

LMx24, LMx24x, LMx24xx, LM2902, LM2902x, LM2902xx, LM2902xxx

Quadruple Operational Amplifiers

1 Features

- Wide supply range:
 - 3 V to 36 V (B, BA versions)
 - 3 V to 30 V (LMx24, LM2902V)
- Low input offset voltage maximum at 25°C:
 - 2 mV (BA versions LM2902A, LM124A)
 - 3 mV (B versions LMx24xA)
- Low input bias current maximum at 25°C:
 - 35 nA (B, BA versions)
- 2-kV ESD protection (HBM) (B, BA, K versions)
- Internal RF and EMI filter (B, BA versions)
- Low quiescent current of 175- μ A/ch typical
- Common-mode input voltage range includes V_{CC-}
- Differential input voltage range equal to maximum-rated supply voltage
- Open-loop differential voltage amplification: 100-V/mV typical
- On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

2 Applications

- [Merchant network and server power supply units](#)
- [Multi-function printers](#)
- [Power supplies and mobile chargers](#)
- [Motor control: AC induction, brushed DC, brushless DC, high-voltage, low-voltage, permanent magnet, and stepper motor](#)
- [Desktop PC and motherboard](#)
- [Indoor and outdoor air conditioners](#)
- [Washers, dryers, and refrigerators](#)
- [AC inverters, string inverters, central inverters, and voltage frequency drives](#)
- [Uninterruptible power supplies](#)

- [Electronic point-of-sale systems](#)

3 Description

These devices consist of four independent, high-gain, frequency-compensated, operational amplifiers that are designed specifically to operate from a single supply or split supply over a wide range of voltages.

Device Information

| PART NUMBER ⁽¹⁾ | PACKAGE | BODY SIZE (NOM) |
|---|------------|--------------------|
| LM324B ⁽²⁾ , LM324BA ⁽²⁾ , LM2902B ⁽²⁾ , LM2902BA ⁽²⁾ , LM324, LM324A, LM324K, LM324KA, LM2902, LM2902K, LM2902KV, LM2902KAV, LM224, LM224A, LM224K, LM224KA, LM124 | SOIC (14) | 8.65 mm × 3.91 mm |
| LM324B ⁽²⁾ , LM324BA ⁽²⁾ , LM2902B ⁽²⁾ , LM2902BA ⁽²⁾ , LM324, LM324A, LM324K, LM324KA, LM2902, LM2902K, LM2902KV, LM2902KAV, LM124 | TSSOP (14) | 5.00 mm × 4.40 mm |
| LM324, LM324A, LM324K, LM324KA, LM2902, LM2902K, LM224, LM224A, LM224K, LM224KA | PDIP (14) | 19.30 mm × 6.35 mm |
| LM324, LM324A, LM324K, LM324KA, LM2902, LM2902K | SO (14) | 9.20 mm × 5.30 mm |
| LM324A, LM2902K | SSOP (14) | 6.20 mm × 5.30 mm |
| LM124A | CDIP (14) | 19.56 mm × 6.67 mm |
| | CFP (14) | 9.21 mm × 5.97 mm |
| | LCCC (20) | 8.90 mm × 8.90 mm |

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

(2) This product is preview only.

Family Comparison

| SPECIFICATION | LM324B LM324BA | LM2902B LM2902BA | LM324 LM324A | LM324K LM324KA | LM2902 | LM2902K LM2902KV LM2902KAV | LM224 LM224A | LM224K LM224KA | LM124 LM124A | Units |
|--------------------------------|--------------------|---------------------|----------------------|----------------------|------------|----------------------------------|---------------------|---------------------|---------------------|-------|
| Supply voltage | 3 to 36 | 3 to 36 | 3 to 30 | 3 to 30 | 3 to 26 | 3 to 26 3 to 30 3 to 30 | 3 to 30 | 3 to 30 | 3 to 30 | V |
| Offset voltage (max, 25°C) | ± 3 ± 2 | ± 3 ± 2 | ± 7 ± 3 | ± 7 ± 3 | ± 7 | ± 7 ± 7 ± 2 | ± 5 ± 3 | ± 5 ± 3 | ± 5 ± 2 | mV |
| Input bias current (typ / max) | 10 / 35 | 10 / 35 | 20 / 250 15 / 100 | 20 / 250 15 / 100 | 20 / 250 | 20 / 250 | 20 / 150 15 / 80 | 20 / 150 15 / 80 | 20 / 150 20 / 50 | nA |
| ESD (HBM) | 2000 | 2000 | 500 | 2000 | 500 | 2000 | 500 | 2000 | 500 | V |
| Operating ambient temperature | -40 to 85 | -40 to 125 | 0 to 70 | 0 to 70 | -40 to 125 | -40 to 125 | -25 to 85 | -25 to 85 | -55 to 125 | °C |



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4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from Revision W (March 2015) to Revision X (May 2022) | Page |
|--|-------------|
| • Updated <i>Features</i> to include the B and BA versions..... | 1 |
| • Added application links to <i>Applications</i> section..... | 1 |
| • Corrected available packages in the <i>Device Information</i> table..... | 1 |
| • Added B and BA versions to <i>Device Information</i> table..... | 1 |
| • Updated package images in the <i>Pin Configuration and Functions</i> section to new format - no specification changes..... | 3 |
| • Renamed GND and Vcc to Vcc- and Vcc+, respectively, in the <i>Pin Functions</i> table | 3 |
| • Added B and BA versions to <i>Absolute Maximum Ratings</i> table | 4 |
| • Added the B and BA versions to the <i>ESD Ratings</i> table | 4 |
| • Added B and BA versions to <i>Recommended Operating Conditions</i> table | 4 |
| • Added the <i>Electrical Characteristics - LM324B and LM324BA</i> table | 6 |
| • Added the <i>Electrical Characteristics - LM2902B and LM2902BA</i> table..... | 8 |
| • Removed <i>Documentation Support</i> and <i>Related Links</i> in the <i>Device and Documentation Support</i> section..... | 20 |

| Changes from Revision V (January 2014) to Revision W (March 2014) | Page |
|--|-------------|
| • Added <i>Applications</i> | 1 |
| • Added <i>Device Information</i> table..... | 1 |
| • Added <i>Mechanical, Packaging, and Orderable Information</i> section..... | 20 |

| Changes from Revision U (August 2010) to Revision V (January 2014) | Page |
|--|-------------|
| • Updated document to new TI data sheet format - no specification changes..... | 1 |
| • Updated <i>Features</i> | 1 |
| • Removed <i>Ordering Information</i> table..... | 3 |
| • Added <i>Pin Functions</i> table | 3 |

