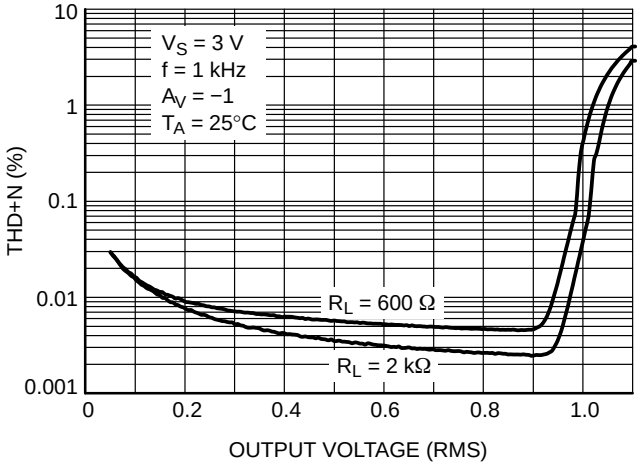



**Figure 4. THD+N vs. Output Voltage**

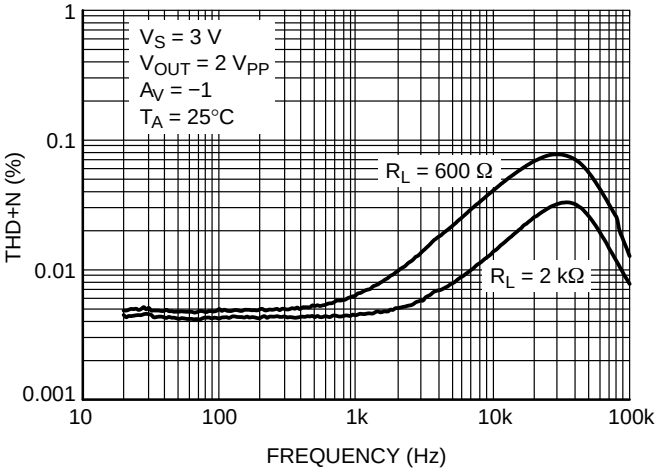



**Figure 5. THD+N vs. Frequency**

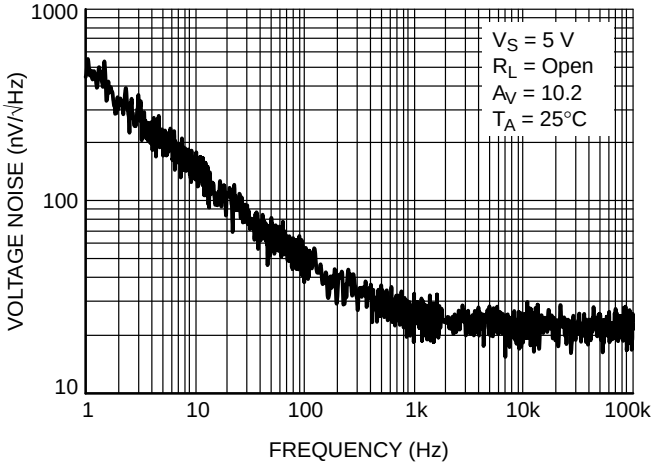



**Figure 6. Input Voltage Noise vs. Frequency**

## TYPICAL CHARACTERISTICS

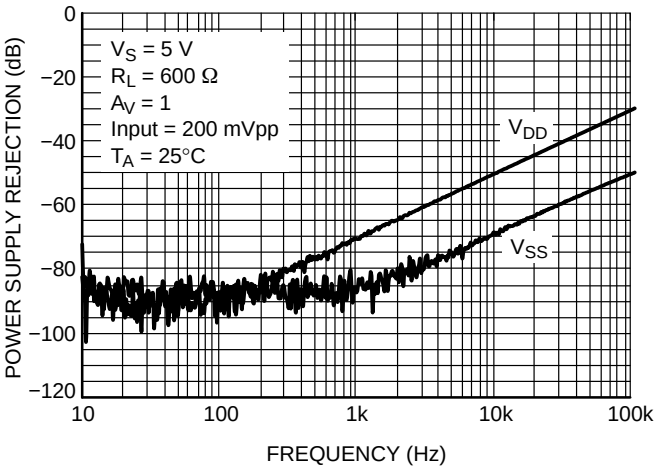



**Figure 7. PSRR vs. Frequency**

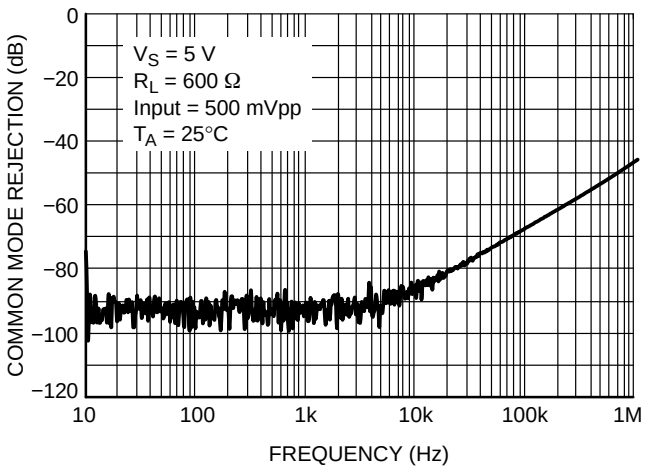



**Figure 8. CMRR vs. Frequency**

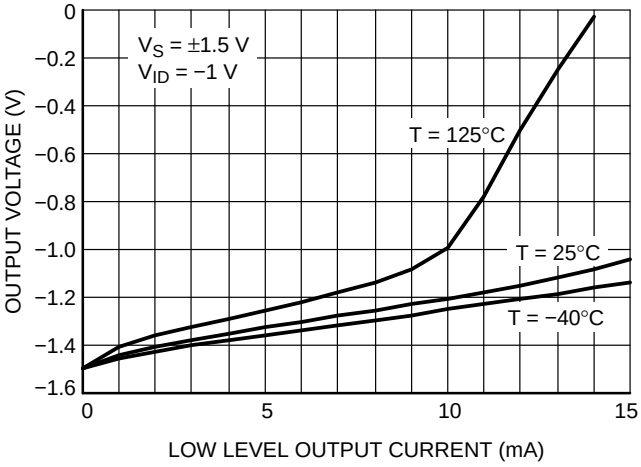



**Figure 9. Low Level Output Voltage vs. Output Current at 3 V Supply**

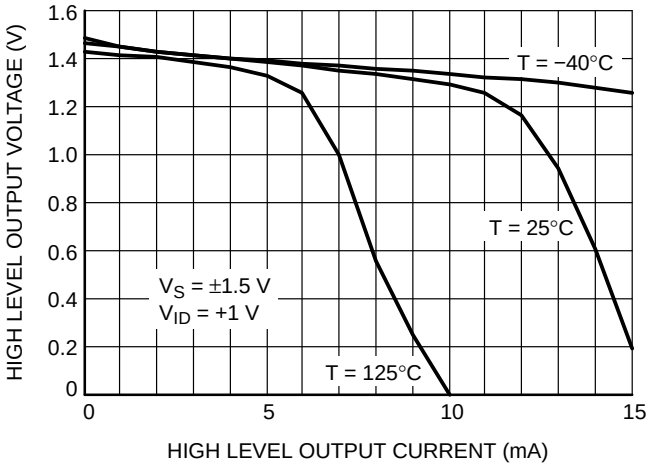



**Figure 10. High level Output Voltage vs. Output Current at 3 V Supply**

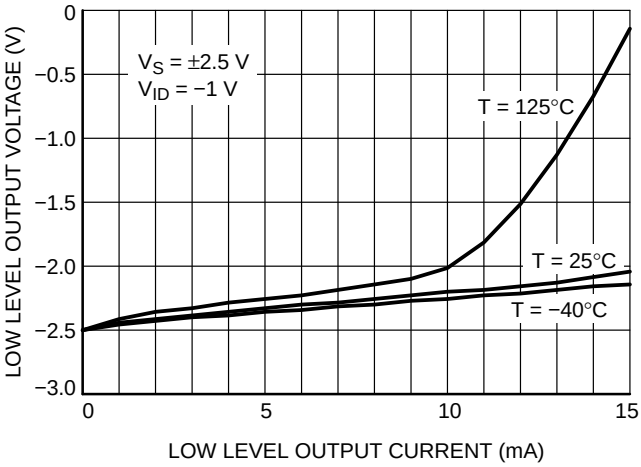



