

# **OPAx314-Q1 3-MHz, Low-Power, Low-Noise, RRIO, 1.8-V CMOS Operational Amplifier**

## **1 Features**

- Qualified for Automotive Applications
- AEC-Q100 Qualified With the Following Results:
  - Device Temperature Grade :  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  Ambient Operating Temperature Range
  - Device HBM Classification Level 2
  - Device CDM Classification Level C6
- Low  $I_Q$ : 150  $\mu\text{A}/\text{ch}$
- Wide Supply Range: 1.8 V to 5.5 V
- Low Noise: 14  $\text{nV}/\sqrt{\text{Hz}}$  at 1 kHz
- Gain Bandwidth: 3 MHz
- Low Input Bias Current: 0.2 pA
- Low Offset Voltage: 0.5 mV
- Unity-Gain Stable
- Internal RF and EMI Filter
- Specified Temperature Range:  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$

## **2 Applications**

- Automotive Applications:
  - ADAS
  - Body Electronics and Lighting
  - Current Sensing
  - Battery Monitoring

## **3 Description**

The OPAx314-Q1 series is a family of single-, and dual-, and quad-channel operational amplifiers (op amps) that represents a new generation of low-power, general-purpose CMOS amplifiers. Rail-to-rail input and output swings, low quiescent current (150  $\mu\text{A}$  typically at 5  $V_S$ ) combined with a wide bandwidth of 3 MHz, and very low noise (14  $\text{nV}/\sqrt{\text{Hz}}$  at 1 kHz) make this device family very attractive for a variety of battery-powered applications that require a good balance between cost and performance. The low-input bias current supports applications with megaohm source impedances.

The robust design of the OPAx314-Q1 series provides ease-of-use to the circuit designer: unity-gain stability with capacitive loads of up to 300 pF, an integrated RF and EMI rejection filter, no phase reversal in overdrive conditions, and high electrostatic discharge (ESD) protection (4-kV HBM).

The device is optimized for low-voltage operation as low as 1.8 V ( $\pm 0.9$  V) and up to 5.5 V ( $\pm 2.75$  V), and is specified over the full extended temperature range of  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

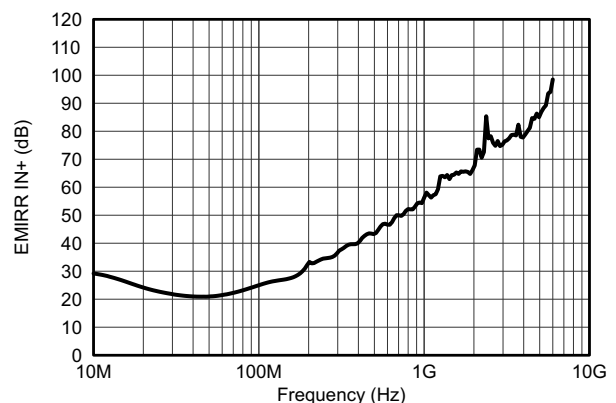
The single-channel device, OPA314-Q1, is offered in the SOT-23 package and the dual-channel device, OPA2314-Q1, is offered in the VSSOP (8) package. The quad-channel OPA4314-Q1 is available in the 14-pin TSSOP package.

### **Device Information<sup>(1)</sup>**

| PART NUMBER | PACKAGE    | BODY SIZE (NOM)          |
|-------------|------------|--------------------------|
| OPA314-Q1   | SOT-23 (5) | 2.90 mm $\times$ 1.60 mm |
| OPA2314-Q1  | VSSOP (8)  | 4.90 mm $\times$ 3.91 mm |
| OPA4314-Q1  | TSSOP (14) | 5.00 mm $\times$ 4.40 mm |

(1) For all available packages, see the orderable addendum at the end of the data sheet.

### **EMIRR vs Frequency**



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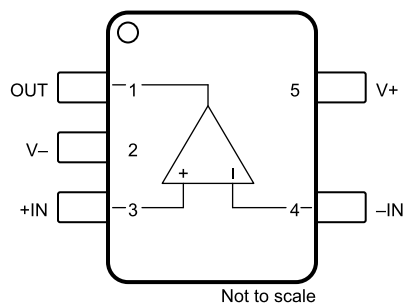
## 4 Revision History

| Changes from Revision A (January 2015) to Revision B                                                                    | Page |
|-------------------------------------------------------------------------------------------------------------------------|------|
| • Added part number OPA4314-Q1 to document .....                                                                        | 1    |
| • Added part number OPA4314-Q1 to the <i>Device Information</i> table .....                                             | 1    |
| • Changed OPA2314-Q1 package from SOIC (8) to VSSOP (8) in the <i>Device Information</i> table .....                    | 1    |
| • Added OPA314-Q1 (SOT-23 package) throughout document .....                                                            | 3    |
| • Added pinout drawing for the OPA4314-Q1 device in the <i>Pin Configurations and Functions</i> section .....           | 5    |
| • Added the Pin Functions: OPA4314-Q1 table to the <i>Pin Configurations and Functions</i> section .....                | 5    |
| • Changed formatting of all <i>Thermal Information</i> table notes .....                                                | 7    |
| • Added footnotes to all <i>Thermal Information</i> tables .....                                                        | 7    |
| • Added <i>Thermal Information: OPA4314-Q1</i> table .....                                                              | 9    |
| • Changed formatting of application report reference in the <i>EMI Susceptibility and Input Filtering</i> section ..... | 20   |
| • Changed package drawing to reflect an example of the 5-pin SOT-23 package in the <i>Layout Example</i> section .....  | 26   |
| • Changed formatting of <i>Related Documentation</i> section .....                                                      | 27   |
| • Added part number OPA4314-Q1 to the <i>Related Links</i> table .....                                                  | 27   |

| Changes from Original (December 2014) to Revision A                                     | Page |
|-----------------------------------------------------------------------------------------|------|
| • Changed the device status from <i>Product Preview</i> to <i>Production Data</i> ..... | 1    |

## 5 Pin Configuration and Functions

**OPA314-Q1 DBV Package  
5-Pin SOT-23  
Top View**

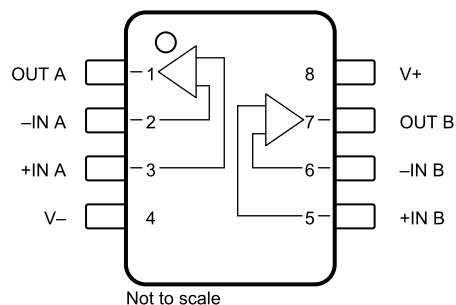


**Pin Functions: OPA314-Q1**

| PIN  |     | I/O | DESCRIPTION                                              |
|------|-----|-----|----------------------------------------------------------|
| NAME | NO. |     |                                                          |
| –IN  | 4   | I   | Inverting input                                          |
| +IN  | 3   | I   | Noninverting input                                       |
| OUT  | 1   | O   | Output                                                   |
| V–   | 2   | —   | Negative supply or ground (for single-supply operation). |
| V+   | 5   | —   | Positive supply                                          |

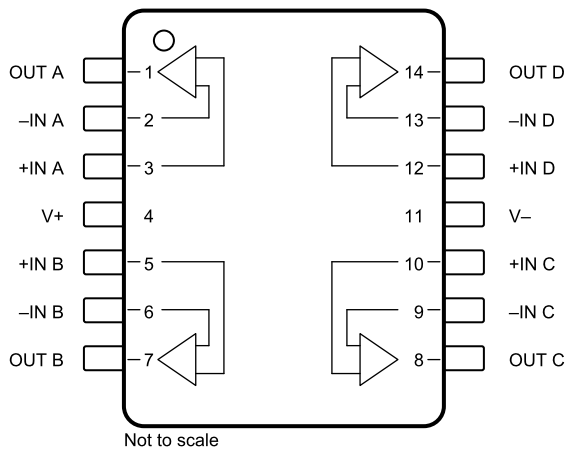
**OPA314-Q1, OPA2314-Q1, OPA4314-Q1**

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[www.ti.com](http://www.ti.com)
**OPA2314-Q1 DGK Package  
8-Pin VSSOP  
Top View**

**Pin Functions: OPA2314-Q1**

| PIN   |     | I/O | DESCRIPTION                                              |
|-------|-----|-----|----------------------------------------------------------|
| NAME  | NO. |     |                                                          |
| -IN A | 2   | I   | Inverting input, channel A                               |
| +IN A | 3   | I   | Noninverting input, channel A                            |
| -IN B | 6   | I   | Inverting input, channel B                               |
| +IN B | 5   | I   | Noninverting input, channel B                            |
| OUT A | 1   | O   | Output, channel A                                        |
| OUT B | 7   | O   | Output, channel B                                        |
| V-    | 4   | —   | Negative supply or ground (for single-supply operation). |
| V+    | 8   | —   | Positive supply                                          |

**OPA4314-Q1 DGK Package  
14-Pin TSSOP  
Top View**



**Pin Functions: OPA4314-Q1**

| PIN   |     | I/O | DESCRIPTION                                              |
|-------|-----|-----|----------------------------------------------------------|
| NAME  | NO. |     |                                                          |
| -IN A | 2   | I   | Inverting input, channel A                               |
| +IN A | 3   | I   | Noninverting input, channel A                            |
| -IN B | 6   | I   | Inverting input, channel B                               |
| +IN B | 5   | I   | Noninverting input, channel B                            |
| -IN C | 9   | I   | Inverting input, channel C                               |
| +IN C | 10  | I   | Noninverting input, channel C                            |
| -IN D | 13  | I   | Inverting input, channel D                               |
| +IN D | 12  | I   | Noninverting input, channel D                            |
| OUT A | 1   | O   | Output, channel A                                        |
| OUT B | 7   | O   | Output, channel B                                        |
| OUT C | 8   | O   | Output, channel C                                        |
| OUT D | 14  | O   | Output, channel D                                        |
| V-    | 11  | —   | Negative supply or ground (for single-supply operation). |
| V+    | 4   | —   | Positive supply                                          |

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) <sup>(1)</sup>

|                                       |                        | MIN        | MAX        | UNIT |
|---------------------------------------|------------------------|------------|------------|------|
| Supply voltage                        |                        |            | 7          | V    |
| Voltage <sup>(2)</sup>                | Signal input terminals | (V–) – 0.5 | (V+) + 0.5 | V    |
| Current <sup>(2)</sup>                | Signal input terminals |            | ±10        | mA   |
| Output short-circuit <sup>(3)</sup>   |                        |            | Continuous | mA   |
| Operating temperature, T <sub>A</sub> |                        | –40        | 150        | °C   |
| Junction temperature, T <sub>J</sub>  |                        |            | 150        | °C   |
| Storage temperature, T <sub>stg</sub> |                        | –65        | 150        | °C   |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5 V beyond the supply rails must be current limited to 10 mA or less.
- (3) Short-circuit to ground, one amplifier per package.

### 6.2 ESD Ratings

|                    |                         |                                                         | VALUE | UNIT |
|--------------------|-------------------------|---------------------------------------------------------|-------|------|
| V <sub>(ESD)</sub> | Electrostatic discharge | Human body model (HBM), per AEC Q100-002 <sup>(1)</sup> | ±2000 | V    |
|                    |                         | Charged device model (CDM), per AEC Q100-011            | ±1000 |      |

- (1) AEC Q100-002 indicates HBM stressing is done in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

### 6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

|                |                               | MIN        | NOM | MAX         | UNIT |
|----------------|-------------------------------|------------|-----|-------------|------|
| V <sub>S</sub> | Supply voltage                | 1.8 (±0.9) |     | 5.5 (±2.75) | V    |
| T <sub>A</sub> | Ambient operating temperature | –40        |     | 125         | °C   |

## 6.4 Thermal Information: OPA314-Q1

| THERMAL METRIC <sup>(1)</sup> |                                                             | OPA314-Q1    | UNIT |
|-------------------------------|-------------------------------------------------------------|--------------|------|
|                               |                                                             | DBV (SOT-23) |      |
|                               |                                                             | 5 PINS       |      |
| $R_{\theta JA}$               | Junction-to-ambient thermal resistance <sup>(2)</sup>       | 221.7        | °C/W |
| $R_{\theta JC(top)}$          | Junction-to-case(top) thermal resistance <sup>(3)</sup>     | 144.7        | °C/W |
| $R_{\theta JB}$               | Junction-to-board thermal resistance <sup>(4)</sup>         | 49.7         | °C/W |
| $\Psi_{JT}$                   | Junction-to-top characterization parameter <sup>(5)</sup>   | 26.1         | °C/W |
| $\Psi_{JB}$                   | Junction-to-board characterization parameter <sup>(6)</sup> | 49           | °C/W |
| $R_{\theta JC(bot)}$          | Junction-to-case(bottom) thermal resistance <sup>(7)</sup>  | N/A          | °C/W |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.
- (2) The junction-to-ambient thermal resistance under natural convection is obtained in a simulation on a JEDEC-standard, high-K board, as specified in JESD51-7, in an environment described in JESD51-2a.
- (3) The junction-to-case (top) thermal resistance is obtained by simulating a cold plate test on the package top. No specific JEDEC-standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.
- (4) The junction-to-board thermal resistance is obtained by simulating in an environment with a ring cold plate fixture to control the PCB temperature, as described in JESD51-8.
- (5) The junction-to-top characterization parameter,  $\Psi_{JT}$ , estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining  $R_{\theta JA}$ , using a procedure described in JESD51-2a (sections 6 and 7).
- (6) The junction-to-board characterization parameter,  $\Psi_{JB}$ , estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining  $R_{\theta JA}$ , using a procedure described in JESD51-2a (sections 6 and 7).
- (7) The junction-to-case (bottom) thermal resistance is obtained by simulating a cold plate test on the exposed (power) pad. No specific JEDEC standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.

