

WS72324

Low-Power Rail-to-Rail Input Output Operational Amplifiers

[Http://www.omnivision-group.com](http://www.omnivision-group.com)

Descriptions

The WS72324 series is a quad low-voltage operational amplifier with rail-to-rail input/output swing. Ultra low quiescent current makes this amplifier ideal for portable, battery operated equipment. The common mode input range includes ground making the device useful for low-side current-shunt measurements.

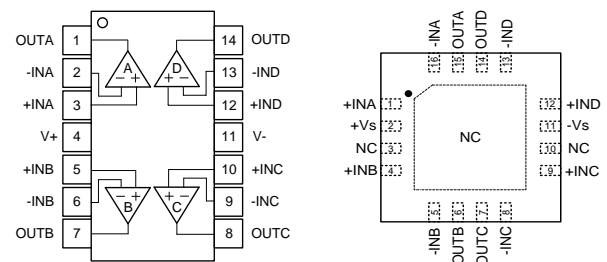
The WS72324 is available with MSL 3 Level in SOP-14L, TSSOP-14L and QFN3x3-16L package. Standard products are Pb-Free and halogen-Free.

Applications

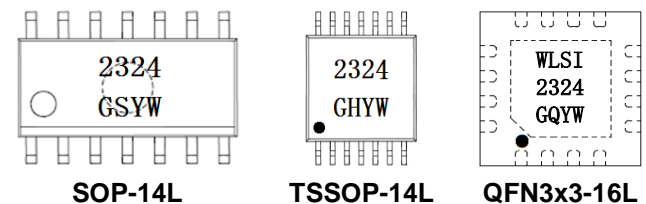
- Active Filters
- Smoke/Gas Sensors
- Battery Powered Electronic Equipments
- Personal Medical Care

Features

- Single Supply Voltage : 1.8~5.5V
- Quiescent Current : 42 μ A Typical
- GBWP : 1.5MHz
- Slew Rate : 1.1V/ μ s
- Offset Voltage : 3mV Maximum
- Offset Voltage Temp. Drift : 1 μ V / $^{\circ}$ C
- THD+N : -102dB@1kHz,
-90dB@10kHz
- CMRR/PSRR : 101dB/105dB
- Output Short-Circuit Curr. : 43mA
- -40 $^{\circ}$ C to 125 $^{\circ}$ C Operation Range
- Drives 2k Ω Resistive Loads
- No Output Crossover Distortion
- No Phase Reversal from Overdriven Input
- Rail-to-Rail Input/Output Swing



SOP-14L/TSSOP-14L QFN3x3-16L
Pin configuration (Top view)



Marking

- 2324 = Device code
 GS = Special code
 GH = Special code
 GQ = Special code
 Y = Year code
 W = Week code

Order Information

| Device | Package | Shipping |
|----------------|------------|-----------------|
| WS72324S-14/TR | SOP-14L | 4000/Reel &Tape |
| WS72324H-14/TR | TSSOP-14L | 4000/Reel &Tape |
| WS72324Q-16/TR | QFN3x3-16L | 3000/Reel &Tape |

Pin Descriptions (WS72324S-14/TR & WS72324H-14/TR)

| Pin Number | Symbol | Descriptions |
|------------|--------|------------------------------------|
| 1 | OUTA | Output of Amplifier A |
| 2 | -INA | Inverting input of Amplifier A |
| 3 | +INA | Non-inverting input of Amplifier A |
| 4 | V+ | Positive supply |
| 5 | +INB | Non-inverting input of Amplifier B |
| 6 | -INB | Inverting input of Amplifier B |
| 7 | OUTB | Output of Amplifier B |
| 8 | OUTC | Output of Amplifier C |
| 9 | -INC | Inverting input of Amplifier C |
| 10 | +INC | Non-inverting input of Amplifier C |
| 11 | V- | Negative supply |
| 12 | +IND | Non-inverting input of Amplifier D |
| 13 | -IND | Inverting input of Amplifier D |
| 14 | OUTD | Output of Amplifier D |

Pin Descriptions (WS72324Q-16/TR)

| Pin Number | Symbol | Descriptions |
|------------|--------|------------------------------------|
| 1 | +INA | Non-inverting input of Amplifier A |
| 2 | V+ | Positive supply |
| 3, 10 | NC | No connect |
| 4 | +INB | Non-inverting input of Amplifier B |
| 5 | -INB | Inverting input of Amplifier B |
| 6 | OUTB | Output of Amplifier B |
| 7 | OUTC | Output of Amplifier C |
| 8 | -INC | Inverting input of Amplifier C |
| 9 | +INC | Non-inverting input of Amplifier C |
| 11 | V- | Negative supply |
| 12 | +IND | Non-inverting input of Amplifier D |
| 13 | -IND | Inverting input of Amplifier D |
| 14 | OUTD | Output of Amplifier D |

Absolute Maximum Ratings

| Parameter | Symbol | Value | Unit |
|--------------------------------------|-----------------|--|------|
| Supply Voltage, ([V+] – [V-]) | $V_S^{(2)}$ | 6 | V |
| Input Differential Voltage | $V_{IDR}^{(3)}$ | ±6 | V |
| Input Common Mode Voltage Range | V_{ICR} | (V ⁻)-0.2 to (V ⁺)+0.2 | V |
| Output Short-Circuit Duration | t_{SO} | Unlimited | / |
| Operating Free-Air Temperature Range | T_A | -40 to 125 | °C |
| Storage Temperature Range | T_{STG} | -65 to 150 | °C |
| Junction Temperature Range | T_J | 150 | °C |
| Lead Temperature Range | T_L | 260 | °C |

Note:

1. Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are only stress ratings, and functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions are not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
2. All voltage values, except differential voltage are with respect to network terminal.
3. Differential voltages are at +IN with respect to -IN.