5 Pin Configuration and Functions

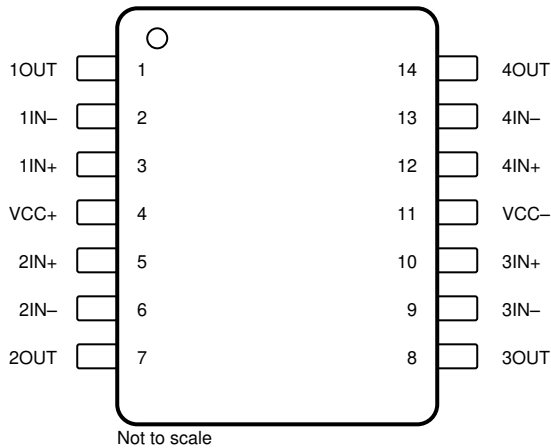


Figure 5-1. D, DB, J, N, NS, PW, and W Package 14-Pin SOIC, SSOP, CDIP, PDIP, SO, TSSOP, and CFP (Top View)

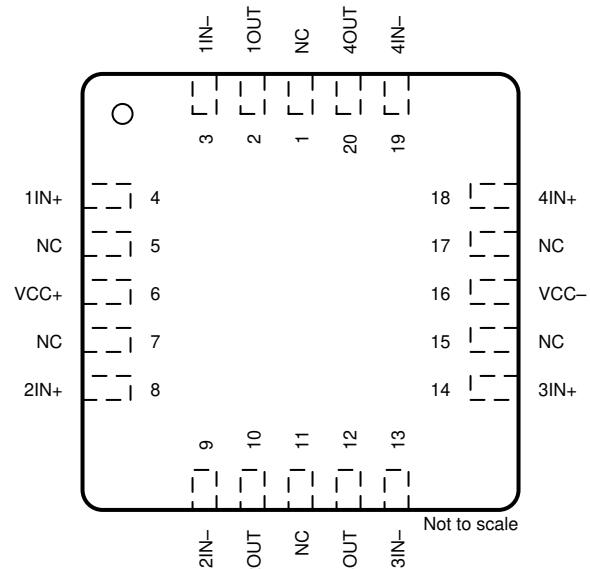


Figure 5-2. FK Package 20-Pin LCCC (Top View)

Table 5-1. Pin Functions

| NAME | PIN | | I/O | DESCRIPTION |
|------------------|---------------------|--|-----|--|
| | LCCC | SOIC, TSSOP, PDIP, SSOP, SO, CDIP, and CFP | | |
| 1IN- | 3 | 2 | I | Negative input |
| 1IN+ | 4 | 3 | I | Positive input |
| 1OUT | 2 | 1 | O | Output |
| 2IN- | 9 | 6 | I | Negative input |
| 2IN+ | 8 | 5 | I | Positive input |
| 2OUT | 10 | 7 | O | Output |
| 3IN- | 13 | 9 | I | Negative input |
| 3IN+ | 14 | 10 | I | Positive input |
| 3OUT | 12 | 8 | O | Output |
| 4IN- | 19 | 13 | I | Negative input |
| 4IN+ | 18 | 12 | I | Positive input |
| 4OUT | 20 | 14 | O | Output |
| V _{CC-} | 16 | 11 | — | Negative (lowest) supply or ground (for single-supply operation) |
| NC | 1, 5, 7, 11, 15, 17 | — | — | Do not connect |
| V _{CC+} | 6 | 4 | — | Positive (highest) supply |

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)⁽¹⁾

| | LM324B, LM324BA, LM2902B, LM2902BA | | LM2902 | | LM324xx, LM224xx, LM2902xxx, LM124x | | UNIT |
|--|---------------------------------------|-----|-----------|-----|--|-----|------|
| | MIN | MAX | MIN | MAX | MIN | MAX | |
| Supply voltage, V_{CC} ⁽²⁾ | 40 | | 26 | | 32 | | V |
| Differential input voltage, V_{ID} ⁽³⁾ | ±40 | | ±26 | | ±32 | | V |
| Input voltage, V_I (either input) | -0.3 | 40 | -0.3 | 26 | -0.3 | 32 | V |
| Duration of output short circuit (one amplifier) to ground at (or below) $T_A = 25^\circ\text{C}$, $V_{CC} \leq 15\text{ V}$ ⁽⁴⁾ | Unlimited | | Unlimited | | Unlimited | | |
| Operating virtual junction temperature, T_J | 150 | | 150 | | 150 | | °C |
| Case temperature for 60 seconds | FK package | | | | 260 | | °C |
| Lead temperature 1.6 mm (1/16 inch) from case for 60 seconds | J or W package | | 300 | | 300 | | °C |
| Storage temperature, T_{stg} | -65 | 150 | -65 | 150 | -65 | 150 | °C |

- Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- All voltage values (except differential voltages and V_{CC} specified for the measurement of I_{OS}) are with respect to the network GND.
- Differential voltages are at $IN+$, with respect to $IN-$.
- Short circuits from outputs to V_{CC} can cause excessive heating and eventual destruction.