## 6.5 Thermal Information: OPA2314-Q1

| THERMAL METRIC <sup>(1)</sup> |                                                             | OPA2314-Q1  | UNIT |
|-------------------------------|-------------------------------------------------------------|-------------|------|
|                               |                                                             | DGK (VSSOP) |      |
|                               |                                                             | 8 PINS      |      |
| $R_{\theta JA}$               | Junction-to-ambient thermal resistance <sup>(2)</sup>       | 138.4       | °C/W |
| $R_{\theta JC(top)}$          | Junction-to-case(top) thermal resistance <sup>(3)</sup>     | 89.5        | °C/W |
| $R_{\theta JB}$               | Junction-to-board thermal resistance <sup>(4)</sup>         | 78.6        | °C/W |
| $\Psi_{JT}$                   | Junction-to-top characterization parameter <sup>(5)</sup>   | 29.9        | °C/W |
| $\Psi_{JB}$                   | Junction-to-board characterization parameter <sup>(6)</sup> | 78.1        | °C/W |
| $R_{\theta JC(bot)}$          | Junction-to-case(bottom) thermal resistance <sup>(7)</sup>  | N/A         | °C/W |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.
- (2) The junction-to-ambient thermal resistance under natural convection is obtained in a simulation on a JEDEC-standard, high-K board, as specified in JESD51-7, in an environment described in JESD51-2a.
- (3) The junction-to-case (top) thermal resistance is obtained by simulating a cold plate test on the package top. No specific JEDEC-standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.
- (4) The junction-to-board thermal resistance is obtained by simulating in an environment with a ring cold plate fixture to control the PCB temperature, as described in JESD51-8.
- (5) The junction-to-top characterization parameter,  $\Psi_{JT}$ , estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining  $R_{\theta JA}$ , using a procedure described in JESD51-2a (sections 6 and 7).
- (6) The junction-to-board characterization parameter,  $\Psi_{JB}$ , estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining  $R_{\theta JA}$ , using a procedure described in JESD51-2a (sections 6 and 7).
- (7) The junction-to-case (bottom) thermal resistance is obtained by simulating a cold plate test on the exposed (power) pad. No specific JEDEC standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.

## 6.6 Thermal Information: OPA4314-Q1

| THERMAL METRIC <sup>(1)</sup> |                                                             | OPA4314-Q1 | UNIT |
|-------------------------------|-------------------------------------------------------------|------------|------|
|                               |                                                             | PW (TSSOP) |      |
|                               |                                                             | 14 PINS    |      |
| $R_{\theta JA}$               | Junction-to-ambient thermal resistance <sup>(2)</sup>       | 121        | °C/W |
| $R_{\theta JC(top)}$          | Junction-to-case(top) thermal resistance <sup>(3)</sup>     | 49.4       | °C/W |
| $R_{\theta JB}$               | Junction-to-board thermal resistance <sup>(4)</sup>         | 62.8       | °C/W |
| $\Psi_{JT}$                   | Junction-to-top characterization parameter <sup>(5)</sup>   | 5.9        | °C/W |
| $\Psi_{JB}$                   | Junction-to-board characterization parameter <sup>(6)</sup> | 62.2       | °C/W |
| $R_{\theta JC(bot)}$          | Junction-to-case(bottom) thermal resistance <sup>(7)</sup>  | N/A        | °C/W |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.
- (2) The junction-to-ambient thermal resistance under natural convection is obtained in a simulation on a JEDEC-standard, high-K board, as specified in JESD51-7, in an environment described in JESD51-2a.
- (3) The junction-to-case (top) thermal resistance is obtained by simulating a cold plate test on the package top. No specific JEDEC-standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.
- (4) The junction-to-board thermal resistance is obtained by simulating in an environment with a ring cold plate fixture to control the PCB temperature, as described in JESD51-8.
- (5) The junction-to-top characterization parameter,  $\Psi_{JT}$ , estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining  $R_{\theta JA}$ , using a procedure described in JESD51-2a (sections 6 and 7).
- (6) The junction-to-board characterization parameter,  $\Psi_{JB}$ , estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining  $R_{\theta JA}$ , using a procedure described in JESD51-2a (sections 6 and 7).
- (7) The junction-to-case (bottom) thermal resistance is obtained by simulating a cold plate test on the exposed (power) pad. No specific JEDEC standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.

## 6.7 Electrical Characteristics

at  $T_A = 25^\circ\text{C}$ ,  $R_L = 10\text{ k}\Omega$  connected to  $V_S / 2$ ,  $V_{CM} = V_S / 2$ , and  $V_{OUT} = V_S / 2$ ,  $V_S = 1.8\text{ V}$  to  $5.5\text{ V}$ , unless otherwise noted. The phrase *overtemperature* refers to values over the specified temperature range of  $T_A = -40^\circ\text{C}$  to  $125^\circ\text{C}$ .<sup>(1)</sup>

| PARAMETER                  |                                             | TEST CONDITIONS                                                                                       | MIN           | TYP       | MAX           | UNIT                         |
|----------------------------|---------------------------------------------|-------------------------------------------------------------------------------------------------------|---------------|-----------|---------------|------------------------------|
| <b>OFFSET VOLTAGE</b>      |                                             |                                                                                                       |               |           |               |                              |
| $V_{OS}$                   | Input offset voltage                        | $V_{CM} = (V_{S+}) - 1.3\text{ V}$                                                                    |               | 0.5       | 2.5           | mV                           |
| $dV_{OS}/dT$               | Input offset voltage vs temperature         |                                                                                                       |               | 1         |               | $\mu\text{V}/^\circ\text{C}$ |
| PSRR                       | vs power supply                             | $V_{CM} = (V_{S+}) - 1.3\text{ V}$                                                                    | 78            | 92        |               | dB                           |
|                            | Input offset voltage overtemperature        |                                                                                                       | 74            |           |               | dB                           |
|                            | Channel separation, DC                      | At DC                                                                                                 |               | 10        |               | $\mu\text{V/V}$              |
| <b>INPUT VOLTAGE RANGE</b> |                                             |                                                                                                       |               |           |               |                              |
| $V_{CM}$                   | Common-mode voltage range                   |                                                                                                       | $(V_-) - 0.2$ |           | $(V_+) + 0.2$ | V                            |
| CMRR                       | Common-mode rejection ratio                 | $V_S = 1.8\text{ V}$ to $5.5\text{ V}$ , $(V_{S-}) - 0.2\text{ V} < V_{CM} < (V_{S+}) - 1.3\text{ V}$ | 75            | 96        |               | dB                           |
|                            |                                             | $V_S = 5.5\text{ V}$ , $V_{CM} = -0.2\text{ V}$ to $5.7\text{ V}$ <sup>(2)</sup>                      | 66            | 80        |               | dB                           |
|                            | Common-mode rejection ratio overtemperature | $V_S = 1.8\text{ V}$ , $(V_{S-}) - 0.2\text{ V} < V_{CM} < (V_{S+}) - 1.3\text{ V}$                   | 70            | 86        |               | dB                           |
|                            |                                             | $V_S = 5.5\text{ V}$ , $(V_{S-}) - 0.2\text{ V} < V_{CM} < (V_{S+}) - 1.3\text{ V}$                   | 73            | 90        |               | dB                           |
|                            |                                             | $V_S = 5.5\text{ V}$ , $V_{CM} = -0.2\text{ V}$ to $5.7\text{ V}$ <sup>(2)</sup>                      | 60            |           |               | dB                           |
| <b>INPUT BIAS CURRENT</b>  |                                             |                                                                                                       |               |           |               |                              |
| $I_B$                      | Input bias current                          |                                                                                                       |               | $\pm 0.2$ | $\pm 10$      | pA                           |
|                            | Input bias current overtemperature          |                                                                                                       |               |           | $\pm 600$     | pA                           |
| $I_{OS}$                   | Input offset current                        |                                                                                                       |               | $\pm 0.2$ | $\pm 10$      | pA                           |
|                            | Input offset current overtemperature        |                                                                                                       |               |           | $\pm 600$     | pA                           |
| <b>NOISE</b>               |                                             |                                                                                                       |               |           |               |                              |
|                            | Input voltage noise (peak-to-peak)          | $f = 0.1\text{ Hz}$ to $10\text{ Hz}$                                                                 |               | 5         |               | $\mu\text{V}_{PP}$           |
| $e_n$                      | Input voltage noise density                 | $f = 10\text{ kHz}$                                                                                   |               | 13        |               | $\text{nV}/\sqrt{\text{Hz}}$ |
|                            |                                             | $f = 1\text{ kHz}$                                                                                    |               | 14        |               | $\text{nV}/\sqrt{\text{Hz}}$ |
| $i_n$                      | Input current noise density                 | $f = 1\text{ kHz}$                                                                                    |               | 5         |               | $\text{fA}/\sqrt{\text{Hz}}$ |

- (1) Parameters with minimum or maximum specification limits are 100% production tested at  $25^\circ\text{C}$ , unless otherwise noted. Overtemperature limits are based on characterization and statistical analysis.
- (2) Specified by design and characterization; not production tested.

## Electrical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $R_L = 10\text{ k}\Omega$  connected to  $V_S / 2$ ,  $V_{CM} = V_S / 2$ , and  $V_{OUT} = V_S / 2$ ,  $V_S = 1.8\text{ V}$  to  $5.5\text{ V}$ , unless otherwise noted. The phrase *overtemperature* refers to values over the specified temperature range of  $T_A = -40^\circ\text{C}$  to  $125^\circ\text{C}$ .<sup>(1)</sup>