ESD, Electrostatic Discharge Protection

| Symbol | Parameter | Condition | Minimum level | Unit |
|--------|--------------------------|--|---------------|------|
| HBM | Human Body Model ESD | MIL-STD-883H Method 3015.8 JEDEC-EIA/JESD22-A114A | ±8000 | V |
| MM | Machine Model ESD | JEDEC-EIA/JESD22-A115 | ±400 | V |
| CDM | Charged Device Model ESD | JEDEC-EIA/JESD22-C101E | ±2000 | V |

Electronics Characteristics

The *denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25^\circ\text{C}$. $V_S = 5\text{V}$, $V_{\text{CM}} = V_{\text{OUT}} = V_S/2$, $R_{\text{load}} = 100\text{k}\Omega$, $C_{\text{load}} = 100\text{pF}$

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit | |
|-----------------------|-------------------------------------|---|------|-------------|-----------|------------------------------|------------------------|
| V_{OS} | Input Offset Voltage | $V_{\text{CM}} = V_S/2$ | * | -3.0 | ± 0.1 | 3.0 | mV |
| α_{VOS} | Input Offset Voltage Drift | | | 1 | | $\mu\text{V}/^\circ\text{C}$ | |
| I_{IB} | Input Bias Current | | | 1 | | pA | |
| I_{OS} | Input Offset Current | | | 1 | | pA | |
| V_n | Input Voltage Noise | $f=0.1\text{Hz to }10\text{Hz}$ | | 4.5 | | $\mu\text{V}_{\text{P-P}}$ | |
| e_n | Input Voltage Noise Density | $f=1\text{kHz}$ | | 30 | | $\text{nV}/\sqrt{\text{Hz}}$ | |
| | | $f=10\text{kHz}$ | | 23 | | | |
| CMRR | Common Mode Rejection Ratio | $V_{\text{CM}}=0.1\text{V to }4.9\text{V}$ | * | 70 | 101 | | dB |
| V_{CM} | Common Mode Input Voltage Range | | * | $(V^-)-0.2$ | | $(V^+)+0.2$ | V |
| PSRR | Power Supply Rejection Ratio | | * | 85 | 105 | | dB |
| A_{VOL} | Open Loop Large Signal Gain | $V_{\text{OUT}}=0.1\text{V to }4.9\text{V}$, $R_{\text{load}}=10\text{k}\Omega$ | * | 100 | 109 | | dB |
| V_{OH} | High Level Output Voltage | $R_{\text{load}}=2\text{k}\Omega$ | | | 50 | | mV |
| | | $R_{\text{load}}=10\text{k}\Omega$ | | | 5 | | |
| V_{OL} | Low Level Output Voltage | $R_{\text{load}}=2\text{k}\Omega$ | | | 40 | | mV |
| | | $R_{\text{load}}=10\text{k}\Omega$ | | | 5 | | |
| I_{SC} | Output Short-Circuit Current | Source Current | | | 43 | | mA |
| | | Sink Current | | | 47 | | |
| I_{Q} | Quiescent Current per Amplifier | | * | | 42 | 62.5 | μA |
| PM | Phase Margin | $R_{\text{load}}=100\text{k}\Omega$, $C_{\text{load}}=100\text{pF}$ | | | 60 | | degrees |
| GM | Gain Margin | $R_{\text{load}}=100\text{k}\Omega$, $C_{\text{load}}=100\text{pF}$ | | | -14 | | dB |
| GBWP | Gain-Bandwidth Product | $f=1\text{kHz}$ | | | 1.5 | | MHz |
| t_s | Settling Time | 1.5 to 3.5V, Unity Gain | | | 0.1% | | μs |
| | | 2.45 to 2.55V, Unity Gain | | | 0.1% | | |
| SR | Slew Rate | $A_V=1$, $V_{\text{OUT}}=1.5\text{V to }3.5\text{V}$, $R_{\text{load}}=100\text{k}\Omega$, $C_{\text{load}}=100\text{pF}$ | | | 1.1 | | $\text{V}/\mu\text{s}$ |
| FPBW | Full Power Bandwidth | $2V_{\text{P-P}}$ | | | 180 | | kHz |
| THD+N | Total Harmonic Distortion and Noise | $f=1\text{kHz}$, $A_V=1$, $R_{\text{load}}=100\text{k}\Omega$, $V_{\text{OUT}}=2V_{\text{PP}}$ | | | -102 | | dB |
| | | $f=10\text{kHz}$, $A_V=1$, $R_{\text{load}}=100\text{k}\Omega$, $V_{\text{OUT}}=2V_{\text{PP}}$ | | | -90 | | |

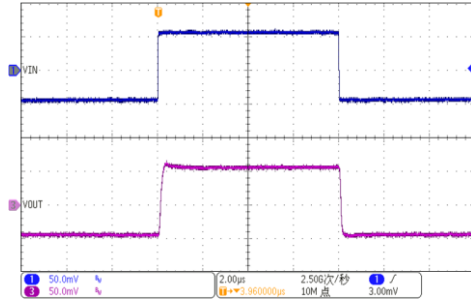
Note:

1. Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.
2. A heat sink may be required to keep the junction temperature below the absolute maximum rating when the output is shorted indefinitely.
3. Thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.
4. Full power bandwidth is calculated from the slew rate $FPBW = SR/(\pi \cdot V_{P-P})$.

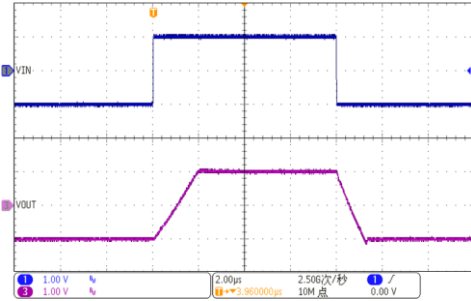
Typical Characteristics

$T_A=25^{\circ}\text{C}$, $V_S=\pm 2.5\text{V}$, $V_{CM}=0\text{V}$, unless otherwise noted