6.2 ESD Ratings

| | | | VALUE | UNIT |
|---|-------------------------|---|-------|------|
| LM324B, LM324BA, LM2902B, LM2902BA, LM224K, LM224KA, LM324K, LM324KA, LM2902K, LM2902KV, LM2902KAV | | | | |
| $V_{(ESD)}$ | Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾ | ±2000 | V |
| | | Charged-device model (CDM), per JEDEC specification JESD22-C101 | ±1000 | |
| LM124, LM124A, LM224, LM224A, LM324, LM324A, LM2902 | | | | |
| $V_{(ESD)}$ | Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾ | ±500 | V |
| | | Charged-device model (CDM), per JEDEC specification JESD22-C101 | ±1000 | |

- JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

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

| | LM324B, LM324BA, LM2902B, LM2902BA | | LM2902 | | LM324xx, LM224xx, LM2902xxx, LM124x | | UNIT |
|--------------------------------------|---------------------------------------|--------------|--------|--------------|--|--------------|------|
| | MIN | MAX | MIN | MAX | MIN | MAX | |
| V_{CC} Supply voltage | 3 | 36 | 3 | 26 | 3 | 30 | V |
| V_{CM} Common-mode voltage | 0 | $V_{CC} - 2$ | 0 | $V_{CC} - 2$ | 0 | $V_{CC} - 2$ | V |
| T_A Operating free air temperature | LM124x | | | | -55 | 125 | °C |
| | LM2902xxx, LM2902Bx | -40 | 125 | -40 | 125 | | |
| | LM324Bx | -40 | 85 | | | | |
| | LM224xx | | | | -25 | 85 | |
| | LM324xx | | | | 0 | 70 | |

6.4 Thermal Information

| THERMAL METRIC ⁽¹⁾ | LMx24, LM2902 | | | | | LMx24 | | | UNIT | |
|-------------------------------------|---|--------------|-------------|------------|---------------|--------------|-------------|------------|-------|------|
| | D (SOIC) | DB (SSOP) | N (PDIP) | NS (SO) | PW (TSSOP) | FK (LCCC) | J (CDIP) | W (CFP) | | |
| | 14 PINS | 14 PINS | 14 PINS | 14 PINS | 14 PINS | 20 PINS | 14 PINS | 14 PINS | | |
| R _{θJA} ^{(2) (3)} | Junction-to-ambient thermal resistance | 86 | 86 | 80 | 76 | 113 | — | — | — | °C/W |
| R _{θJC} ⁽⁴⁾ | Junction-to-case (top) thermal resistance | — | — | — | — | — | 5.61 | 15.05 | 14.65 | °C/W |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.
- (2) Short circuits from outputs to VCC can cause excessive heating and eventual destruction.
- (3) Maximum power dissipation is a function of T_{J(max)}, R_{θJA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is P_D = (T_{J(max)} – T_A)/R_{θJA}. Operating at the absolute maximum T_J of 150°C can affect reliability.
- (4) Maximum power dissipation is a function of T_{J(max)}, R_{θJA}, and T_C. The maximum allowable power dissipation at any allowable case temperature is P_D = (T_{J(max)} – T_C)/R_{θJC}. Operating at the absolute maximum T_J of 150°C can affect reliability.