| PARAMETER                 |                                                        | TEST CONDITIONS                                                                                             | MIN | TYP      | MAX | UNIT             |
|---------------------------|--------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|-----|----------|-----|------------------|
| <b>INPUT CAPACITANCE</b>  |                                                        |                                                                                                             |     |          |     |                  |
| $C_{IN}$                  | Differential                                           | $V_S = 5\text{ V}$                                                                                          |     | 1        |     | pF               |
|                           | Common-mode                                            | $V_S = 5\text{ V}$                                                                                          |     | 5        |     | pF               |
| <b>OPEN-LOOP GAIN</b>     |                                                        |                                                                                                             |     |          |     |                  |
| $A_{OL}$                  | Open-loop voltage gain                                 | $V_S = 1.8\text{ V}$ , $0.2\text{ V} < V_O < (V+) - 0.2\text{ V}$ , $R_L = 10\text{ k}\Omega$               | 90  | 115      |     | dB               |
|                           |                                                        | $V_S = 5.5\text{ V}$ , $0.2\text{ V} < V_O < (V+) - 0.2\text{ V}$ , $R_L = 10\text{ k}\Omega$               | 100 | 128      |     | dB               |
|                           |                                                        | $V_S = 1.8\text{ V}$ , $0.5\text{ V} < V_O < (V+) - 0.5\text{ V}$ , $R_L = 2\text{ k}\Omega$ <sup>(2)</sup> | 90  | 100      |     | dB               |
|                           |                                                        | $V_S = 5.5\text{ V}$ , $0.5\text{ V} < V_O < (V+) - 0.5\text{ V}$ , $R_L = 2\text{ k}\Omega$ <sup>(2)</sup> | 94  | 110      |     | dB               |
|                           | Open-loop voltage gain overtemperature                 | $V_S = 5.5\text{ V}$ , $0.2\text{ V} < V_O < (V+) - 0.2\text{ V}$ , $R_L = 10\text{ k}\Omega$               | 90  | 110      |     | dB               |
|                           |                                                        | $V_S = 5.5\text{ V}$ , $0.5\text{ V} < V_O < (V+) - 0.2\text{ V}$ , $R_L = 2\text{ k}\Omega$                |     | 100      |     | dB               |
|                           | Phase margin                                           | $V_S = 5\text{ V}$ , $G = 1$ , $R_L = 10\text{ k}\Omega$                                                    |     | 65       |     | degrees          |
| <b>FREQUENCY RESPONSE</b> |                                                        |                                                                                                             |     |          |     |                  |
| GBW                       | Gain-bandwidth product                                 | $V_S = 1.8\text{ V}$ , $R_L = 10\text{ k}\Omega$ , $C_L = 10\text{ pF}$                                     |     | 2.7      |     | MHz              |
|                           |                                                        | $V_S = 5\text{ V}$ , $R_L = 10\text{ k}\Omega$ , $C_L = 10\text{ pF}$                                       |     | 3        |     | MHz              |
| SR                        | Slew rate <sup>(3)</sup>                               | $V_S = 5\text{ V}$ , $G = 1$                                                                                |     | 1.5      |     | V/ $\mu\text{s}$ |
| $t_S$                     | Settling time                                          | To 0.1%, $V_S = 5\text{ V}$ , 2-V step, $G = 1$                                                             |     | 2.3      |     | $\mu\text{s}$    |
|                           |                                                        | To 0.01%, $V_S = 5\text{ V}$ , 2-V step, $G = 1$                                                            |     | 3.1      |     | $\mu\text{s}$    |
|                           | Overload recovery time                                 | $V_S = 5\text{ V}$ , $V_{IN} \times \text{Gain} > V_S$                                                      |     | 5.2      |     | $\mu\text{s}$    |
| THD+N                     | Total harmonic distortion + noise <sup>(4)</sup>       | $V_S = 5\text{ V}$ , $V_O = 1\text{ V}_{RMS}$ , $G = 1$ , $f = 1\text{ kHz}$ , $R_L = 10\text{ k}\Omega$    |     | 0.001%   |     |                  |
| <b>OUTPUT</b>             |                                                        |                                                                                                             |     |          |     |                  |
| $V_O$                     | Voltage output swing from supply rails                 | $V_S = 1.8\text{ V}$ , $R_L = 10\text{ k}\Omega$                                                            |     | 5        | 15  | mV               |
|                           |                                                        | $V_S = 5.5\text{ V}$ , $R_L = 10\text{ k}\Omega$                                                            |     | 5        | 20  | mV               |
|                           |                                                        | $V_S = 1.8\text{ V}$ , $R_L = 2\text{ k}\Omega$                                                             |     | 15       | 30  | mV               |
|                           |                                                        | $V_S = 5.5\text{ V}$ , $R_L = 2\text{ k}\Omega$                                                             |     | 22       | 40  | mV               |
|                           | Voltage output swing from supply rails overtemperature | $V_S = 5.5\text{ V}$ , $R_L = 10\text{ k}\Omega$                                                            |     |          | 30  | mV               |
|                           |                                                        | $V_S = 5.5\text{ V}$ , $R_L = 2\text{ k}\Omega$                                                             |     | 60       |     | mV               |
| $I_{SC}$                  | Short-circuit current                                  | $V_S = 5\text{ V}$                                                                                          |     | $\pm 20$ |     | mA               |
| $R_O$                     | Open-loop output impedance                             | $V_S = 5.5\text{ V}$ , $f = 100\text{ Hz}$                                                                  |     | 570      |     | $\Omega$         |
| <b>POWER SUPPLY</b>       |                                                        |                                                                                                             |     |          |     |                  |
| $V_S$                     | Specified voltage range                                |                                                                                                             | 1.8 |          | 5.5 | V                |
| $I_Q$                     | Quiescent current per amplifier                        | $V_S = 1.8\text{ V}$ , $I_O = 0\text{ mA}$                                                                  |     | 130      | 180 | $\mu\text{A}$    |
|                           |                                                        | $V_S = 5\text{ V}$ , $I_O = 0\text{ mA}$                                                                    |     | 150      | 190 | $\mu\text{A}$    |
|                           | Quiescent current per amplifier overtemperature        | $V_S = 5\text{ V}$ , $I_O = 0\text{ mA}$                                                                    |     |          | 220 | $\mu\text{A}$    |
|                           | Power-on time                                          | $V_S = 0\text{ V}$ to $5\text{ V}$ , to 90% $I_Q$ level                                                     |     | 44       |     | $\mu\text{s}$    |
| <b>TEMPERATURE</b>        |                                                        |                                                                                                             |     |          |     |                  |
|                           | Specified range                                        |                                                                                                             | -40 |          | 125 | $^\circ\text{C}$ |
|                           | Operating range                                        |                                                                                                             | -40 |          | 150 | $^\circ\text{C}$ |
|                           | Storage range                                          |                                                                                                             | -65 |          | 150 | $^\circ\text{C}$ |

(3) Signifies the slower value of the positive or negative slew rate.

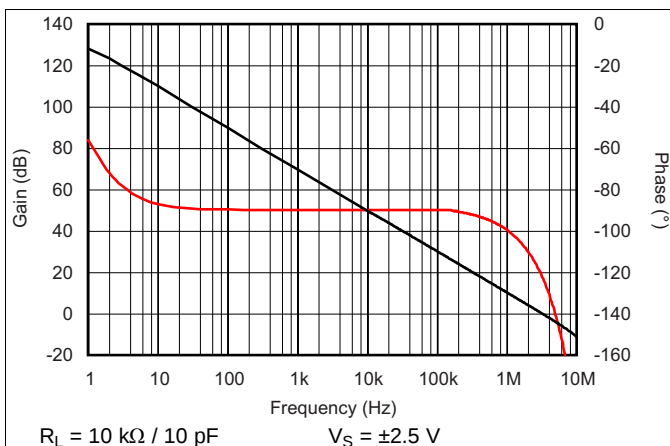
(4) Third-order filter; bandwidth = 80 kHz at -3 dB.

## 6.8 Typical Characteristics

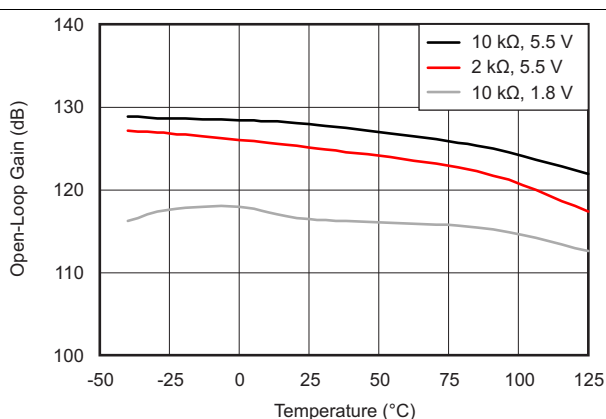
at  $T_A = 25^\circ\text{C}$ ,  $R_L = 10\text{ k}\Omega$  connected to  $V_S / 2$ ,  $V_{CM} = V_S / 2$ , and  $V_{OUT} = V_S / 2$ , unless otherwise noted

**Table 1. Characteristic Performance Measurements**

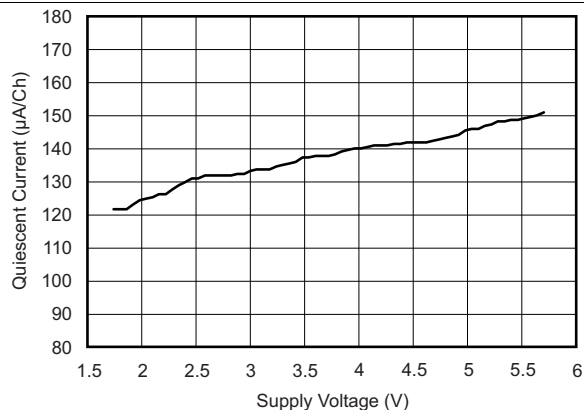
| TITLE                                                                                   | FIGURE                    |
|-----------------------------------------------------------------------------------------|---------------------------|
| Open-Loop Gain and Phase vs Frequency                                                   | <a href="#">Figure 1</a>  |
| Open-Loop Gain vs Temperature                                                           | <a href="#">Figure 2</a>  |
| Quiescent Current vs Supply Voltage                                                     | <a href="#">Figure 3</a>  |
| Quiescent Current vs Temperature                                                        | <a href="#">Figure 4</a>  |
| Offset Voltage Production Distribution                                                  | <a href="#">Figure 5</a>  |
| Offset Voltage Drift Distribution                                                       | <a href="#">Figure 6</a>  |
| Offset Voltage vs Common-Mode Voltage (Maximum Supply)                                  | <a href="#">Figure 7</a>  |
| Offset Voltage vs Temperature                                                           | <a href="#">Figure 8</a>  |
| CMRR and PSRR vs Frequency (RTI)                                                        | <a href="#">Figure 9</a>  |
| CMRR and PSRR vs Temperature                                                            | <a href="#">Figure 10</a> |
| 0.1-Hz to 10-Hz Input Voltage Noise (5.5 V)                                             | <a href="#">Figure 11</a> |
| Input Voltage Noise Spectral Density vs Frequency (1.8 V, 5.5 V)                        | <a href="#">Figure 12</a> |
| Input Voltage Noise vs Common-Mode Voltage (5.5 V)                                      | <a href="#">Figure 13</a> |
| Input Bias and Offset Current vs Temperature                                            | <a href="#">Figure 14</a> |
| Open-Loop Output Impedance vs Frequency                                                 | <a href="#">Figure 15</a> |
| Maximum Output Voltage vs Frequency and Supply Voltage                                  | <a href="#">Figure 16</a> |
| Output Voltage Swing vs Output Current (over Temperature)                               | <a href="#">Figure 17</a> |
| Closed-Loop Gain vs Frequency, $G = 1, -1, 10$ (1.8 V)                                  | <a href="#">Figure 18</a> |
| Closed-Loop Gain vs Frequency, $G = 1, -1, 10$ (5.5 V)                                  | <a href="#">Figure 19</a> |
| Small-Signal Overshoot vs Load Capacitance                                              | <a href="#">Figure 20</a> |
| Small-Signal Step Response, Noninverting (1.8 V)                                        | <a href="#">Figure 21</a> |
| Small-Signal Step Response, Noninverting ( 5.5 V)                                       | <a href="#">Figure 22</a> |
| Large-Signal Step Response, Noninverting (1.8 V)                                        | <a href="#">Figure 23</a> |
| Large-Signal Step Response, Noninverting ( 5.5 V)                                       | <a href="#">Figure 24</a> |
| Positive Overload Recovery                                                              | <a href="#">Figure 25</a> |
| Negative Overload Recovery                                                              | <a href="#">Figure 26</a> |
| No Phase Reversal                                                                       | <a href="#">Figure 27</a> |
| Channel Separation vs Frequency (Dual)                                                  | <a href="#">Figure 28</a> |
| THD+N vs Amplitude ( $G = 1, 2\text{ k}\Omega, 10\text{ k}\Omega$ )                     | <a href="#">Figure 29</a> |
| THD+N vs Amplitude ( $G = -1, 2\text{ k}\Omega, 10\text{ k}\Omega$ )                    | <a href="#">Figure 30</a> |
| THD+N vs Frequency ( $0.5\text{ V}_{RMS}, G = 1, 2\text{ k}\Omega, 10\text{ k}\Omega$ ) | <a href="#">Figure 31</a> |
| EMIRR                                                                                   | <a href="#">Figure 32</a> |



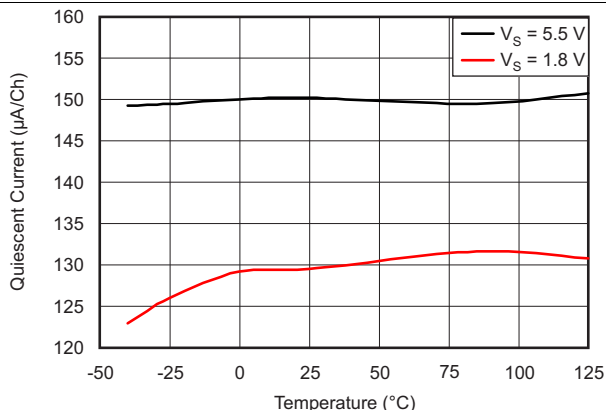
**Figure 1. Open-loop Gain and Phase vs Frequency**



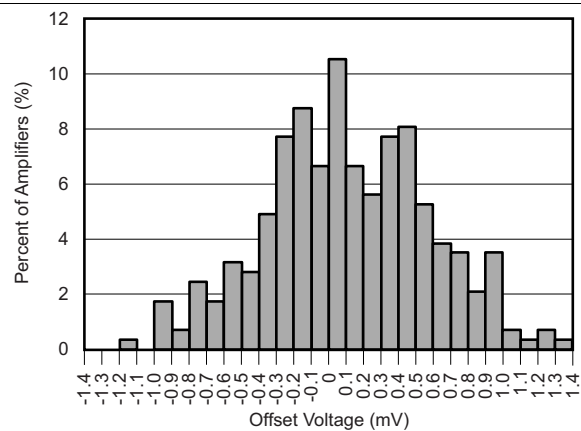
**Figure 2. Open-Loop Gain vs Temperature**