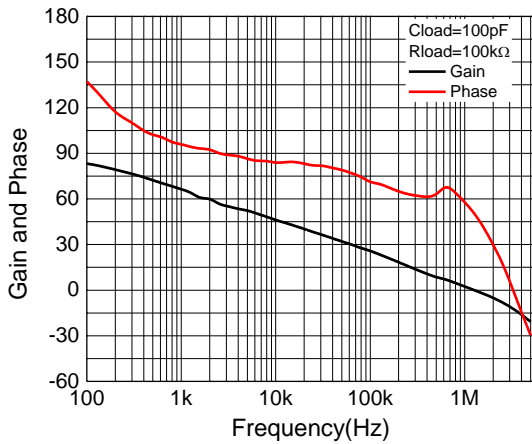
Small-Signal Step Response, 100mV Step



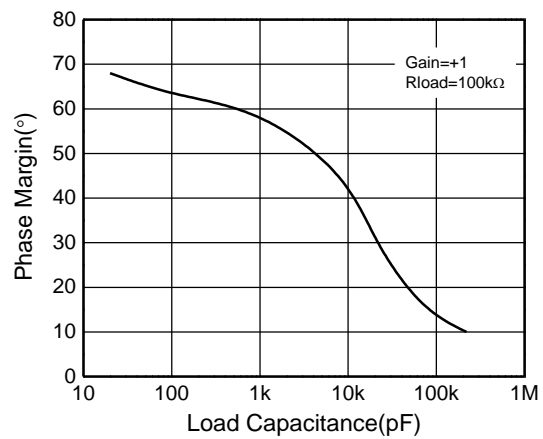
Large-Signal Step Response, 2V Step



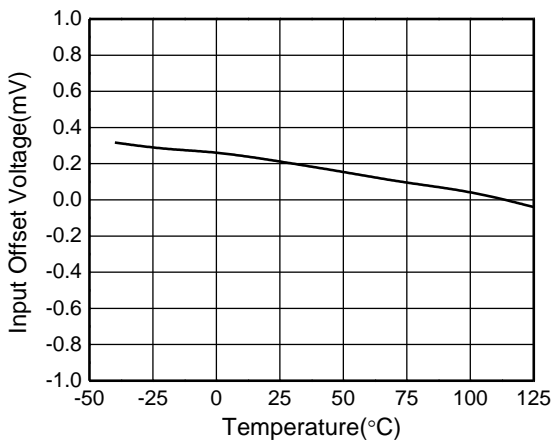
Open-Loop Gain and Phase



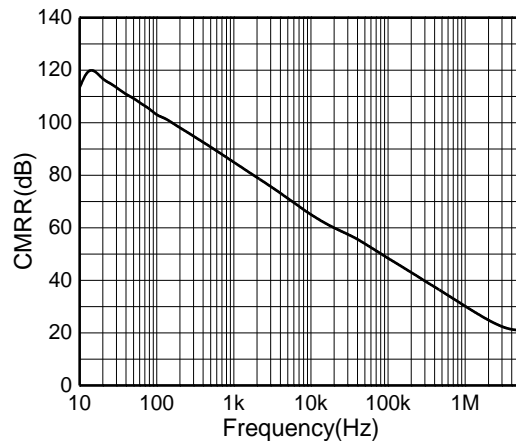
Phase Margin vs. C_{load} (Stable for Any C_{load})



Input Offset Voltage vs. Temperature



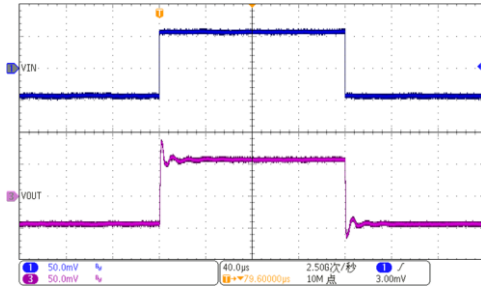
CMRR vs. Frequency



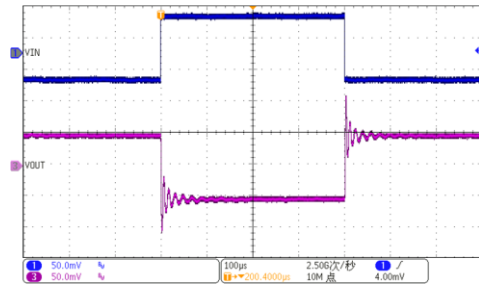
Typical Characteristics (continued)

$T_A=25^\circ\text{C}$, $V_S=\pm 2.5\text{V}$, $V_{CM}=0\text{V}$, unless otherwise noted

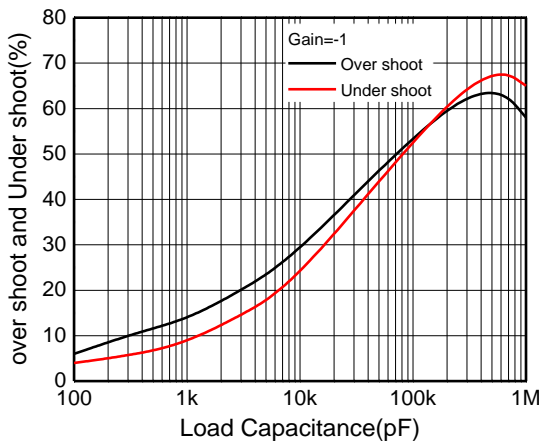
Over Shoot Voltage, $C_{load}=47\text{nF}$,
 $R_{FB}=10\text{k}\Omega$, Gain=+1



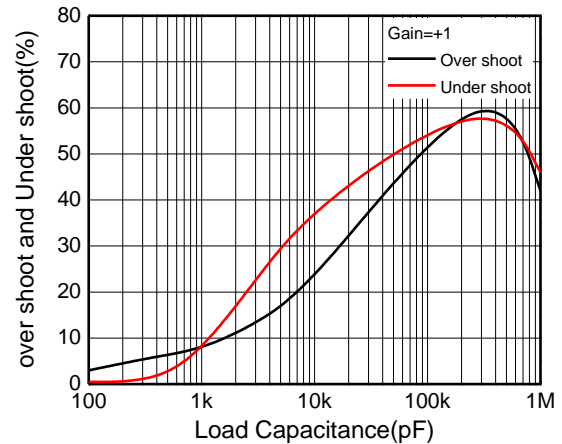
Over Shoot Voltage, $C_{load}=47\text{nF}$,
 $R_{load}=40\text{k}\Omega$, Gain=-1