6.5 Electrical Characteristics - LM324B and LM324BA

For $V_S = (V_{CC+}) - (V_{CC-}) = 5\text{ V to }36\text{ V}$ ($\pm 2.5\text{ V to } \pm 18\text{ V}$), at $T_A = 25^\circ\text{C}$, $V_{CM} = V_{OUT} = V_S / 2$, and $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$ (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | | MIN | TYP | MAX | UNIT |
|----------------------------|--|---|--|--|--|--------------------|---------------|--------------------------------------|
| OFFSET VOLTAGE | | | | | | | | |
| V_{OS} | Input offset voltage | LM324B | | | | ± 0.3 | ± 3.0 | mV |
| | | | | | $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | | ± 4.0 | |
| | | LM324BA | | | | ± 0.3 | ± 2 | |
| | | | | | $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | | | |
| dV_{OS}/dT | Input offset voltage drift | $R_S = 0\ \Omega$ | | | $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | ± 7 | | $\mu\text{V}/^\circ\text{C}$ |
| PSRR | Input offset voltage versus power supply | | | | 65 | 100 | | dB |
| | Channel separation | $f = 1\text{ kHz to } 20\text{ kHz}$ | | | | 120 | | dB |
| INPUT VOLTAGE RANGE | | | | | | | | |
| V_{CM} | Common-mode voltage range | $V_S = 3\text{ V to } 36\text{ V}$ | | | V- | $(V+) - 1.5$ | | V |
| | | $V_S = 5\text{ V to } 36\text{ V}$ | | $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | V- | $(V+) - 2$ | | |
| CMRR | Common-mode rejection ratio | $(V-) \leq V_{CM} \leq (V+) - 1.5\text{ V}$ | $V_S = 3\text{ V to } 36\text{ V}$ | | 70 | 80 | | dB |
| | | $(V-) \leq V_{CM} \leq (V+) - 2\text{ V}$ | $V_S = 5\text{ V to } 36\text{ V}$ | $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | 65 | 80 | | |
| INPUT BIAS CURRENT | | | | | | | | |
| I_B | Input bias current | | | | | -10 | -35 | nA |
| | | | | | $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | | -50 | |
| dI_{OS}/dT | Input offset current drift | | | | $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | 10 | | $\text{pA}/^\circ\text{C}$ |
| I_{OS} | Input offset current | | | | | ± 0.5 | ± 4 | nA |
| | | | | | $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | | ± 5 | |
| dI_{OS}/dT | Input offset current drift | | | | $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | 10 | | $\text{pA}/^\circ\text{C}$ |
| NOISE | | | | | | | | |
| E_N | Input voltage noise | $f = 0.1\text{ to } 10\text{ Hz}$ | | | | 3 | | μV_{PP} |
| e_N | Input voltage noise density | $R_S = 100\ \Omega, V_I = 0\text{ V}, f = 1\text{ kHz}$ (see Figure 8) | | | | 35 | | $\text{nV}/\sqrt{\text{Hz}}$ |
| INPUT CAPACITANCE | | | | | | | | |
| Z_{ID} | Differential | | | | | $10 \parallel 0.1$ | | $\text{M}\Omega \parallel \text{pF}$ |
| Z_{ICM} | Common-mode | | | | | $4 \parallel 1.5$ | | $\text{G}\Omega \parallel \text{pF}$ |
| OPEN-LOOP GAIN | | | | | | | | |
| A_{OL} | Open-loop voltage gain | $V_S = 15\text{ V}, V_O = 1\text{ V to } 11\text{ V}, R_L \geq 2\text{ k}\Omega$, connected to (V-) | | | 50 | 100 | | V/mV |
| | | | | $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | 25 | | | |
| FREQUENCY RESPONSE | | | | | | | | |
| GBW | Gain-bandwidth product | $R_L = 1\text{ M}\Omega, C_L = 20\text{ pF}$ (see Figure 7) | | | | 1.2 | | MHz |
| SR | Slew rate | $R_L = 1\text{ M}\Omega, C_L = 30\text{ pF}, V_I = \pm 10\text{ V}$ (see Figure 7) | | | | 0.5 | | V/ μs |
| θ_m | Phase margin | $G = +1, R_L = 10\text{ k}\Omega, C_L = 20\text{ pF}$ | | | | 56 | | $^\circ$ |
| t_s | Settling time | To 0.1%, $V_S = 5\text{ V}, 2\text{-V Step}, G = +1, C_L = 100\text{ pF}$ | | | | 4 | | μs |
| | Overload recovery time | $V_{IN} \times \text{gain} > V_S$ | | | | 10 | | μs |
| THD+N | Total harmonic distortion + noise | $G = +1, f = 1\text{ kHz}, V_O = 3.53\text{ }V_{RMS}, V_S = 36\text{ V}, R_L = 100\text{ k}\Omega, I_{OUT} \leq 50\ \mu\text{A}, \text{BW} = 80\text{ kHz}$ | | | | 0.001% | | |
| OUTPUT | | | | | | | | |
| V_O | Voltage output swing from rail | Positive Rail (V+) | | | $I_{OUT} = -50\ \mu\text{A}$ | 1.35 | 1.5 | V |
| V_O | | | | | $I_{OUT} = -1\text{ mA}$ | 1.4 | 1.6 | V |
| V_O | | | | | $I_{OUT} = -5\text{ mA}$ | 1.5 | 1.75 | V |
| V_O | | Negative Rail (V-) | | | $I_{OUT} = 50\ \mu\text{A}$ | 100 | 150 | mV |
| V_O | | | | | $I_{OUT} = 1\text{ mA}$ | 0.75 | 1 | V |
| V_O | | | $V_S = 5\text{ V}, R_L \leq 10\text{ k}\Omega$ connected to (V-) | | $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | 5 | 20 | mV |
| I_O | Output current | Source | $V_S = 15\text{ V}; V_O = V-; V_{ID} = 1\text{ V}$ | | | -20 | -30 | mA |
| | | | | | $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | -10 | | |
| | | Sink | $V_S = 15\text{ V}; V_O = V+; V_{ID} = -1\text{ V}$ | | | 10 | 20 | mA |
| | | | | | $T_A = -40^\circ\text{C to } 85^\circ\text{C}$ | 5 | | |
| | | $V_{ID} = -1\text{ V}; V_O = (V-) + 200\text{ mV}$ | | | 50 | 85 | μA | |
| I_{SC} | Short-circuit current | $V_S = 20\text{ V}, (V+) = 10\text{ V}, (V-) = -10\text{ V}, V_O = 0\text{ V}$ | | | | ± 40 | ± 60 | mA |
| C_{LOAD} | Capacitive load drive | | | | | 100 | | pF |

6.5 Electrical Characteristics - LM324B and LM324BA (continued)

For $V_S = (V_{CC+}) - (V_{CC-}) = 5\text{ V to }36\text{ V}$ ($\pm 2.5\text{ V to } \pm 18\text{ V}$), at $T_A = 25^\circ\text{C}$, $V_{CM} = V_{OUT} = V_S / 2$, and $R_L = 10\text{k}$ connected to $V_S / 2$ (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---------------------|---------------------------------|---------------------------------------|---|-----|-----|-----|---------------|
| R_O | Open-loop output impedance | $f = 1\text{ MHz}, I_O = 0\text{ A}$ | | | 300 | | Ω |
| POWER SUPPLY | | | | | | | |
| I_Q | Quiescent current per amplifier | $V_S = 5\text{ V}; I_O = 0\text{ A}$ | $T_A = -40^\circ\text{C to }85^\circ\text{C}$ | | 175 | 300 | μA |
| | | $V_S = 36\text{ V}; I_O = 0\text{ A}$ | $T_A = -40^\circ\text{C to }85^\circ\text{C}$ | | 350 | 750 | μA |