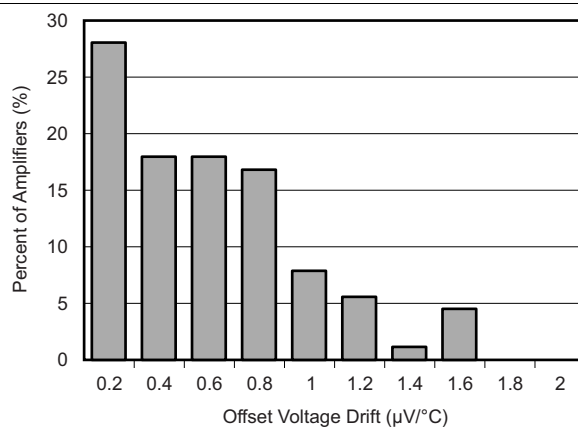
**Figure 3. Quiescent Current vs Supply**



**Figure 4. Quiescent Current vs Temperature**



**Figure 5. Offset Voltage Production Distribution**



**Figure 6. Offset Voltage Drift Distribution**

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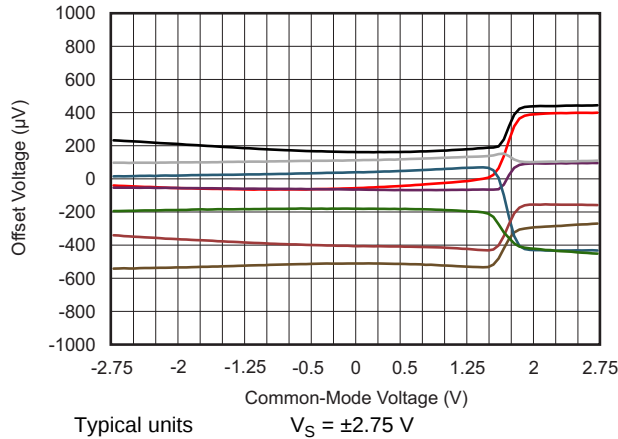


Figure 7. Offset Voltage vs Common-Mode Voltage

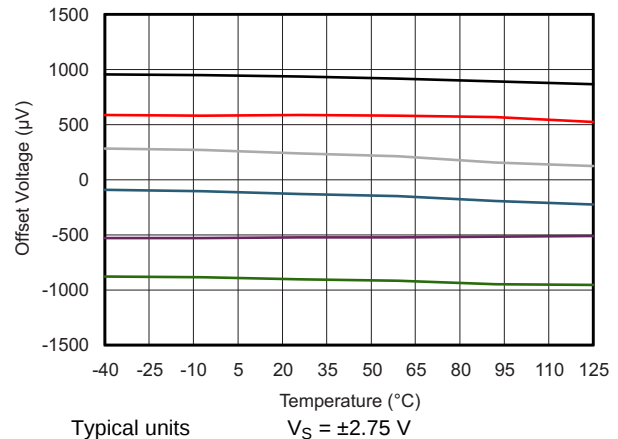


Figure 8. Offset Voltage vs Temperature

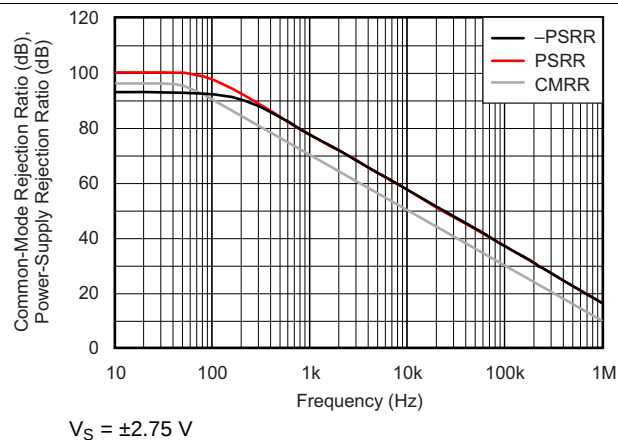


Figure 9. CMRR and PSRR vs Frequency (Referred-to-Input)

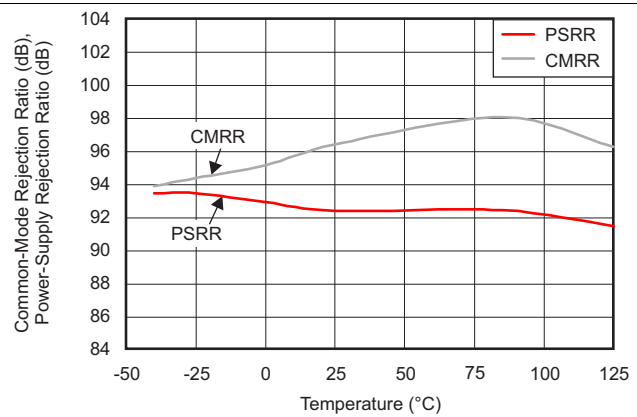


Figure 10. CMRR and PSRR vs Temperature

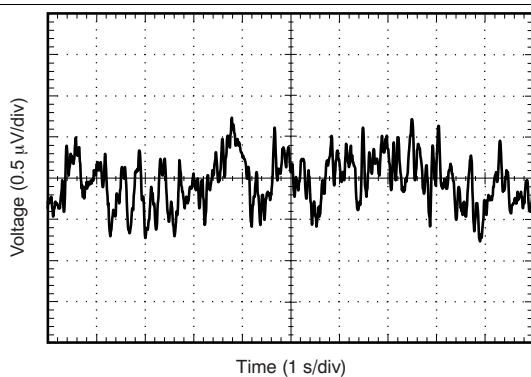


Figure 11. 0.1-Hz to 10-Hz Input Voltage Noise

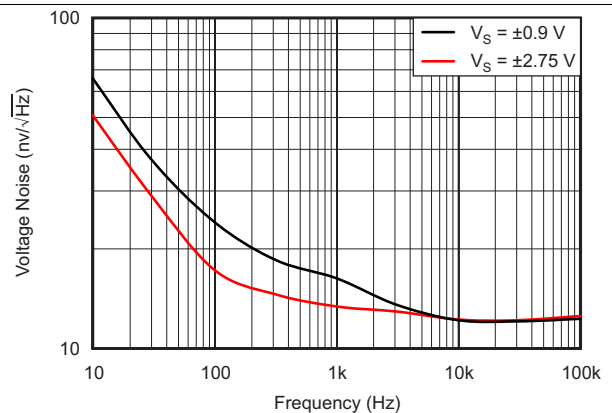


Figure 12. Input Voltage Noise Spectral Density vs Frequency

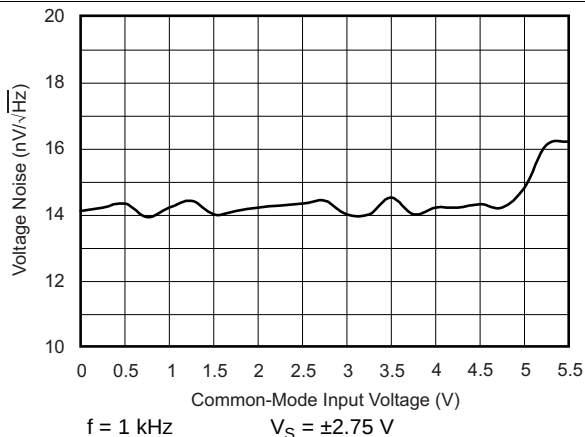


Figure 13. Voltage Noise vs Common-Mode Voltage

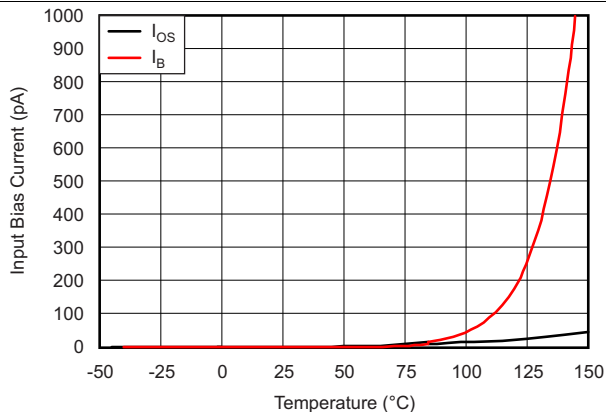


Figure 14. Input Bias and Offset Current vs Temperature

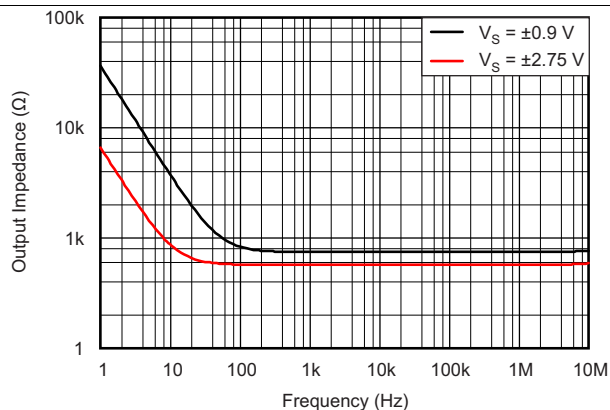


Figure 15. Open-Loop Output Impedance vs Frequency

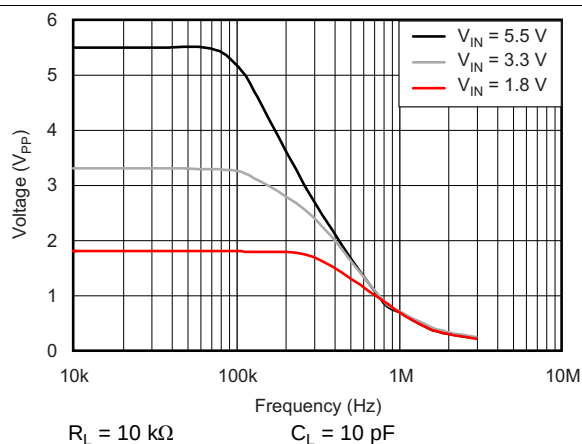


Figure 16. Maximum Output Voltage vs Frequency and Supply Voltage

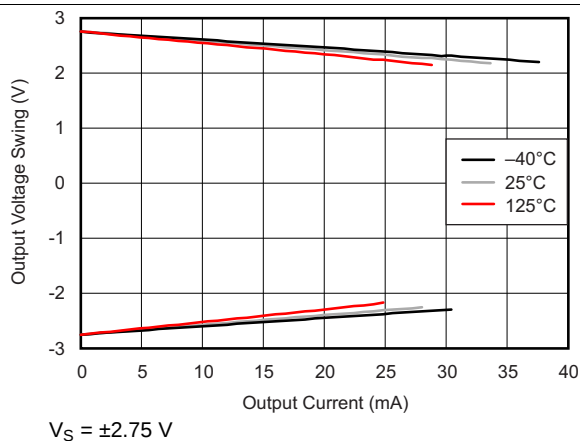


Figure 17. Output Voltage Swing vs Output Current (Overtemperature)

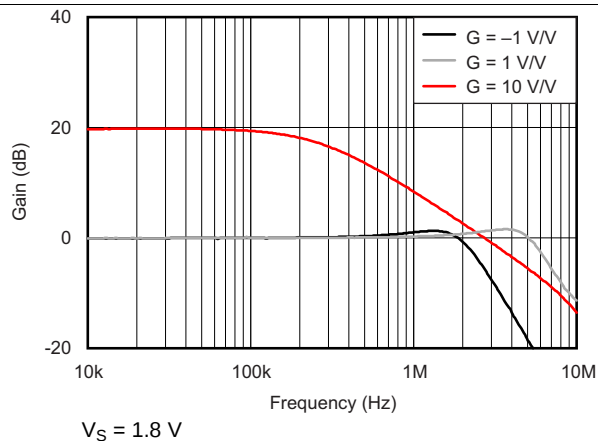


Figure 18. Closed-Loop Gain vs Frequency

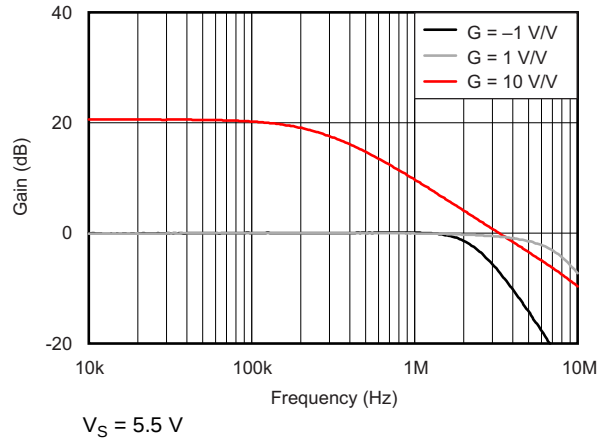


Figure 19. Closed-Loop Gain vs Frequency

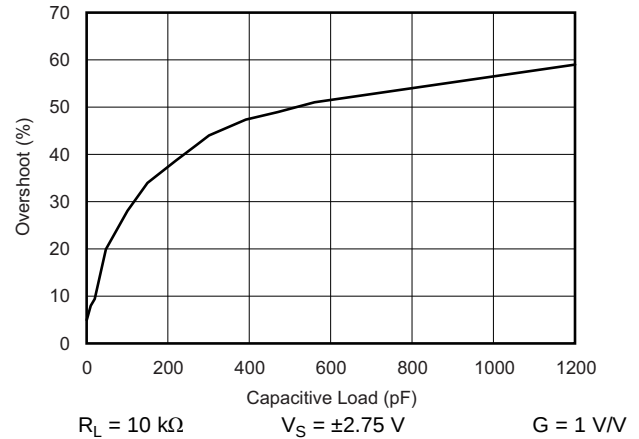


Figure 20. Small-Signal Overshoot vs Load Capacitance

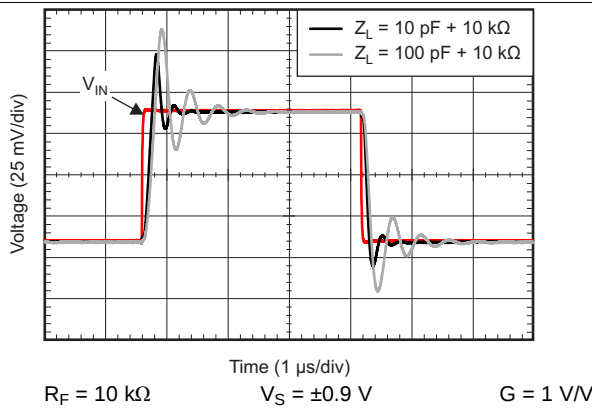


Figure 21. Small-Signal Pulse Response (Noninverting)