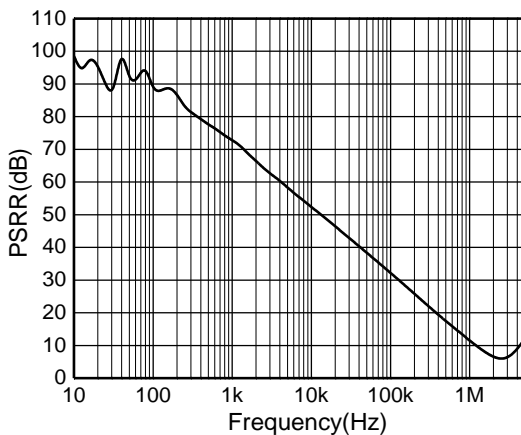
Over-Shoot % vs. C_{load}
Gain=-1, $R_{FB}=20\text{k}\Omega$



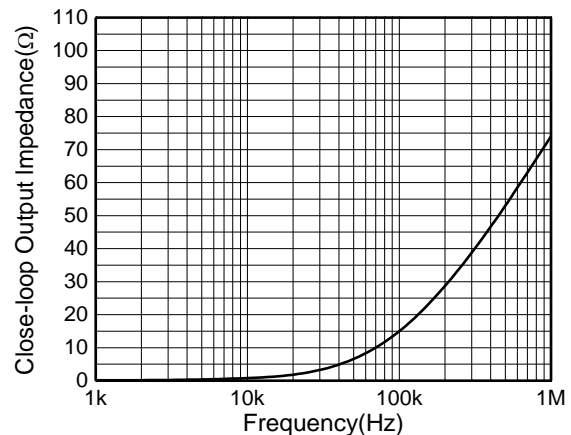
Over-Shoot % vs. C_{load}
Gain=+1



PSRR vs. Frequency



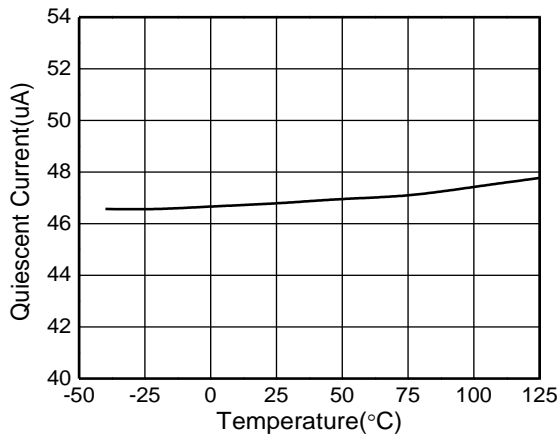
Closed-Loop Output Impedance vs. Frequency



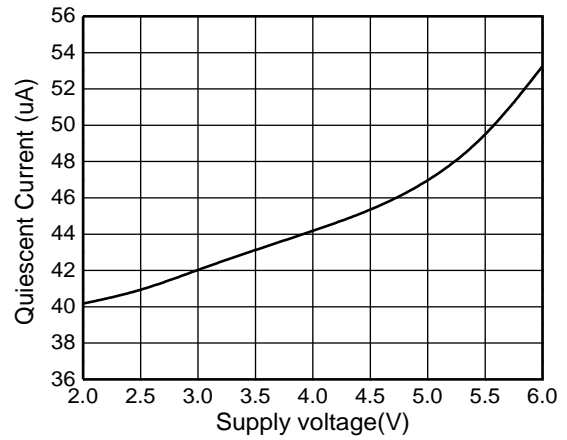
Typical Characteristics (continued)

$T_A=25^{\circ}\text{C}$, $V_S=\pm 2.5\text{V}$, $V_{CM}=0\text{V}$, unless otherwise noted

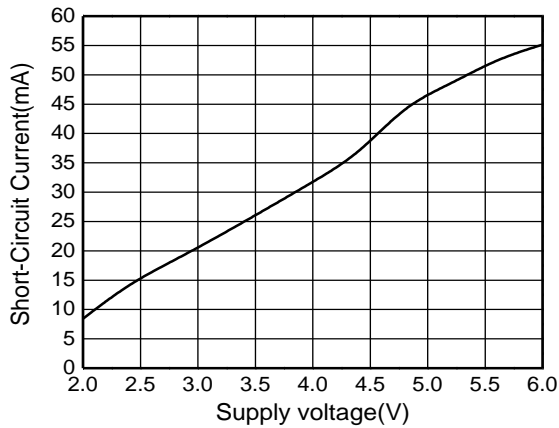
Quiescent Supply Current vs. Temperature



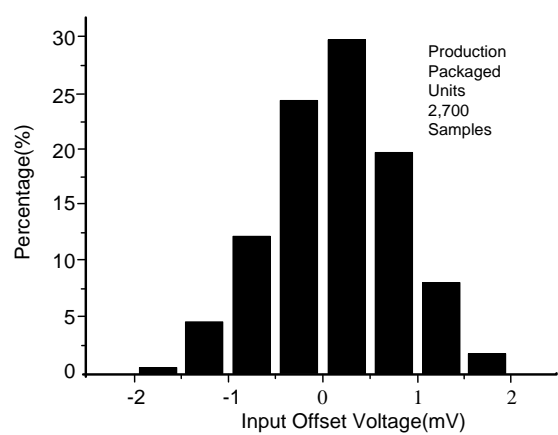
Quiescent Supply Current vs. Supply Voltage