6.6 Electrical Characteristics - LM2902B and LM2902BA

For $V_S = (V_{CC+}) - (V_{CC-}) = 5\text{ V to }36\text{ V}$ ($\pm 2.5\text{ V to } \pm 18\text{ V}$), at $T_A = 25^\circ\text{C}$, $V_{CM} = V_{OUT} = V_S / 2$, and $R_L = 10\text{ k}\Omega$ connected to $V_S / 2$ (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|----------------------------|--|---|--|--|--------------------|---------------|--------------------------------------|
| OFFSET VOLTAGE | | | | | | | |
| V_{OS} | Input offset voltage | LM2902B | | | ± 0.3 | ± 3.0 | mV |
| | | | $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | | | ± 4.0 | |
| | | LM2902BA | | | ± 0.3 | ± 2 | |
| | | | $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | | | 2.5 | |
| dV_{OS}/dT | Input offset voltage drift | $R_S = 0\ \Omega$ | $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | | ± 7 | | $\mu\text{V}/^\circ\text{C}$ |
| PSRR | Input offset voltage versus power supply | | | 65 | 100 | | dB |
| | Channel separation | $f = 1\text{ kHz to }20\text{ kHz}$ | | | 120 | | dB |
| INPUT VOLTAGE RANGE | | | | | | | |
| V_{CM} | Common-mode voltage range | $V_S = 3\text{ V to }36\text{ V}$ | | V- | | $(V+) - 1.5$ | V |
| | | $V_S = 5\text{ V to }36\text{ V}$ | | $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | V- | | |
| CMRR | Common-mode rejection ratio | $(V-) \leq V_{CM} \leq (V+) - 1.5\text{ V}$ | $V_S = 3\text{ V to }36\text{ V}$ | | 70 | 80 | dB |
| | | $(V-) \leq V_{CM} \leq (V+) - 2\text{ V}$ | $V_S = 5\text{ V to }36\text{ V}$ | $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | 65 | 80 | |
| INPUT BIAS CURRENT | | | | | | | |
| I_B | Input bias current | | | | -10 | -35 | nA |
| | | | $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | | | -50 | |
| dI_{OS}/dT | Input offset current drift | | $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | | 10 | | $\text{pA}/^\circ\text{C}$ |
| I_{OS} | Input offset current | | | | ± 0.5 | ± 4 | nA |
| | | | $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | | | ± 5 | |
| dI_{OS}/dT | Input offset current drift | | $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | | 10 | | $\text{pA}/^\circ\text{C}$ |
| NOISE | | | | | | | |
| E_N | Input voltage noise | $f = 0.1\text{ to }10\text{ Hz}$ | | | 3 | | μV_{PP} |
| e_N | Input voltage noise density | $R_S = 100\ \Omega, V_I = 0\text{ V}, f = 1\text{ kHz}$ (see Figure 8) | | | 35 | | $\text{nV}/\sqrt{\text{Hz}}$ |
| INPUT CAPACITANCE | | | | | | | |
| Z_{ID} | Differential | | | | $10 \parallel 0.1$ | | $\text{M}\Omega \parallel \text{pF}$ |
| Z_{ICM} | Common-mode | | | | $4 \parallel 1.5$ | | $\text{G}\Omega \parallel \text{pF}$ |
| OPEN-LOOP GAIN | | | | | | | |
| A_{OL} | Open-loop voltage gain | $V_S = 15\text{ V}, V_O = 1\text{ V to }11\text{ V}, R_L \geq 2\text{ k}\Omega$, connected to (V-) | | | 50 | 100 | V/mV |
| | | | | $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | 25 | | |
| FREQUENCY RESPONSE | | | | | | | |
| GBW | Gain-bandwidth product | $R_L = 1\text{ M}\Omega, C_L = 20\text{ pF}$ (see Figure 7) | | | 1.2 | | MHz |
| SR | Slew rate | $R_L = 1\text{ M}\Omega, C_L = 30\text{ pF}, V_I = \pm 10\text{ V}$ (see Figure 7) | | | 0.5 | | V/ μs |
| θ_m | Phase margin | $G = +1, R_L = 10\text{ k}\Omega, C_L = 20\text{ pF}$ | | | 56 | | $^\circ$ |
| t_s | Settling time | To 0.1%, $V_S = 5\text{ V}, 2\text{-V Step}, G = +1, C_L = 100\text{ pF}$ | | | 4 | | μs |
| | Overload recovery time | $V_{IN} \times \text{gain} > V_S$ | | | 10 | | μs |
| THD+N | Total harmonic distortion + noise | $G = +1, f = 1\text{ kHz}, V_O = 3.53\text{ }V_{RMS}, V_S = 36\text{ V}, R_L = 100\text{ k}\Omega, I_{OUT} \leq 50\ \mu\text{A}, \text{BW} = 80\text{ kHz}$ | | | 0.001% | | |
| OUTPUT | | | | | | | |
| V_O | Voltage output swing from rail | Positive Rail (V+) | | $I_{OUT} = -50\ \mu\text{A}$ | 1.35 | 1.5 | V |
| V_O | | | | $I_{OUT} = -1\text{ mA}$ | 1.4 | 1.6 | V |
| V_O | | | | $I_{OUT} = -5\text{ mA}$ | 1.5 | 1.75 | V |
| V_O | | Negative Rail (V-) | | $I_{OUT} = 50\ \mu\text{A}$ | 100 | 150 | mV |
| V_O | | | | $I_{OUT} = 1\text{ mA}$ | 0.75 | 1 | V |
| V_O | | | $V_S = 5\text{ V}, R_L \leq 10\text{ k}\Omega$ connected to (V-) | $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | 5 | 20 | mV |
| I_O | Output current | Source | $V_S = 15\text{ V}; V_O = V-; V_{ID} = 1\text{ V}$ | | -20 | -30 | mA |
| | | | | $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | -10 | | mA |
| | | Sink | $V_S = 15\text{ V}; V_O = V+; V_{ID} = -1\text{ V}$ | | 10 | 20 | mA |
| | | | | $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | 5 | | mA |
| | | $V_{ID} = -1\text{ V}; V_O = (V-) + 200\text{ mV}$ | | 50 | 85 | μA | |
| I_{SC} | Short-circuit current | $V_S = 20\text{ V}, (V+) = 10\text{ V}, (V-) = -10\text{ V}, V_O = 0\text{ V}$ | | | ± 40 | ± 60 | mA |
| C_{LOAD} | Capacitive load drive | | | | 100 | | pF |