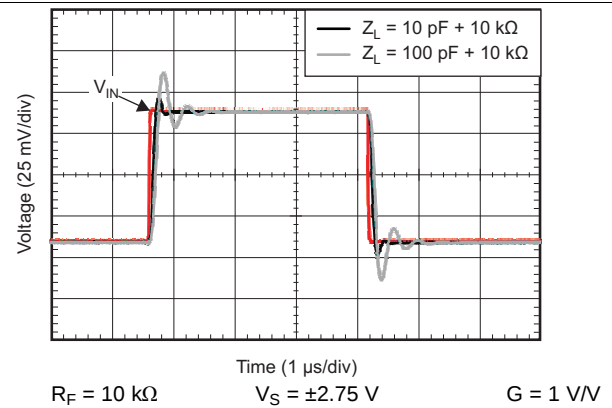


Figure 22. Small-Signal Pulse Response (Inverting)

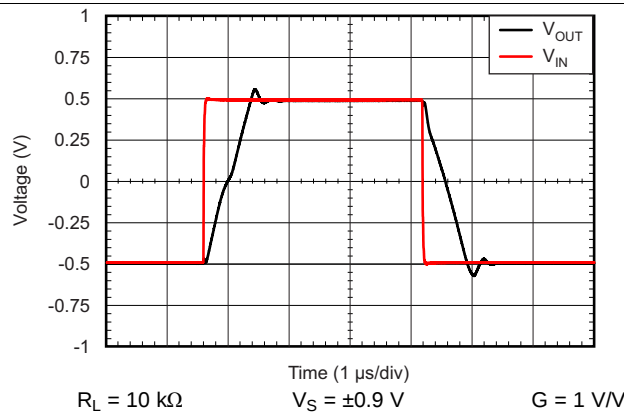


Figure 23. Large-Signal Pulse Response (Noninverting)

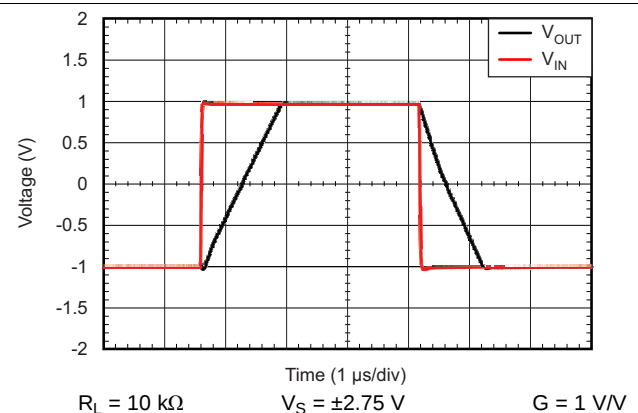
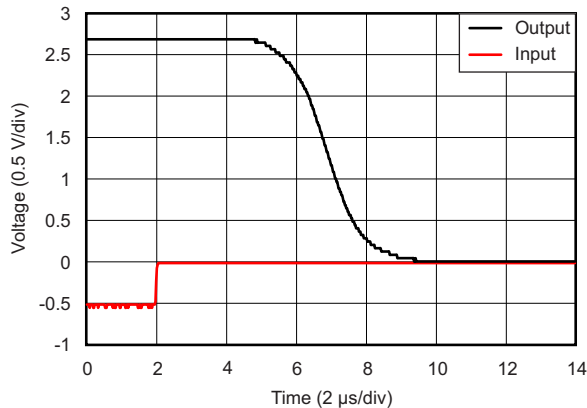
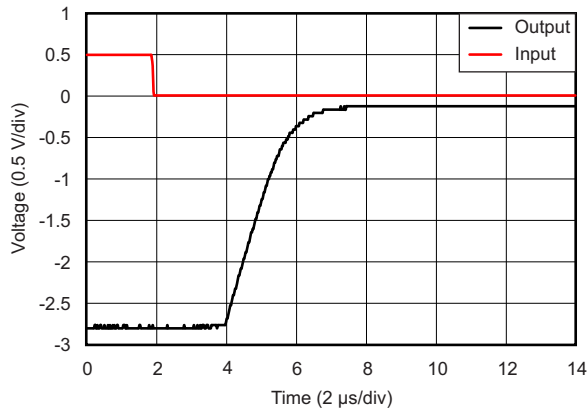


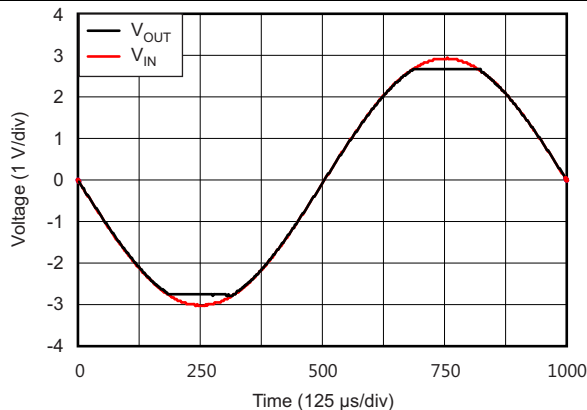
Figure 24. Large-Signal Pulse Response (Inverting)



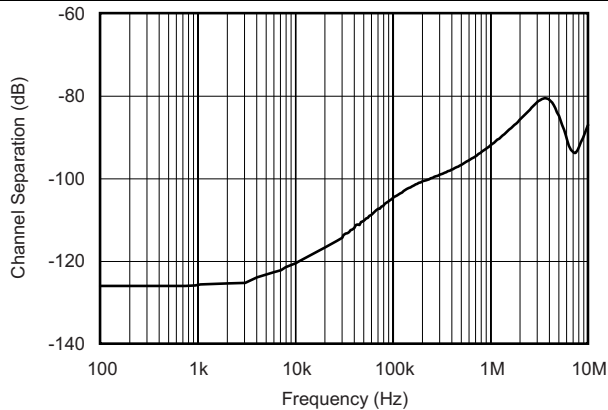
**Figure 25. Positive Overload Recovery**



**Figure 26. Negative Overload Recovery**

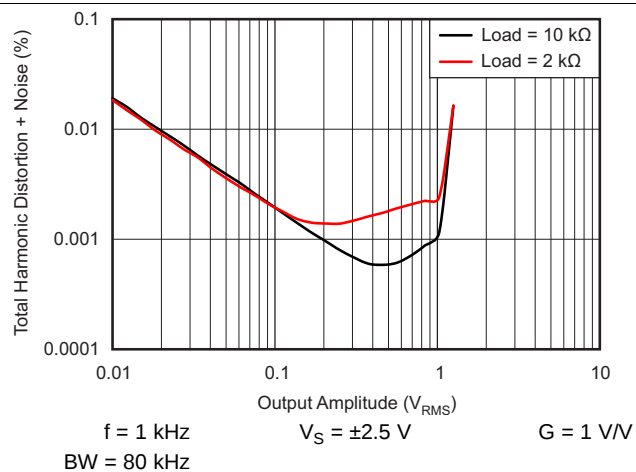


**Figure 27. No Phase Reversal**

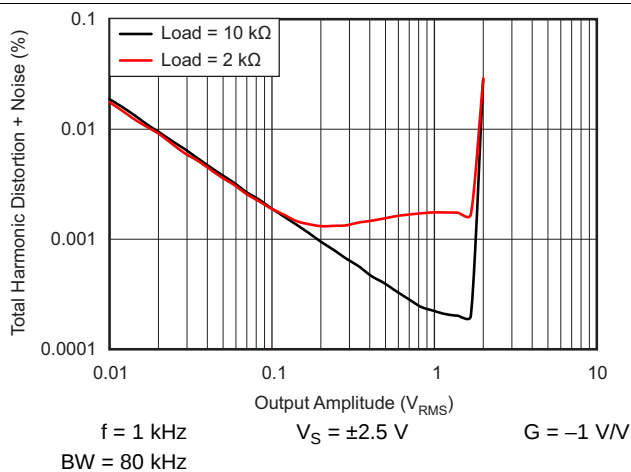


$V_S = \pm 2.75 \text{ V}$

**Figure 28. Channel Separation vs Frequency**



**Figure 29. THD+N vs Output Amplitude (G = 1 V/V)**

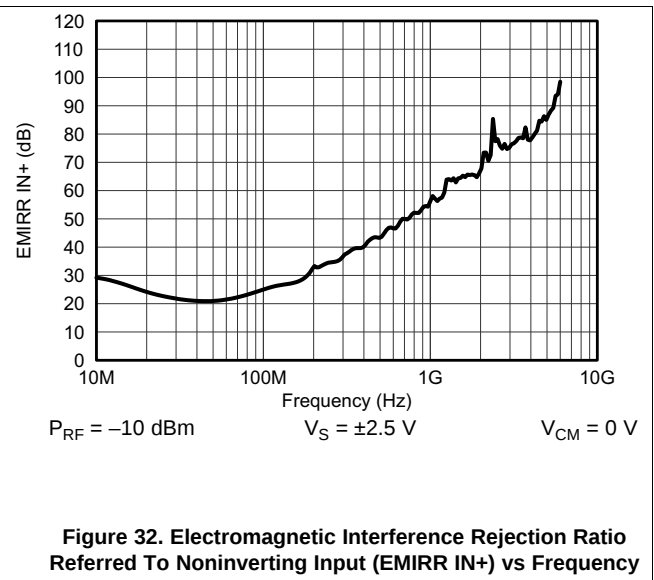
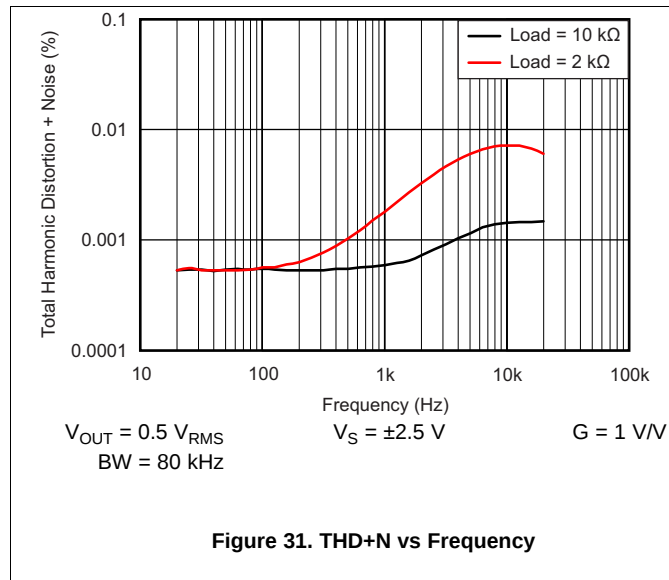