**Figure 11. Low Level Output Voltage vs. Output Current at 5 V Supply**

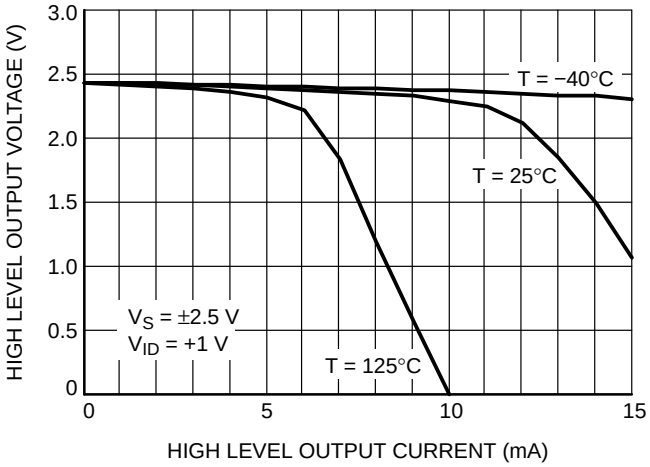



**Figure 12. High Level Output Voltage vs. Output Current at 5 V Supply**

## TYPICAL CHARACTERISTICS

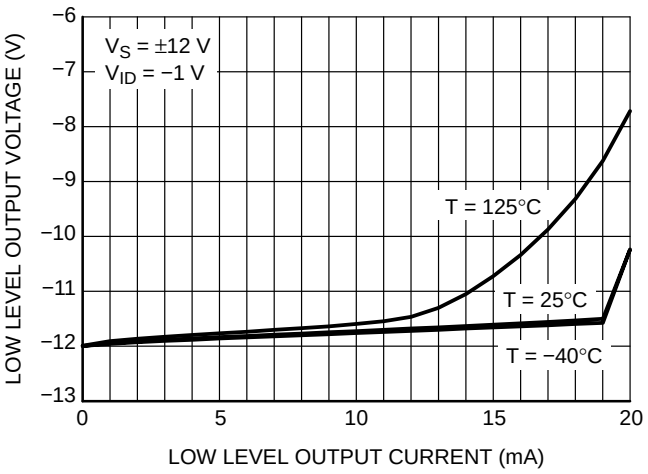



**Figure 13. Low Level Output Voltage vs. Output Current at 24 V Supply**

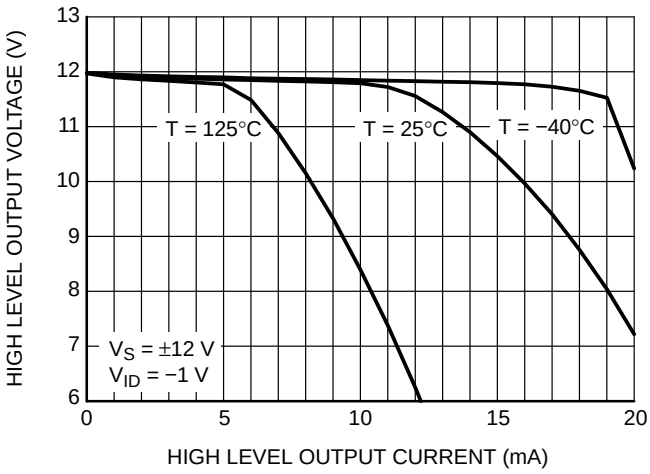



**Figure 14. High Level Output Voltage vs. Output Current at 24 V Supply**

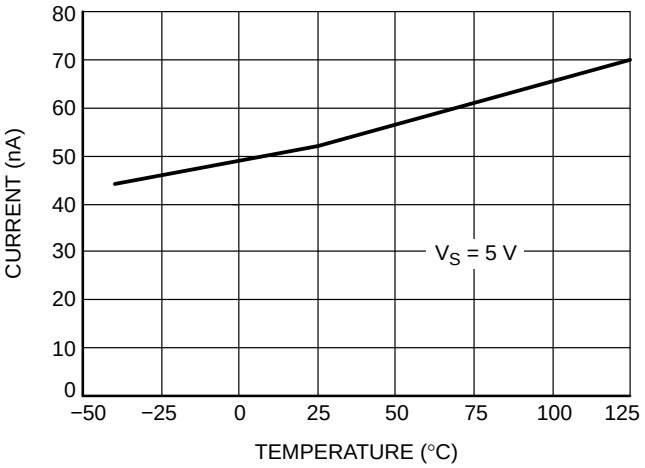



**Figure 15. Input Bias Current vs. Temperature**

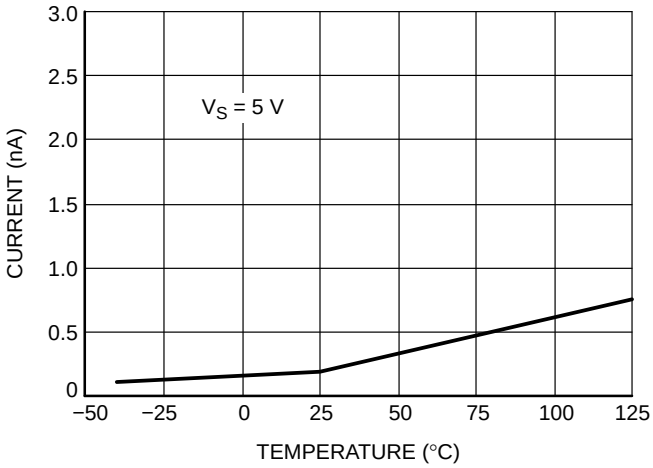



**Figure 16. Input Offset Current vs. Temperature**

## TYPICAL CHARACTERISTICS

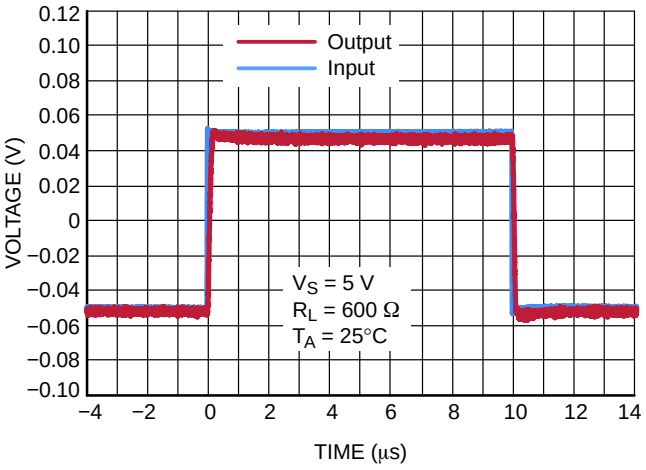