6.6 Electrical Characteristics - LM2902B and LM2902BA (continued)

For $V_S = (V_{CC+}) - (V_{CC-}) = 5\text{ V to }36\text{ V}$ ($\pm 2.5\text{ V to } \pm 18\text{ V}$), at $T_A = 25^\circ\text{C}$, $V_{CM} = V_{OUT} = V_S / 2$, and $R_L = 10\text{k}$ connected to $V_S / 2$ (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP | MAX | UNIT |
|---------------------|---------------------------------|---------------------------------------|--|-----|-----|-----|---------------|
| R_O | Open-loop output impedance | $f = 1\text{ MHz}, I_O = 0\text{ A}$ | | | 300 | | Ω |
| POWER SUPPLY | | | | | | | |
| I_Q | Quiescent current per amplifier | $V_S = 5\text{ V}; I_O = 0\text{ A}$ | $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | | 175 | 300 | μA |
| | | $V_S = 36\text{ V}; I_O = 0\text{ A}$ | $T_A = -40^\circ\text{C to }125^\circ\text{C}$ | | 350 | 750 | μA |

6.7 Electrical Characteristics for LMx24 and LM324K

at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

| PARAMETER | TEST CONDITIONS ⁽¹⁾ | | T_A ⁽²⁾ | LM124, LM224 | | | LM324, LM324K | | | UNIT | | | |
|--|---|--|----------------------|------------------------------|--------------------|----------|---------------------|--------------------|----------|---------------|-----|-----|----|
| | | | | MIN | TYP ⁽³⁾ | MAX | MIN | TYP ⁽³⁾ | MAX | | | | |
| V_{IO} Input offset voltage | $V_{CC} = 5\text{ V to MAX}$, $V_{IC} = V_{ICRmin}$, $V_O = 1.4\text{ V}$ | | 25°C | 3 | | 5 | 3 | | 7 | mV | | | |
| | | | Full range | | | 7 | | | 9 | | | | |
| I_{IO} Input offset current | $V_O = 1.4\text{ V}$ | | 25°C | 2 | | 30 | 2 | | 50 | nA | | | |
| | | | Full range | | | 100 | | | 150 | | | | |
| I_{IB} Input bias current | $V_O = 1.4\text{ V}$ | | 25°C | -20 | | -150 | -20 | | -250 | nA | | | |
| | | | Full range | | | -300 | | | -500 | | | | |
| V_{ICR} Common-mode input voltage range | $V_{CC} = 5\text{ V to MAX}$ | | 25°C | 0 to $V_{CC} - 1.5$ | | | 0 to $V_{CC} - 1.5$ | | | V | | | |
| | | | Full range | 0 to $V_{CC} - 2$ | | | 0 to $V_{CC} - 2$ | | | | | | |
| V_{OH} High-level output voltage | $R_L = 2\text{ k}\Omega$ $V_{CC} = \text{MAX}$ | | 25°C | $V_{CC} - 1.5$ | | | $V_{CC} - 1.5$ | | | V | | | |
| | | | Full range | $R_L = 2\text{ k}\Omega$ | | 26 | | 26 | | | | | |
| | | | | $R_L \geq 10\text{ k}\Omega$ | | 27 | | 28 | | | 27 | | 28 |
| V_{OL} Low-level output voltage | $R_L \leq 10\text{ k}\Omega$ | | Full range | 5 | | 20 | 5 | | 20 | mV | | | |
| A_{VD} Large-signal differential voltage amplification | $V_{CC+} = 15\text{ V}$, $V_O = 1\text{ V to } 11\text{ V}$, $R_L \geq 2\text{ k}\Omega$ | | 25°C | 50 | | 100 | 25 | | 100 | V/mV | | | |
| | | | Full range | | | 25 | | | 15 | | | | |
| CMRR Common-mode rejection ratio | $V_{IC} = V_{ICRmin}$ | | 25°C | 70 | | 80 | 65 | | 80 | dB | | | |
| k_{SVR} Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$) | | | 25°C | 65 | | 100 | 65 | | 100 | dB | | | |
| V_{O1}/V_{O2} Crosstalk attenuation | $f = 1\text{ kHz to } 20\text{ kHz}$ | | 25°C | 120 | | | 120 | | | dB | | | |
| I_O Output current | $V_{CC} = 15\text{ V}$, $V_{ID} = 1\text{ V}$, $V_O = 0$ | | Source | 25°C | -20 | | -30 | -60 | -20 | | -30 | -60 | mA |
| | | | | Full range | | | -10 | | | -10 | | | |
| | $V_{CC} = 15\text{ V}$, $V_{ID} = -1\text{ V}$, $V_O = 15\text{ V}$ | | Sink | 25°C | 10 | | 20 | 10 | | 20 | | | |
| | | | | Full range | | | 5 | | | 5 | | | |
| $V_{ID} = -1\text{ V}$, $V_O = 200\text{ mV}$ | | | 25°C | 12 | | 30 | 12 | | 30 | μA | | | |
| I_{OS} Short-circuit output current | V_{CC} at 5 V , $V_O = 0$, V_{CC} at -5 V | | 25°C | ± 40 | | ± 60 | ± 40 | | ± 60 | mA | | | |
| I_{CC} Supply current (four amplifiers) | $V_O = 2.5\text{ V}$, no load | | Full range | 0.7 | | 1.2 | 0.7 | | 1.2 | mA | | | |
| | $V_{CC} = \text{MAX}$, $V_O = 0.5 V_{CC}$, no load | | Full range | 1.4 | | 3 | 1.4 | | 3 | | | | |

- (1) All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified. MAX V_{CC} for testing purposes is 26 V for LM2902 and 30 V for the others.
- (2) Full range is -55°C to $+125^\circ\text{C}$ for LM124, -25°C to $+85^\circ\text{C}$ for LM224, and 0°C to 70°C for LM324.
- (3) All typical values are at $T_A = 25^\circ\text{C}$.