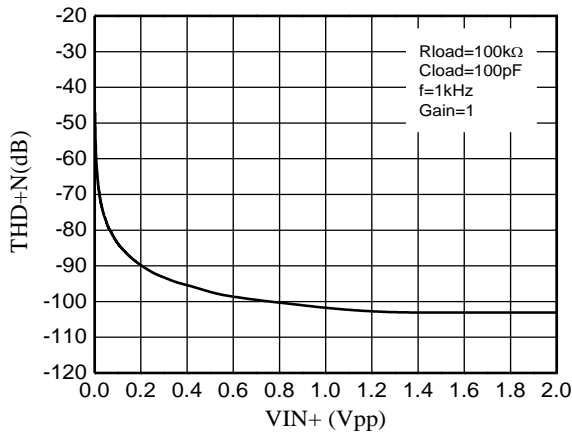
Short-Circuit Current vs. Supply Voltage



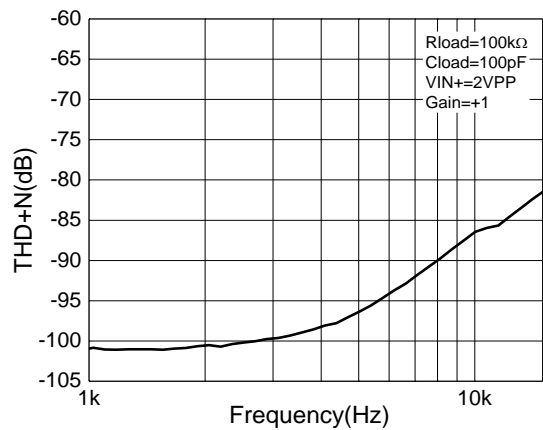
Input Offset Voltage Distribution



THD+N vs. V_{in+}



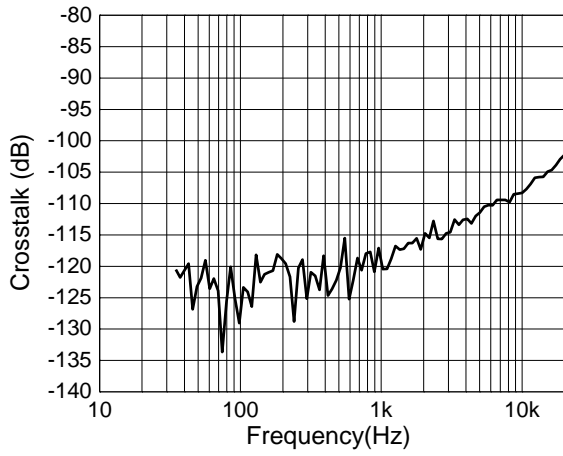
THD+N vs. Frequency



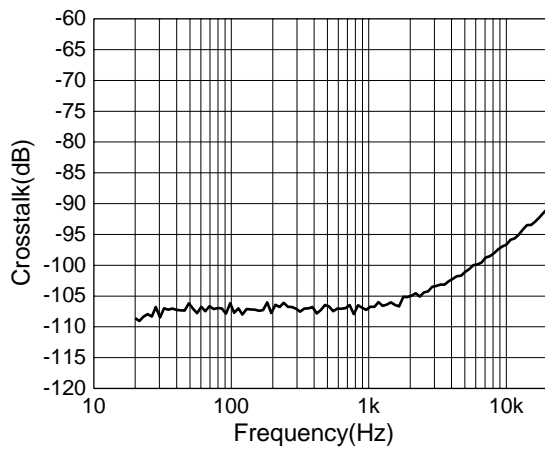
Typical Characteristics (continued)

$T_A=25^{\circ}\text{C}$, $V_S=\pm 2.5\text{V}$, $V_{CM}=0\text{V}$, unless otherwise noted

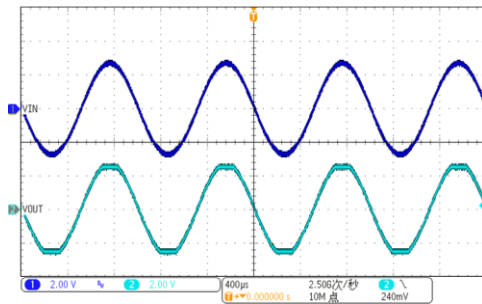
Crosstalk, A-Channel to B-Channel



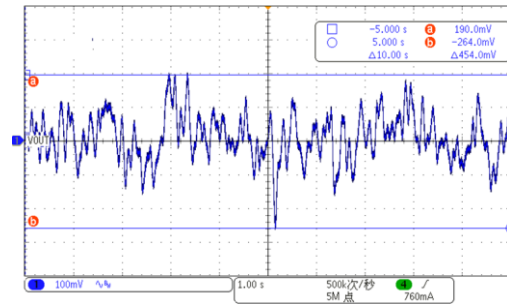
Crosstalk, A-Channel to C-Channel



$V_{IN}=-0.2\text{V}$ to 5.7V , No Phase Reversal

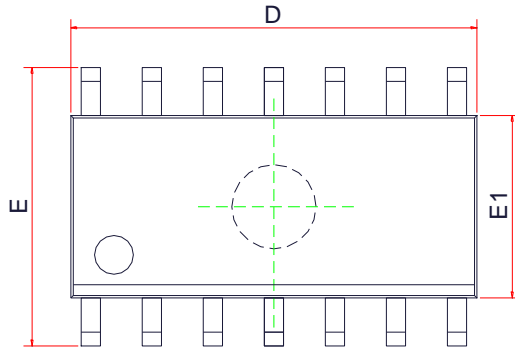


0.1Hz to 10Hz Integrated Input Noise,
Gain = 100000

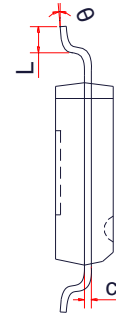


PACKAGE OUTLINE DIMENSIONS

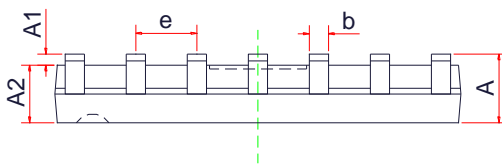
SOP-14L



TOP VIEW



SIDE VIEW



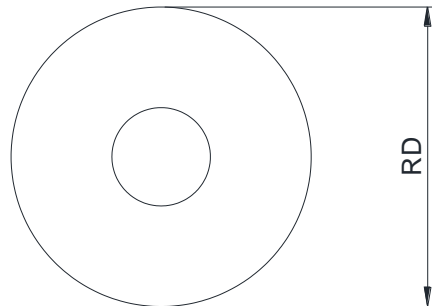
SIDE VIEW

| Symbol | Dimensions In Millimeters (mm) | | |
|--------|--------------------------------|------|------|
| | Min. | Typ. | Max. |
| A | - | - | 1.75 |
| A1 | 0.10 | - | 0.25 |
| A2 | 1.25 | - | - |
| b | 0.31 | 0.41 | 0.51 |
| c | 0.10 | - | 0.25 |
| D | 8.45 | 8.65 | 8.85 |
| E | 5.80 | 6.00 | 6.20 |
| E1 | 3.80 | 3.90 | 4.00 |
| e | 1.27 BSC | | |
| L | 0.40 | - | 1.27 |
| θ | 0° | - | 8° |