**Figure 30. THD+N vs Output Amplitude (G = -1 V/V)**

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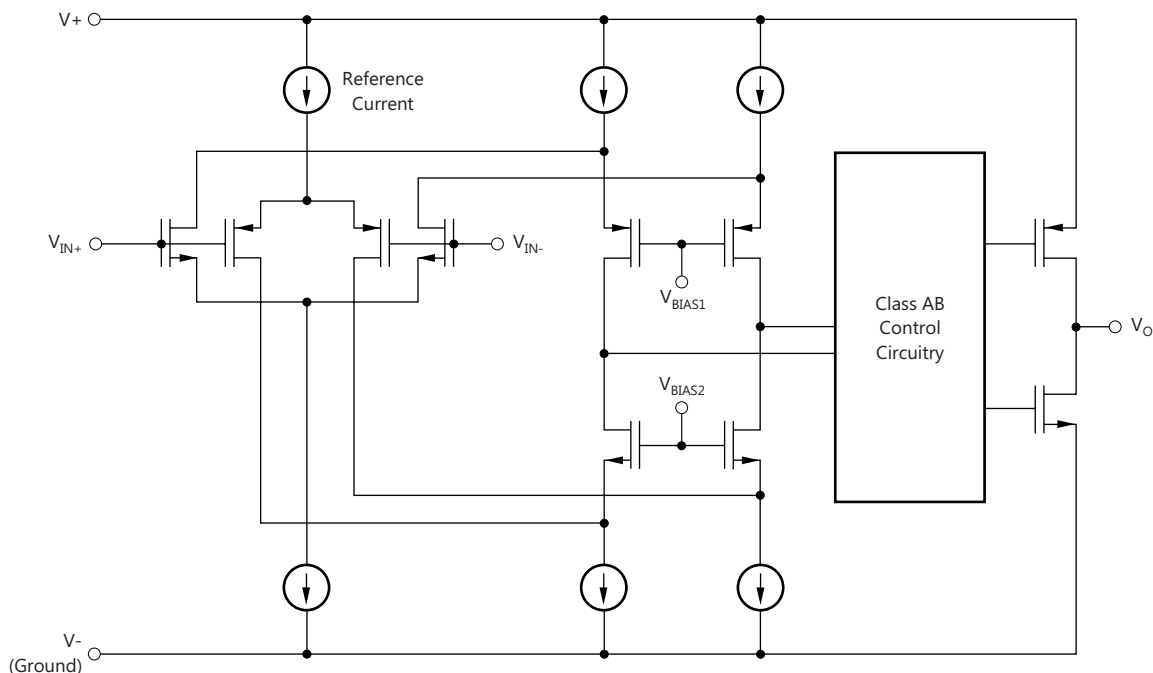


## 7 Detailed Description

### 7.1 Overview

The OPAx314-Q1 is a family of low-power, rail-to-rail input and output operational amplifiers. These devices operate from 1.8 V to 5.5 V, are unity-gain stable, and are suitable for a wide range of general-purpose applications. The class AB output stage is capable of driving  $\leq 10\text{-k}\Omega$  loads connected to any point between  $V^+$  and ground. The input common-mode voltage range includes both rails and allows the OPAx314-Q1 series to be used in virtually any single-supply application. Rail-to-rail input and output swing significantly increases dynamic range, especially in low-supply applications, and makes them ideal for driving sampling analog-to-digital converters (ADCs).

### 7.2 Functional Block Diagram



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### 7.3 Feature Description

#### 7.3.1 Operating Voltage

The OPAx314-Q1 op-amp family is fully specified and ensured for operation from 1.8 V to 5.5 V. In addition, many specifications apply from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ . Parameters that vary significantly with operating voltages or temperature are shown in the [Typical Characteristics](#) section. Power-supply pins must be bypassed with 0.01- $\mu\text{F}$  ceramic capacitors.

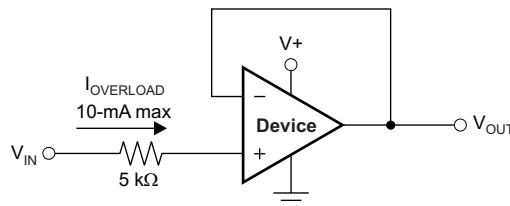
#### 7.3.2 Rail-to-Rail Input

The input common-mode voltage range of the OPAx314-Q1 family extends 200 mV beyond the supply rails. This performance is achieved with a complementary input stage: an N-channel input differential pair in parallel with a P-channel differential pair. The N-channel pair is active for input voltages close to the positive rail, typically  $(V^+) - 1.3\text{ V}$  to 200 mV above the positive supply. The P-channel pair is on for inputs from 200 mV below the negative supply to approximately  $(V^+) - 1.3\text{ V}$ . A small transition region exists, typically  $(V^+) - 1.4\text{ V}$  to  $(V^+) - 1.2\text{ V}$ , in which both pairs are on. This 200-mV transition region can vary up to 300 mV with process variation. Thus, the transition region (both stages on) can range from  $(V^+) - 1.7\text{ V}$  to  $(V^+) - 1.5\text{ V}$  on the low end, up to  $(V^+) - 1.1\text{ V}$  to  $(V^+) - 0.9\text{ V}$  on the high end. Within this transition region, PSRR, CMRR, offset voltage, offset drift, and THD may be degraded compared to device operation outside this region.

## Feature Description (continued)

### 7.3.3 Input and ESD Protection

The OPAx314-Q1 family incorporates internal electrostatic discharge (ESD) protection circuits on all pins. In the case of input and output pins, this protection primarily consists of current-steering diodes connected between the input and power-supply pins. These ESD protection diodes also provide in-circuit, input overdrive protection, as long as the current is limited to 10 mA as stated in the [Absolute Maximum Ratings](#) table. [Figure 33](#) shows how a series input resistor can be added to the driven input to limit the input current. The added resistor contributes thermal noise at the amplifier input and the value must be kept to a minimum in noise-sensitive applications.



**Figure 33. Input Current Protection**

### 7.3.4 Common-Mode Rejection Ratio (CMRR)

CMRR for the OPAx314-Q1 family is specified in several ways so the best match for a given application may be used; see the [Electrical Characteristics](#) table. First, the CMRR of the device in the common-mode range below the transition region [ $V_{CM} < (V+) - 1.3 \text{ V}$ ] is given. This specification is the best indicator of the capability of the device when the application requires use of one of the differential input pairs. Second, the CMRR over the entire common-mode range is specified at ( $V_{CM} = -0.2 \text{ V}$  to  $5.7 \text{ V}$ ). This last value includes the variations seen through the transition region, as shown in [Figure 7](#).

### 7.3.5 EMI Susceptibility and Input Filtering

Op amps vary with regard to the susceptibility of the device to electromagnetic interference (EMI). If conducted EMI enters the op-amp, the dc offset observed at the amplifier output may shift from the nominal value while EMI is present. This shift is a result of signal rectification associated with the internal semiconductor junctions. While all op-amp pin functions can be affected by EMI, the signal input pins are likely to be the most susceptible. The OPAx314-Q1 family incorporates an internal input low-pass filter that reduces the amplifiers response to EMI. Both common-mode and differential mode filtering are provided by this filter. The filter is designed for a cutoff frequency of approximately 80 MHz (–3 dB), with a roll-off of 20 dB per decade.

Texas Instruments has developed the ability to accurately measure and quantify the immunity of an operational amplifier over a broad frequency spectrum extending from 10 MHz to 6 GHz. The EMI rejection ratio (EMIRR) metric allows op amps to be directly compared by the EMI immunity. [Figure 32](#) shows the results of this testing on the OPAx314-Q1 family. Detailed information can also be found in the [EMI Rejection Ratio of Operational Amplifiers](#) application report, available for download from [www.ti.com](http://www.ti.com).

### 7.3.6 Rail-to-Rail Output

Designed as a micro-power, low-noise operational amplifier, the OPAx314-Q1 family delivers a robust output drive capability. A class AB output stage with common-source transistors is used to achieve full rail-to-rail output swing capability. For resistive loads up to 10 kΩ, the output swings typically to within 5 mV of either supply rail regardless of the power-supply voltage applied. Different load conditions change the ability of the amplifier to swing close to the rails; see [Figure 17](#).

## 7.4 Device Functional Modes

The OPAx314-Q1 family is powered on when the supply is connected. The device can operate as a single-supply operational amplifier or a dual-supply amplifier, depending on the application.

## 8 Application and Implementation

### NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

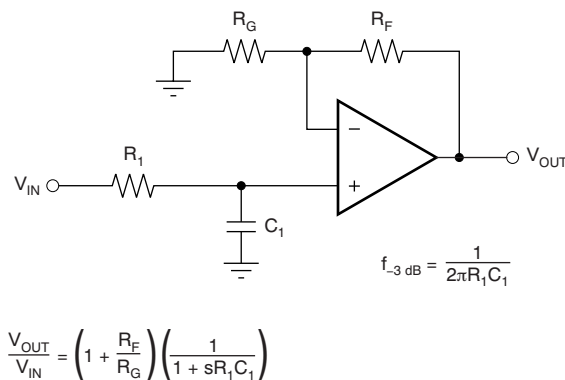
### 8.1 Application Information

The OPAx314-Q1 family is a low-power, rail-to-rail input and output operational amplifier specifically designed for portable applications. The device operates from 1.8 V to 5.5 V, is unity-gain stable, and suitable for a wide range of general-purpose applications. The class AB output stage is capable of driving  $\leq 10\text{-k}\Omega$  loads connected to any point between V+ and ground. The input common-mode voltage range includes both rails, and allows the OPAx314-Q1 family to be used in virtually any single-supply application. Rail-to-rail input and output swing significantly increases dynamic range, especially in low-supply applications, and makes the device ideal for driving sampling analog-to-digital converters (ADCs).

The OPAx314-Q1 family features a 3-MHz bandwidth and 1.5-V/ $\mu\text{s}$  slew rate with only 150- $\mu\text{A}$  supply current per channel, providing good AC performance at very low power consumption. DC applications are also well served with a very-low input noise voltage of 14 nV/ $\sqrt{\text{Hz}}$  at 1 kHz, low-input bias current (0.2 pA), and an input offset voltage of 0.5 mV (typical).

#### 8.1.1 General Configurations

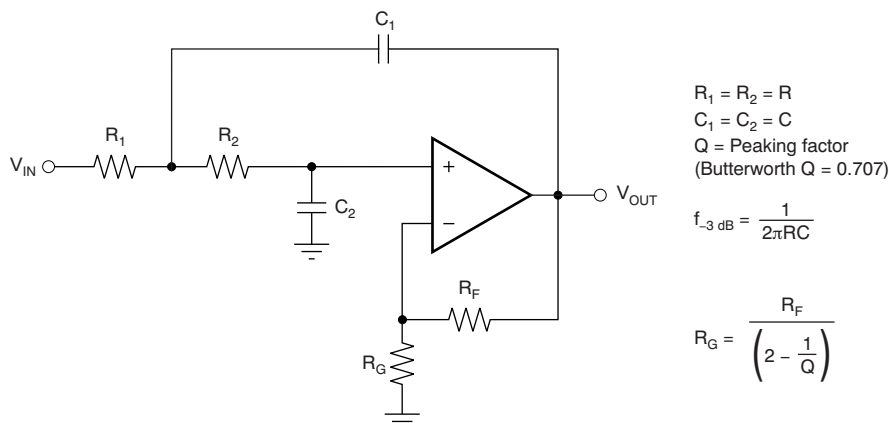
When receiving low-level signals, limiting the bandwidth of the incoming signals into the system is often required. The simplest way to establish this limited bandwidth is to place an RC filter at the noninverting terminal of the amplifier, as shown in Figure 34.



**Figure 34. Single-Pole Low-Pass Filter**

If additional attenuation is needed, a multiple pole filter is required. The Sallen-Key filter can be used for this task, as shown in Figure 35. For best results, the amplifier must have a bandwidth that is eight to ten times the filter frequency bandwidth. Failure to follow this guideline can result in phase shift of the amplifier.

## Application Information (continued)

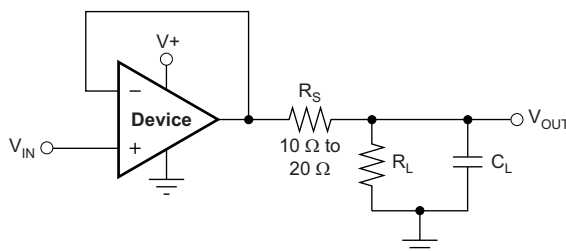


**Figure 35. Two-Pole Low-Pass Sallen-Key Filter**

### 8.1.2 Capacitive Load and Stability

The OPAx314-Q1 family is designed to be used in applications where driving a capacitive load is required. As with all op amps, specific instances can occur where the OPAx314-Q1 can become unstable. The particular op-amp circuit configuration, layout, gain, and output loading are some of the factors to consider when establishing whether or not an amplifier is stable in operation. An op-amp in the unity-gain (1 V/V) buffer configuration that drives a capacitive load exhibits a greater tendency to be unstable than an amplifier operated at a higher noise gain. The capacitive load, in conjunction with the op-amp output resistance, creates a pole within the feedback loop that degrades the phase margin. The degradation of the phase margin increases as the capacitive loading increases. When operating in the unity-gain configuration, the OPAx314-Q1 remains stable with a pure capacitive load up to approximately 1 nF. The equivalent series resistance (ESR) of some very large capacitors ( $C_L$  greater than 1  $\mu$ F) is sufficient to alter the phase characteristics in the feedback loop such that the amplifier remains stable. Increasing the amplifier closed-loop gain allows the amplifier to drive increasingly larger capacitance. This increased capability is evident when observing the overshoot response of the amplifier at higher voltage gains; see , [Figure 20](#).