6.8 Electrical Characteristics for LM2902 and LM2902V

at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

| PARAMETER | TEST CONDITIONS ⁽¹⁾ | | T_A ⁽²⁾ | LM2902 | | | LM2902V | | | UNIT |
|--|---|------------------------------|----------------------|---------------------|--------------------|---------------------|----------|------------------------------|-----|------|
| | | | | MIN | TYP ⁽³⁾ | MAX | MIN | TYP ⁽³⁾ | MAX | |
| V_{IO} Input offset voltage | $V_{CC} = 5\text{ V to MAX}$, $V_{IC} = V_{ICRmin}$, $V_O = 1.4\text{ V}$ | Non-A-suffix devices | 25°C | 3 | 7 | | 3 | 7 | mV | |
| | | | Full range | | 10 | | 10 | | | |
| | | A-suffix devices | 25°C | | | | 1 | 2 | | |
| | | | Full range | | | | | 4 | | |
| $\Delta V_{IO}/\Delta T$ Input offset voltage temperature drift | $R_S = 0\ \Omega$ | | Full range | | | | 7 | $\mu\text{V}/^\circ\text{C}$ | | |
| I_{IO} Input offset current | $V_O = 1.4\text{ V}$ | | 25°C | 2 | 50 | | 2 | 50 | nA | |
| | | | Full range | | 300 | | 150 | | | |
| $\Delta I_{IO}/\Delta T$ Input offset voltage temperature drift | | | Full range | | | | 10 | $\text{pA}/^\circ\text{C}$ | | |
| I_{IB} Input bias current | $V_O = 1.4\text{ V}$ | | 25°C | -20 | -250 | | -20 | -250 | nA | |
| | | | Full range | | -500 | | -500 | | | |
| V_{ICR} Common-mode input voltage range | $V_{CC} = 5\text{ V to MAX}$ | | 25°C | 0 to $V_{CC} - 1.5$ | | 0 to $V_{CC} - 1.5$ | | V | | |
| | | | Full range | 0 to $V_{CC} - 2$ | | 0 to $V_{CC} - 2$ | | | | |
| V_{OH} High-level output voltage | $R_L = 10\text{ k}\Omega$ | | 25°C | $V_{CC} - 1.5$ | | $V_{CC} - 1.5$ | | V | | |
| | $V_{CC} = \text{MAX}$ | $R_L = 2\text{ k}\Omega$ | Full range | 22 | | 26 | | | | |
| | | $R_L \geq 10\text{ k}\Omega$ | Full range | 23 | 24 | 27 | | | | |
| V_{OL} Low-level output voltage | $R_L \leq 10\text{ k}\Omega$ | | Full range | 5 | 20 | 5 | 20 | mV | | |
| A_{VD} Large-signal differential voltage amplification | $V_{CC} = 15\text{ V}$, $V_O = 1\text{ V to } 11\text{ V}$, $R_L \geq 2\text{ k}\Omega$ | | 25°C | 25 | 100 | 25 | 100 | V/mV | | |
| | | | Full range | 15 | | 15 | | | | |
| CMRR Common-mode rejection ratio | $V_{IC} = V_{ICRmin}$ | | 25°C | 50 | 80 | 60 | 80 | dB | | |
| k_{SVR} Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$) | | | 25°C | 50 | 100 | 60 | 100 | dB | | |
| V_{O1}/V_{O2} Crosstalk attenuation | $f = 1\text{ kHz to } 20\text{ kHz}$ | | 25°C | 120 | | 120 | | dB | | |
| I_O Output current | $V_{CC} = 15\text{ V}$, $V_{ID} = 1\text{ V}$, $V_O = 0$ | Source | 25°C | -20 | -30 | -60 | -20 | -30 | -60 | mA |
| | | | Full range | -10 | | -10 | | | | |
| | $V_{CC} = 15\text{ V}$, $V_{ID} = -1\text{ V}$, $V_O = 15\text{ V}$ | Sink | 25°C | 10 | 20 | | 10 | 20 | | |
| | | | Full range | 5 | | 5 | | | | |
| | $V_{ID} = -1\text{ V}$, $V_O = 200\text{ mV}$ | | 25°C | 30 | | 12 | 40 | μA | | |
| I_{OS} Short-circuit output current | V_{CC} at 5 V, $V_O = 0$, V_{CC} at -5 V | | 25°C | ± 40 | ± 60 | ± 40 | ± 60 | mA | | |
| I_{CC} Supply current (four amplifiers) | $V_O = 2.5\text{ V}$, no load | | Full range | 0.7 | 1.2 | 0.7 | 1.2 | mA | | |
| | $V_{CC} = \text{MAX}$, $V_O = 0.5 V_{CC}$, no load | | Full range | 1.4 | 3 | 1.4 | 3 | | | |

- (1) All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified. MAX V_{CC} for testing purposes is 26 V for LM2902 and 32 V for LM2902V.
- (2) Full range is -40°C to $+125^\circ\text{C}$ for LM2902.
- (3) All typical values are at $T_A = 25^\circ\text{C}$.