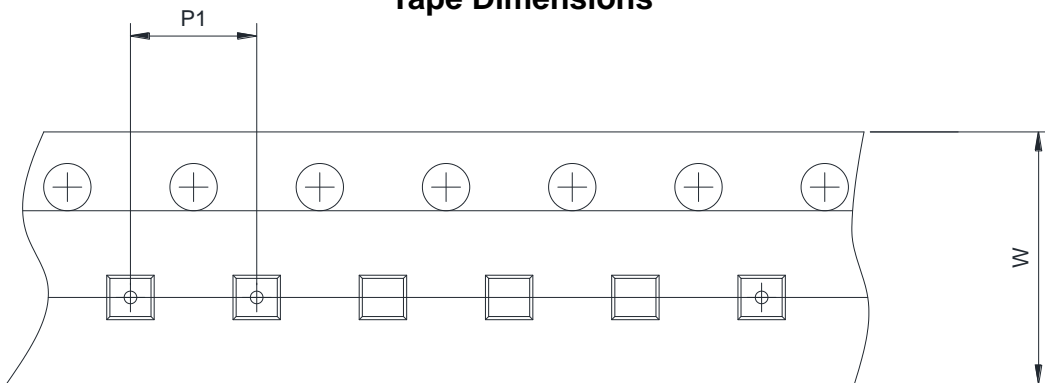
TAPE AND REEL INFORMATION

SOP-14L

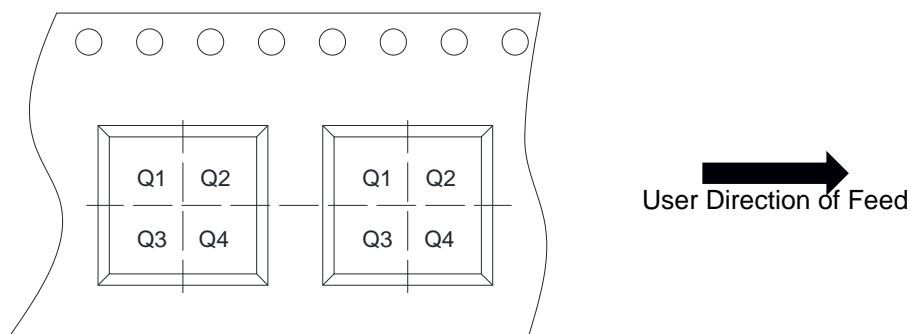
Reel Dimensions



Tape Dimensions



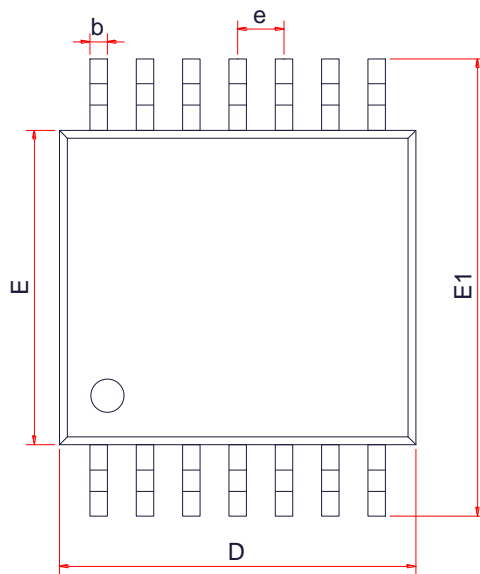
Quadrant Assignments For PIN1 Orientation In Tape



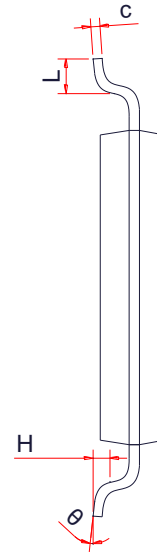
| | | | |
|------|---|--|---|
| RD | Reel Dimension | <input type="checkbox"/> 7inch | <input checked="" type="checkbox"/> 13inch |
| W | Overall width of the carrier tape | <input type="checkbox"/> 8mm | <input type="checkbox"/> 12mm <input checked="" type="checkbox"/> 16mm |
| P1 | Pitch between successive cavity centers | <input type="checkbox"/> 2mm | <input type="checkbox"/> 4mm <input checked="" type="checkbox"/> 8mm |
| Pin1 | Pin1 Quadrant | <input checked="" type="checkbox"/> Q1 | <input type="checkbox"/> Q2 <input type="checkbox"/> Q3 <input type="checkbox"/> Q4 |