One technique for increasing the capacitive load drive capability of the amplifier operating in a unity-gain configuration is to insert a small resistor, typically 10  $\Omega$  to 20  $\Omega$ , in series with the output, as shown in [Figure 36](#). This resistor significantly reduces the overshoot and ringing associated with large capacitive loads. One possible problem with this technique, however, is that a voltage divider is created with the added series resistor and any resistor connected in parallel with the capacitive load. The voltage divider introduces a gain error at the output that reduces the output swing.



**Figure 36. Improving Capacitive Load Drive**

## 8.2 Typical Application

Some applications require differential signals. [Figure 37](#) shows a simple circuit to convert a single-ended input of 0.1 V to 2.4 V into a differential output of  $\pm 2.3$  V on a single 2.7-V supply. The output range is intentionally limited to maximize linearity. The circuit is composed of two amplifiers. One amplifier functions as a buffer and creates a voltage ( $V_{OUT+}$ ). The second amplifier inverts the input and adds a reference voltage to generate  $V_{OUT-}$ . Both  $V_{OUT+}$  and  $V_{OUT-}$  range from 0.1 V to 2.4 V. The difference ( $V_{DIFF}$ ) is the difference between  $V_{OUT+}$  and  $V_{OUT-}$ . This makes the differential output voltage range 2.3 V.

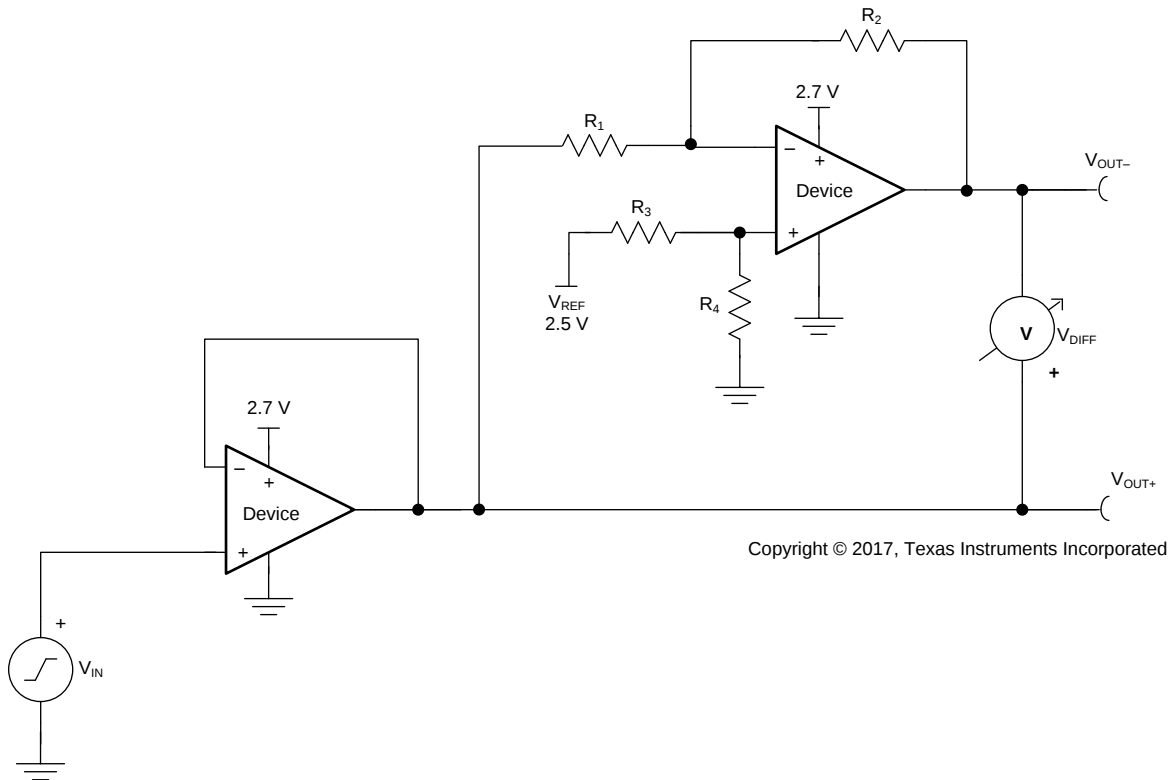


Figure 37. Schematic for a Single-Ended Input to Differential Output Conversion

### 8.2.1 Design Requirements

The design requirements are as follows:

- Supply voltage: 2.7 V
- Reference voltage: 2.5 V
- Input: 0.1 V to 2.4 V
- Output differential:  $\pm 2.3$  V
- Output common-mode voltage: 1.25 V
- Small-signal bandwidth: 1 MHz

### 8.2.2 Detailed Design Procedure

The circuit in [Figure 37](#) takes a single-ended input signal,  $V_{IN}$ , and generates two output signals,  $V_{OUT+}$  and  $V_{OUT-}$  using two amplifiers and a reference voltage,  $V_{REF}$ .  $V_{OUT+}$  is the output of the first amplifier and is a buffered version of the input signal,  $V_{IN}$  (as shown in [Equation 1](#)).  $V_{OUT-}$  is the output of the second amplifier which uses  $V_{REF}$  to add an offset voltage to  $V_{IN}$  and feedback to add inverting gain. The transfer function for  $V_{OUT-}$  is given in [Equation 2](#).

$$V_{OUT+} = V_{IN} \quad (1)$$

$$V_{OUT-} = V_{REF} \times \left( \frac{R_4}{R_3 + R_4} \right) \times \left( 1 + \frac{R_2}{R_1} \right) - V_{IN} \times \frac{R_2}{R_1} \quad (2)$$

## Typical Application (continued)

The differential output signal ( $V_{DIFF}$ ) is the difference between the two single-ended output signals ( $V_{OUT+}$  and  $V_{OUT-}$ ). Equation 3 shows the transfer function for  $V_{DIFF}$ . By applying the conditions that  $R_1 = R_2$  and  $R_3 = R_4$ , the transfer function is simplified into Equation 6. Using this configuration, the maximum input signal is equal to the reference voltage and the maximum output of each amplifier is equal to  $V_{REF}$ . The differential output range is  $2 \times V_{REF}$ . Furthermore, the common-mode voltage is one half of  $V_{REF}$  (see Equation 7).

$$V_{DIFF} = V_{OUT+} - V_{OUT-} = V_{IN} \times \left(1 + \frac{R_2}{R_1}\right) - V_{REF} \times \left(\frac{R_4}{R_3 + R_4}\right) \times \left(1 + \frac{R_2}{R_1}\right) \quad (3)$$

$$V_{OUT+} = V_{IN} \quad (4)$$

$$V_{OUT-} = V_{REF} - V_{IN} \quad (5)$$

$$V_{DIFF} = 2 \times V_{IN} - V_{REF} \quad (6)$$

$$V_{CM} = \left(\frac{V_{OUT+} + V_{OUT-}}{2}\right) = \frac{1}{2} V_{REF} \quad (7)$$

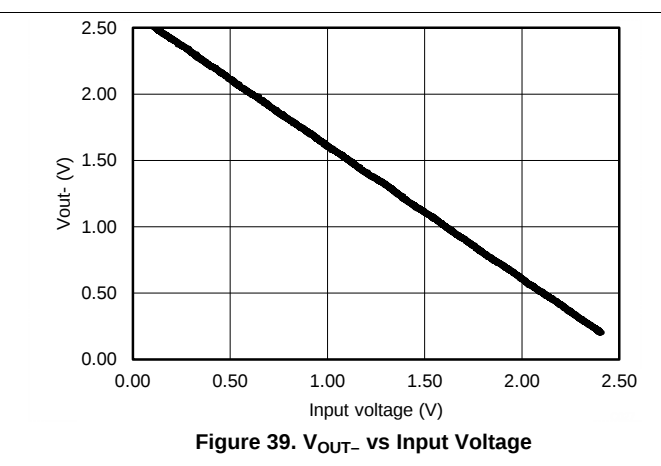
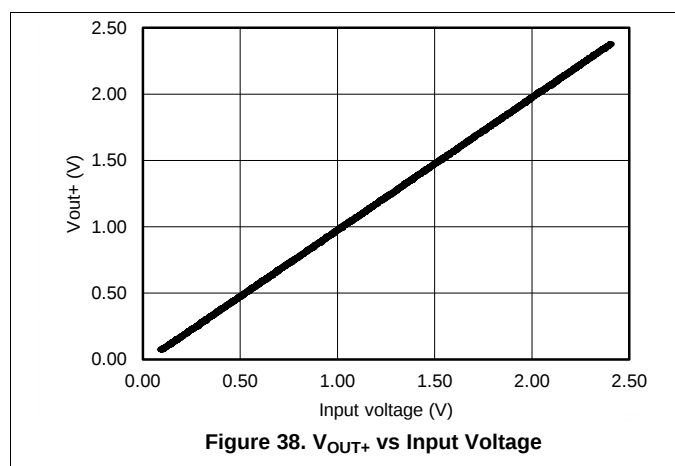
### 8.2.2.1 Amplifier Selection

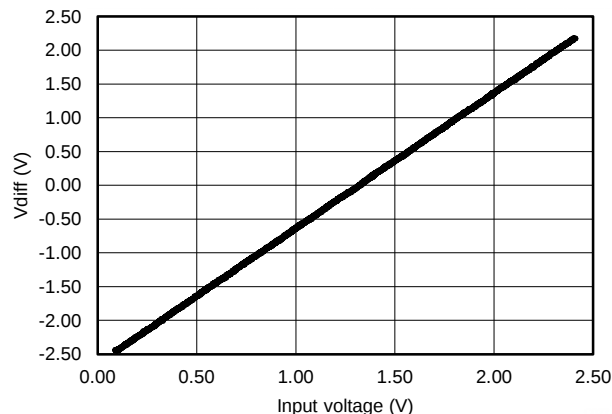
Linearity over the input range is key for good dc accuracy. The common-mode input range and output swing limitations determine the linearity. In general, an amplifier with rail-to-rail input and output swing is required. Bandwidth is a key concern for this design, so the OPAx314-Q1 family is selected because the bandwidth is greater than the target of 1 MHz. The bandwidth and power ratio makes this device power efficient and the low offset and drift ensure good accuracy for moderate precision applications.

### 8.2.2.2 Passive Component Selection

Because the transfer function of  $V_{OUT-}$  is heavily reliant on resistors ( $R_1$ ,  $R_2$ ,  $R_3$ , and  $R_4$ ), use resistors with low tolerances to maximize performance and minimize error. This design uses resistors with resistance values of 49.9 k $\Omega$  and tolerances of 0.1%. However, if the noise of the system is a key parameter, smaller resistance values (6 k $\Omega$  or lower) can be selected to keep the overall system noise low. This ensures that the noise from the resistors is lower than the amplifier noise.

### 8.2.3 Application Curves





**Figure 40.  $V_{DIFF}$  vs Input Voltage**

## 9 Power Supply Recommendations

The OPAx314-Q1 family is specified for operation from 1.8 V to 5.5 V ( $\pm 0.9$  V to  $\pm 2.75$  V); many specifications apply from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ . The [Typical Characteristics](#) section presents parameters that can exhibit significant variance with regard to operating voltage or temperature.

### CAUTION

Supply voltages larger than 7 V can permanently damage the device (see the [Absolute Maximum Ratings](#) table).

Place 0.1- $\mu\text{F}$  bypass capacitors close to the power-supply pins to reduce errors coupling in from noisy or high-impedance power supplies. For more detailed information on bypass capacitor placement, see the [Layout Guidelines](#) section.