**Figure 17. Noninverting Small Signal Transient Response**

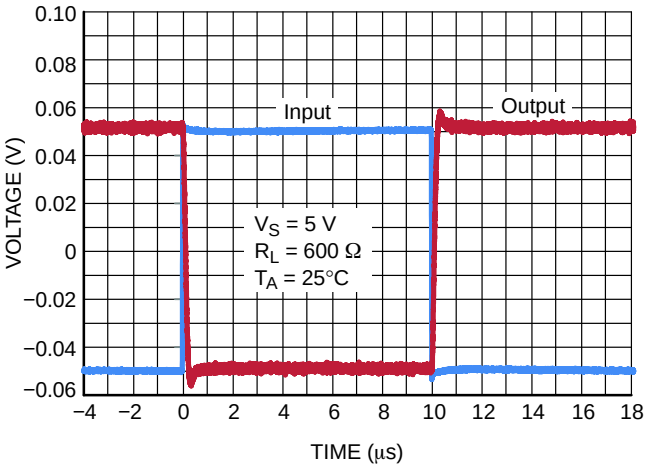



**Figure 18. Inverting Small Signal Transient Response**

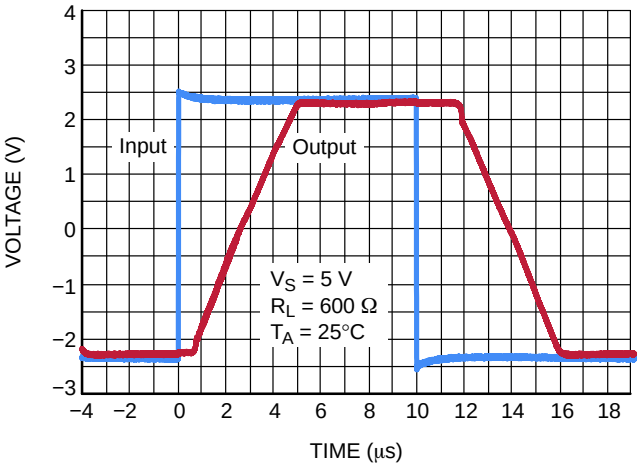



**Figure 19. Noninverting Large Signal Transient Response**

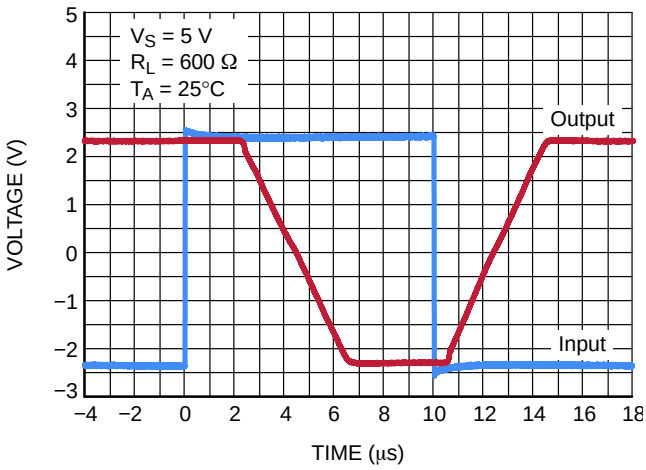


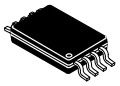

**Figure 20. Inverting Large Signal Transient Response**

# MECHANICAL CASE OUTLINE
## PACKAGE DIMENSIONS

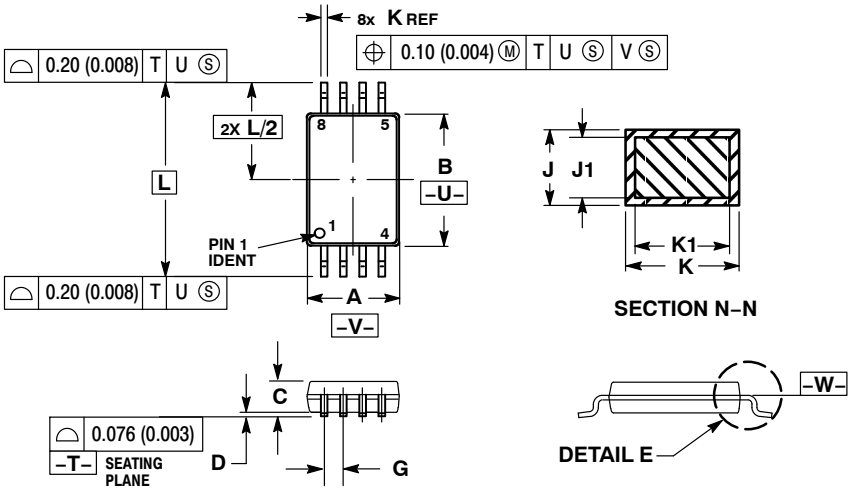
ON Semiconductor®

**TSSOP−8**
CASE 948S−01
ISSUE C

DATE 20 JUN 2008



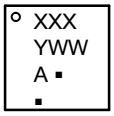
**SCALE 2:1**




NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A DOES NOT INCLUDE MOLD FLASH. PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
5. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
6. DIMENSION A AND B ARE TO BE DETERMINED AT DATUM PLANE −W−.

| | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | 2.90 | 3.10 | 0.114 | 0.122 |
| B | 4.30 | 4.50 | 0.169 | 0.177 |
| C | --- | 1.10 | --- | 0.043 |
| D | 0.05 | 0.15 | 0.002 | 0.006 |
| F | 0.50 | 0.70 | 0.020 | 0.028 |
| G | 0.65 BSC | | 0.026 BSC | |
| J | 0.09 | 0.20 | 0.004 | 0.008 |
| J1 | 0.09 | 0.16 | 0.004 | 0.006 |
| K | 0.19 | 0.30 | 0.007 | 0.012 |
| K1 | 0.19 | 0.25 | 0.007 | 0.010 |
| L | 6.40 BSC | | 0.252 BSC | |
| M | 0° | 8° | 0° | 8° |

### GENERIC MARKING DIAGRAM*




XXX = Specific Device Code
A = Assembly Location
Y = Year
WW = Work Week
▪ = Pb−Free Package

*This information is generic. Please refer to device data sheet for actual part marking. Pb−Free indicator, “G” or microdot “ ▪”, may or may not be present.

| | | |
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| STATUS: | ON SEMICONDUCTOR STANDARD | |
| NEW STANDARD: | | |
| DESCRIPTION: | TSSOP−8 | PAGE 1 OF 2 |

| ISSUE | REVISION | DATE |
|---|---|---|
| O | RELEASED FOR PRODUCTION. | 18 APR 2000 |
| A | ADDED MARKING DIAGRAM INFORMATION. REQ. BY V. BASS. | 13 JAN 2006 |
| B | CORRECTED MARKING DIAGRAM PIN 1 LOCATION AND MARKING. REQ. BY C. REBELLO. | 13 MAR 2006 |
| C | REMOVED EXPOSED PAD VIEW AND DIMENSIONS P AND P1. CORRECTED MARKING INFORMATION. REQ. BY C. REBELLO. | 20 JUN 2008 |
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