PACKAGE OUTLINE DIMENSIONS

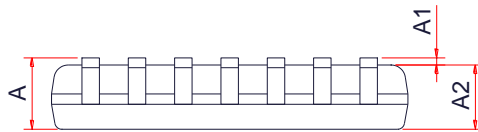
TSSOP-14L



TOP VIEW



SIDE VIEW



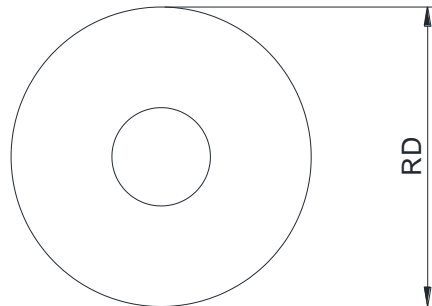
SIDE VIEW

| Symbol | Dimensions in Millimeters | | |
|----------|---------------------------|------|------|
| | Min. | Typ. | Max. |
| A | - | - | 1.20 |
| A1 | 0.05 | - | 0.15 |
| A2 | 0.80 | 0.90 | 1.00 |
| b | 0.19 | - | 0.30 |
| c | 0.09 | - | 0.20 |
| D | 4.90 | 5.00 | 5.10 |
| E | 4.30 | 4.40 | 4.50 |
| E1 | 6.25 | 6.40 | 6.55 |
| e | 0.65 BSC | | |
| L | 0.50 | 0.60 | 0.70 |
| H | 0.25Typ | | |
| θ | 1 ° | - | 7 ° |

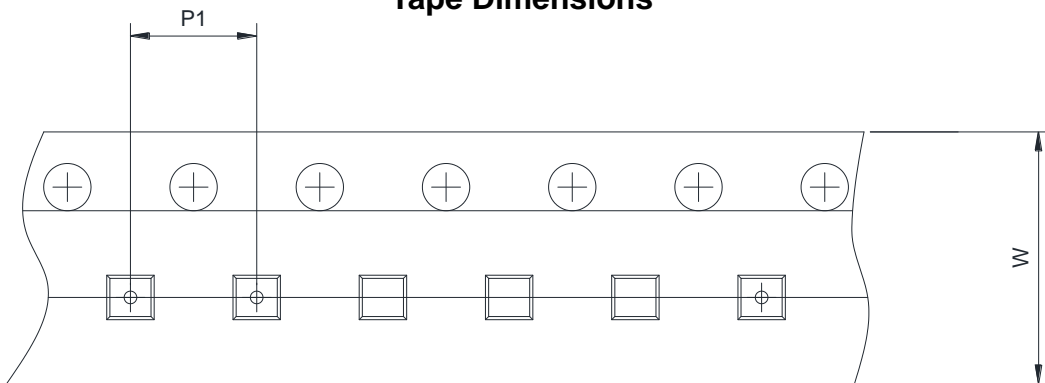
TAPE AND REEL INFORMATION

TSSOP-14L

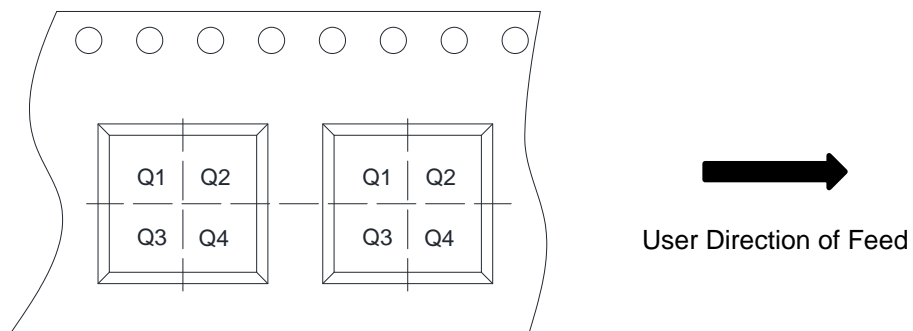
Reel Dimensions



Tape Dimensions



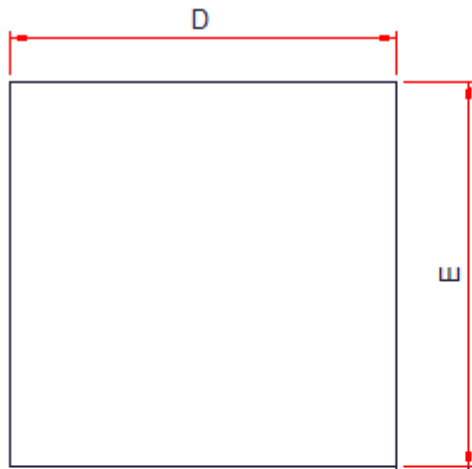
Quadrant Assignments For PIN1 Orientation In Tape



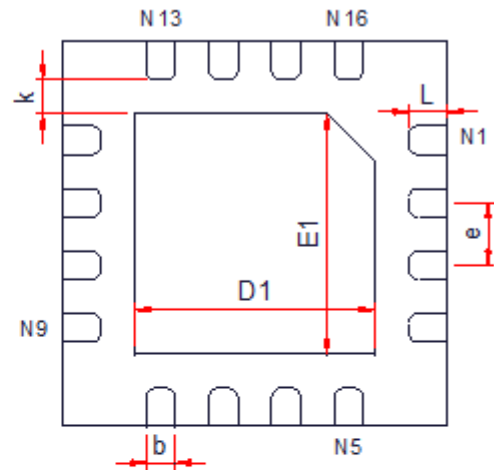
| | | | |
|------|---|--|---|
| RD | Reel Dimension | <input type="checkbox"/> 7inch | <input checked="" type="checkbox"/> 13inch |
| W | Overall width of the carrier tape | <input type="checkbox"/> 8mm | <input checked="" type="checkbox"/> 12mm <input type="checkbox"/> 16mm |
| P1 | Pitch between successive cavity centers | <input type="checkbox"/> 2mm | <input type="checkbox"/> 4mm <input checked="" type="checkbox"/> 8mm |
| Pin1 | Pin1 Quadrant | <input checked="" type="checkbox"/> Q1 | <input type="checkbox"/> Q2 <input type="checkbox"/> Q3 <input type="checkbox"/> Q4 |