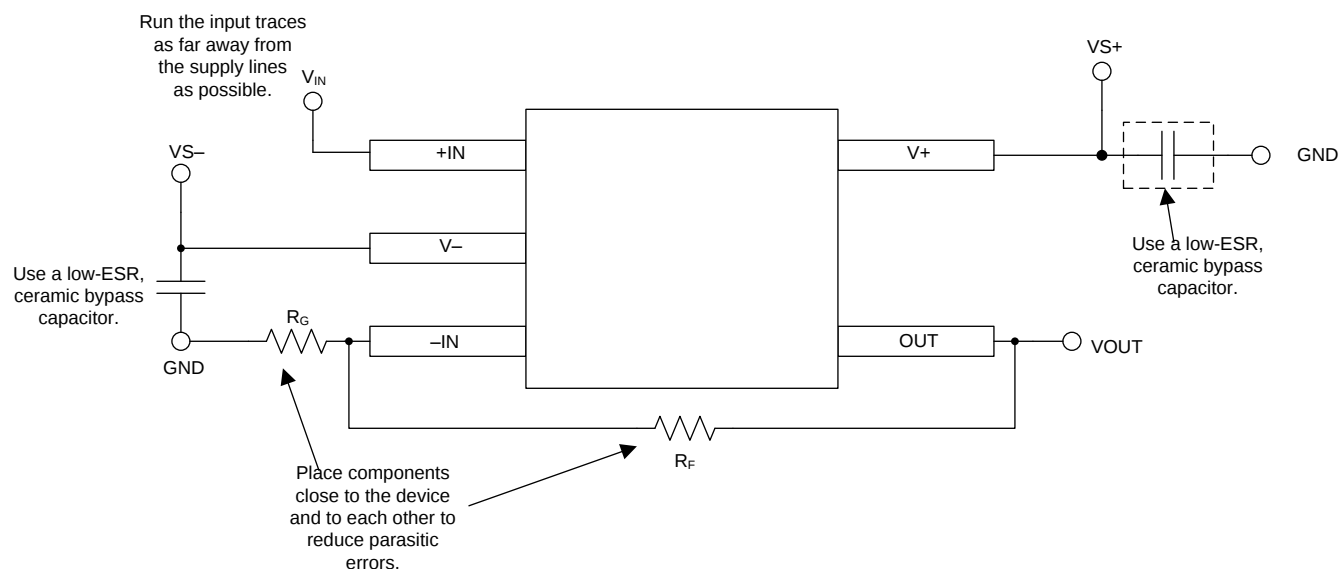
## 10 Layout

### 10.1 Layout Guidelines

For best operational performance of the device, use good PCB layout practices, including:

- Noise can propagate into analog circuitry through the power pins of the circuit as a whole and the operational amplifier. Bypass capacitors are used to reduce the coupled noise by providing low-impedance power sources local to the analog circuitry.
  - Connect low-ESR, 0.1- $\mu$ F ceramic bypass capacitors between each supply pin and ground, placed as close to the device as possible. A single bypass capacitor from V+ to ground is applicable for single-supply applications.
- Separate grounding for analog and digital portions of the circuitry is one of the simplest and most effective methods of noise suppression. One or more layers on multilayer PCBs are usually devoted to ground planes. A ground plane helps distribute heat and reduces EMI noise pickup. Make sure to physically separate digital and analog grounds, paying attention to the flow of the ground current.
- To reduce parasitic coupling, run the input traces as far away from the supply or output traces as possible. If these traces cannot be kept separate, crossing the sensitive trace perpendicularly is much better than crossing in parallel with the noisy trace.
- Place the external components as close to the device as possible. Keeping  $R_F$  and  $R_G$  close to the inverting input minimizes parasitic capacitance, as shown in Figure 41.
- Keep the length of input traces as short as possible. Always remember that the input traces are the most sensitive part of the circuit.
- Consider a driven, low-impedance guard ring around the critical traces. A guard ring can significantly reduce leakage currents from nearby traces that are at different potentials.

### 10.2 Layout Example



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**Figure 41. Operational Amplifier Board Layout for Noninverting Configuration**

## 11 Device and Documentation Support

### 11.1 Documentation Support

#### 11.1.1 Related Documentation

For related documentation see the following:

- [EMI Rejection Ratio of Operational Amplifiers](#)

#### 11.1.2 Related Links

[Table 2](#) lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

**Table 2. Related Links**

| PARTS      | PRODUCT FOLDER             | ORDER NOW                  | TECHNICAL DOCUMENTS        | TOOLS & SOFTWARE           | SUPPORT & COMMUNITY        |
|------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| OPA314-Q1  | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> |
| OPA2314-Q1 | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> |
| OPA4314-Q1 | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> | <a href="#">Click here</a> |

### 11.2 Trademarks

### 11.3 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

### 11.4 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

## 12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

## PACKAGING INFORMATION

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2) | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| OPA2314AQDRQ1    | ACTIVE        | SOIC         | D                  | 8    | 2500           | RoHS & Green    | NIPDAU                               | Level-3-260C-168 HR  | -40 to 125   | O2314Q                  | <a href="#">Samples</a> |
| OPA314AQDBVRQ1   | ACTIVE        | SOT-23       | DBV                | 5    | 3000           | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 125   | 14ZD                    | <a href="#">Samples</a> |
| OPA314AQDBVTQ1   | ACTIVE        | SOT-23       | DBV                | 5    | 250            | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 125   | 14ZD                    | <a href="#">Samples</a> |
| OPA4314AQPWRQ1   | ACTIVE        | TSSOP        | PW                 | 14   | 2000           | RoHS & Green    | NIPDAU                               | Level-2-260C-1 YEAR  | -40 to 125   | 4314Q1                  | <a href="#">Samples</a> |

<sup>(1)</sup> 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.

**OBSELETE:** TI has discontinued the production of the device.

<sup>(2)</sup> **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

<sup>(3)</sup> MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

<sup>(4)</sup> There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

<sup>(5)</sup> 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.

<sup>(6)</sup> Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**OTHER QUALIFIED VERSIONS OF OPA2314-Q1, OPA314-Q1, OPA4314-Q1 :**

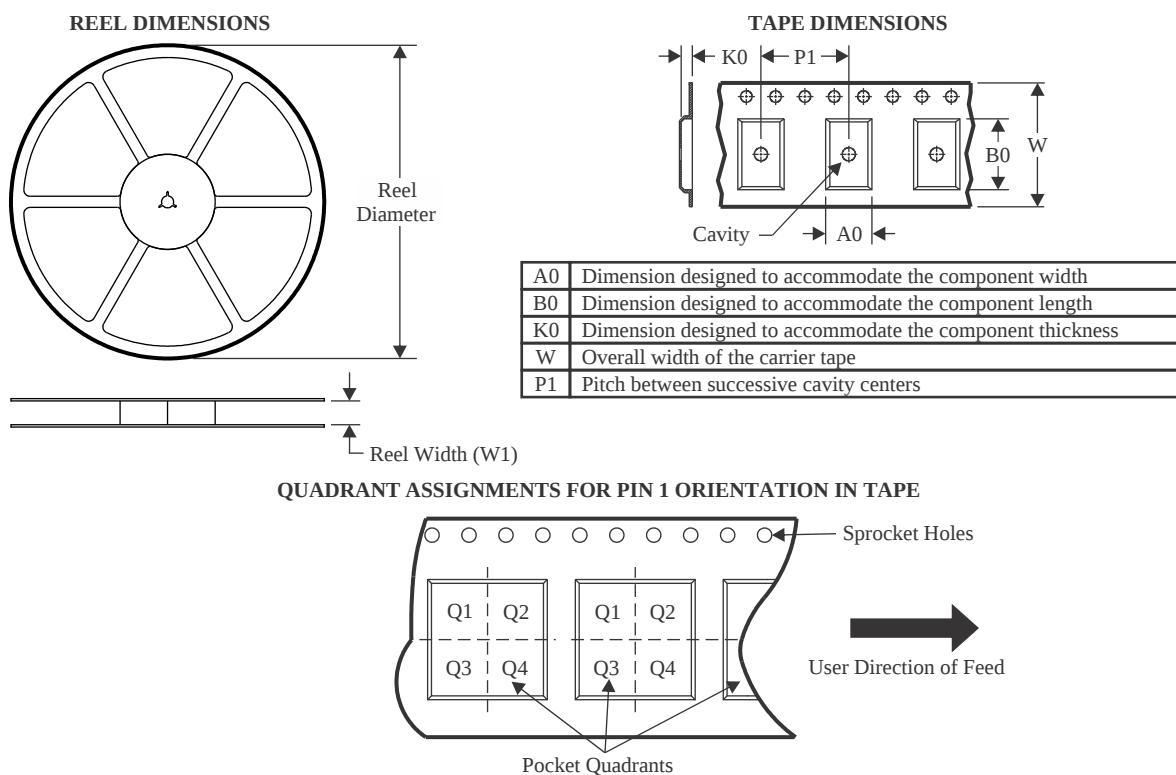
- Catalog: [OPA2314](#), [OPA314](#), [OPA4314](#)

- Enhanced Product: [OPA2314-EP](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

## TAPE AND REEL INFORMATION



\*All dimensions are nominal

| Device         | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| OPA2314AQDRQ1  | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| OPA314AQDBVRQ1 | SOT-23       | DBV             | 5    | 3000 | 178.0              | 9.0                | 3.3     | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| OPA4314AQPWRQ1 | TSSOP        | PW              | 14   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device         | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| OPA2314AQDRQ1  | SOIC         | D               | 8    | 2500 | 356.0       | 356.0      | 35.0        |
| OPA314AQDBVRQ1 | SOT-23       | DBV             | 5    | 3000 | 180.0       | 180.0      | 18.0        |
| OPA4314AQPWRQ1 | TSSOP        | PW              | 14   | 2000 | 356.0       | 356.0      | 35.0        |

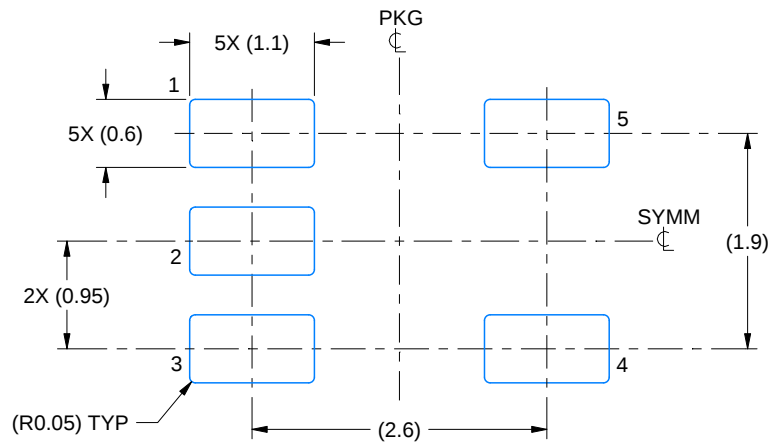


# EXAMPLE BOARD LAYOUT

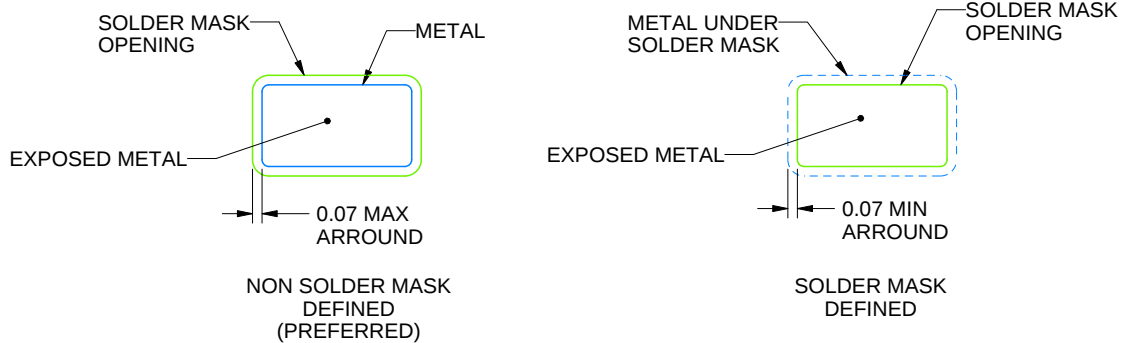
DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:15X



SOLDER MASK DETAILS

4214839/G 03/2023

NOTES: (continued)

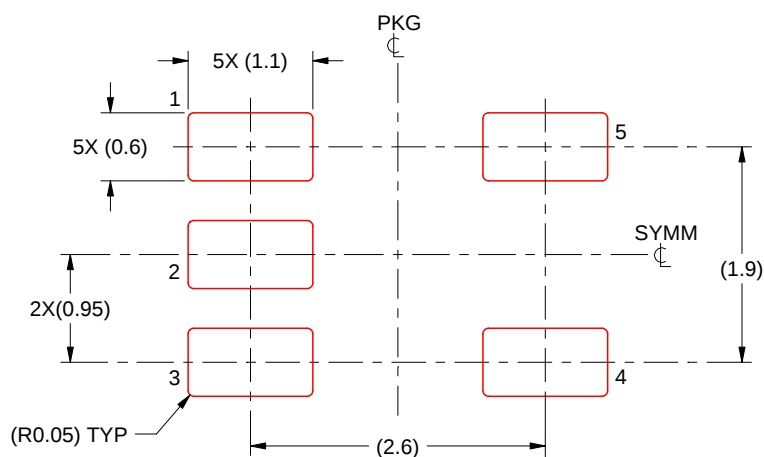
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:15X

4214839/G 03/2023

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



4040064-3/G 02/11

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - 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.



## PACKAGE OUTLINE

**SOIC - 1.75 mm max height**

SMALL OUTLINE INTEGRATED CIRCUIT



1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.

**D0008A**

**SOIC - 1.75 mm max height**

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:8X



## SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE  
BASED ON .005 INCH [0.125 MM] THICK STENCIL  
SCALE:8X

4214825/C 02/2019

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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