PACKAGE OUTLINE DIMENSIONS

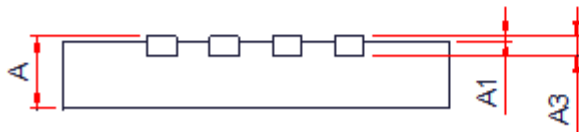
QFN3x3-16L



TOP VIEW



BOTTOM VIEW



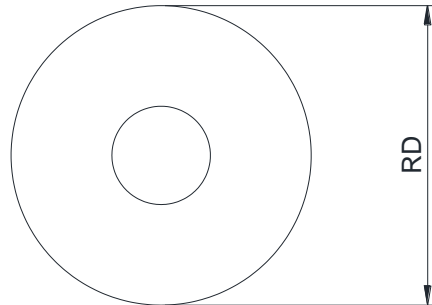
SIDE VIEW

| Symbol | Dimensions in Millimeters | | |
|--------|---------------------------|------|------|
| | Min. | Typ. | Max. |
| A | 0.70 | 0.75 | 0.80 |
| A1 | 0.00 | 0.02 | 0.05 |
| A3 | 0.203 REF | | |
| D | 2.90 | 3.00 | 3.10 |
| E | 2.90 | 3.00 | 3.10 |
| D1 | 1.60 | 1.70 | 1.80 |
| E1 | 1.60 | 1.70 | 1.80 |
| k | 0.30 | 0.35 | 0.40 |
| b | 0.20 | 0.25 | 0.30 |
| e | 0.50 BSC | | |
| L | 0.25 | 0.30 | 0.35 |

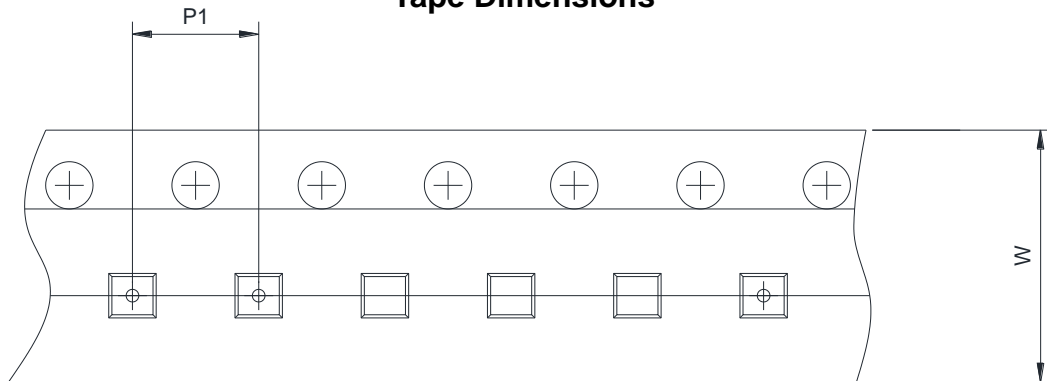
TAPE AND REEL INFORMATION

QFN3x3-16L

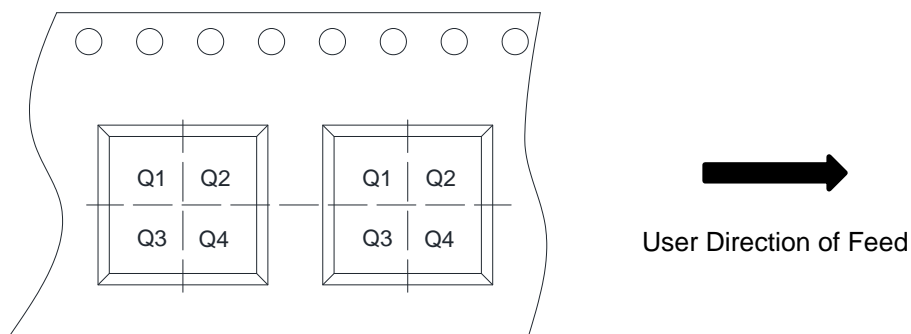
Reel Dimensions



Tape Dimensions



Quadrant Assignments For PIN1 Orientation In Tape



| | | | |
|------|---|--------------------------------|--|
| RD | Reel Dimension | <input type="checkbox"/> 7inch | <input checked="" type="checkbox"/> 13inch |
| W | Overall width of the carrier tape | <input type="checkbox"/> 8mm | <input checked="" type="checkbox"/> 12mm <input type="checkbox"/> 16mm |
| P1 | Pitch between successive cavity centers | <input type="checkbox"/> 2mm | <input type="checkbox"/> 4mm <input checked="" type="checkbox"/> 8mm |
| Pin1 | Pin1 Quadrant | <input type="checkbox"/> Q1 | <input checked="" type="checkbox"/> Q2 <input type="checkbox"/> Q3 <input type="checkbox"/> Q4 |

X-ON Electronics

Largest Supplier of Electrical and Electronic Components

Click to view similar products for [Operational Amplifiers - Op Amps](#) category:

Click to view products by [Will Semiconductor](#) manufacturer:

Other Similar products are found below :

[430227FB](#) [LT1678IS8](#) [NCV33202DMR2G](#) [NJM324E](#) [M38510/13101BPA](#) [NTE925](#) [AZV358MTR-G1](#) [AP4310AUMTR-AG1](#)
[AZV358MMTR-G1](#) [SCY33178DR2G](#) [NCV20034DR2G](#) [NTE778S](#) [NTE871](#) [NTE937](#) [NJU7057RB1-TE2](#) [SCY6358ADR2G](#)
[NJM2904CRB1-TE1](#) [UPC4570G2-E1-A](#) [UPC4741G2-E1-A](#) [NJM8532RB1-TE1](#) [EL2250CS](#) [EL5100IS](#) [EL5104IS](#) [EL5127CY](#) [EL5127CZY](#)
[EL5133IW](#) [EL5152IS](#) [EL5156IS](#) [EL5162IS](#) [EL5202IY](#) [EL5203IY](#) [EL5204IY](#) [EL5210CS](#) [EL5210CZY](#) [EL5211IYE](#) [EL5220CY](#)
[EL5223CLZ](#) [EL5223CR](#) [EL5224ILZ](#) [EL5227CLZ](#) [EL5227CRZ](#) [EL5244CS](#) [EL5246CS](#) [EL5246CSZ](#) [EL5250IY](#) [EL5251IS](#) [EL5257IS](#)
[EL5260IY](#) [EL5261IS](#) [EL5300IU](#)