6.9 Electrical Characteristics for LMx24A and LM324KA

at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

| PARAMETER | TEST CONDITIONS ⁽¹⁾ | T_A ⁽²⁾ | LM124A | | | LM224A | | | LM324A, LM324KA | | | UNIT | |
|--|--|----------------------|------------------------------|--------------------|----------------|--------|--------------------|----------------|-----------------|--------------------|----------------|------|----|
| | | | MIN | TYP ⁽³⁾ | MAX | MIN | TYP ⁽³⁾ | MAX | MIN | TYP ⁽³⁾ | MAX | | |
| V_{IO} Input offset voltage | $V_{CC} = 5\text{ V to }30\text{ V}$, $V_{IC} = V_{ICRmin}$, $V_O = 1.4\text{ V}$ | 25°C | | | 2 | | 2 | 3 | | 2 | 3 | mV | |
| | | Full range | | | 4 | | | 4 | | | 5 | | |
| I_{IO} Input offset current | $V_O = 1.4\text{ V}$ | 25°C | | | 10 | | 2 | 15 | | 2 | 30 | nA | |
| | | Full range | | | 30 | | | 30 | | | 75 | | |
| I_{IB} Input bias current | $V_O = 1.4\text{ V}$ | 25°C | | | -50 | | -15 | -80 | | -15 | -100 | nA | |
| | | Full range | | | -100 | | | -100 | | | -200 | | |
| V_{ICR} Common-mode input voltage range | $V_{CC} = 30\text{ V}$ | 25°C | 0 to | | $V_{CC} - 1.5$ | 0 to | | $V_{CC} - 1.5$ | 0 to | | $V_{CC} - 1.5$ | V | |
| | | Full range | 0 to | | $V_{CC} - 2$ | 0 to | | $V_{CC} - 2$ | 0 to | | $V_{CC} - 2$ | | |
| V_{OH} High-level output voltage | $R_L = 2\text{ k}\Omega$ $V_{CC} = 30\text{ V}$ | 25°C | | | $V_{CC} - 1.5$ | | | $V_{CC} - 1.5$ | | | $V_{CC} - 1.5$ | V | |
| | | Full range | $R_L = 2\text{ k}\Omega$ | | 26 | | 26 | | 26 | | | | |
| | | | $R_L \geq 10\text{ k}\Omega$ | | 27 | | 27 | 28 | | 27 | 28 | | |
| V_{OL} Low-level output voltage | $R_L \leq 10\text{ k}\Omega$ | Full range | | | 20 | | 5 | 20 | | 5 | 20 | mV | |
| A_{VD} Large-signal differential voltage amplification | $V_{CC} = 15\text{ V}$, $V_O = 1\text{ V to }11\text{ V}$, $R_L \geq 2\text{ k}\Omega$ | 25°C | 50 | 100 | | 50 | 100 | | 25 | 100 | V/mV | | |
| | | Full range | 25 | | | 25 | | | 15 | | | | |
| CMRR Common-mode rejection ratio | $V_{IC} = V_{ICRmin}$ | 25°C | 70 | | | 70 | 80 | | 65 | 80 | dB | | |
| k_{SVR} Supply-voltage rejection ratio ($\Delta V_{CC} / \Delta V_{IO}$) | | 25°C | 65 | | | 65 | 100 | | 65 | 100 | dB | | |
| V_{O1} / V_{O2} Crosstalk attenuation | $f = 1\text{ kHz to }20\text{ kHz}$ | 25°C | | 120 | | | 120 | | | 120 | dB | | |
| I_O Output current | $V_{CC} = 15\text{ V}$, $V_{ID} = 1\text{ V}$, $V_O = 0$ | Source | 25°C | | -20 | | -20 | -30 | -60 | -20 | -30 | -60 | mA |
| | | | Full range | | | -10 | | | -10 | | | -10 | |
| | $V_{CC} = 15\text{ V}$, $V_{ID} = -1\text{ V}$, $V_O = 15\text{ V}$ | Sink | 25°C | | 10 | | 10 | 20 | | 1 | 20 | | |
| | | | Full range | | | 5 | | 5 | | 5 | | | |
| | $V_{ID} = -1\text{ V}$, $V_O = 200\text{ mV}$ | 25°C | | 12 | | 12 | 30 | | 12 | 30 | μA | | |
| I_{OS} Short-circuit output current | V_{CC} at 5 V, V_{CC} - at -5 V, $V_O = 0$ | 25°C | | ± 40 | ± 60 | | ± 40 | ± 60 | | ± 40 | ± 60 | mA | |
| I_{CC} Supply current (four amplifiers) | $V_O = 2.5\text{ V}$, no load | Full range | | 0.7 | 1.2 | | 0.7 | 1.2 | | 0.7 | 1.2 | mA | |
| | $V_{CC} = 30\text{ V}$, $V_O = 15\text{ V}$, no load | Full range | | 1.4 | 3. | | 1.4 | 3 | | 1.4 | 3 | | |

- (1) All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified.
 (2) Full range is -55°C to +125°C for LM124A, -25°C to +85°C for LM224A, and 0°C to 70°C for LM324A.
 (3) All typical values are at $T_A = 25^\circ\text{C}$.

6.10 Operating Conditions

$V_{CC} = \pm 15\text{ V}$, $T_A = 25^\circ\text{C}$

| PARAMETER | TEST CONDITIONS | TYP | UNIT |
|--------------------------------------|--|-----|------------------------|
| SR Slew rate at unity gain | $R_L = 1\text{ M}\Omega$, $C_L = 30\text{ pF}$, $V_I = \pm 10\text{ V}$ (see Figure 7-1) | 0.5 | V/ μs |
| B_1 Unity-gain bandwidth | $R_L = 1\text{ M}\Omega$, $C_L = 20\text{ pF}$ (see Figure 7-1) | 1.2 | MHz |
| V_n Equivalent input noise voltage | $R_S = 100\ \Omega$, $V_I = 0\text{ V}$, $f = 1\text{ kHz}$ (see Figure 7-2) | 35 | nV/ $\sqrt{\text{Hz}}$ |

6.11 Typical Characteristics: All Devices Except B and BA versions

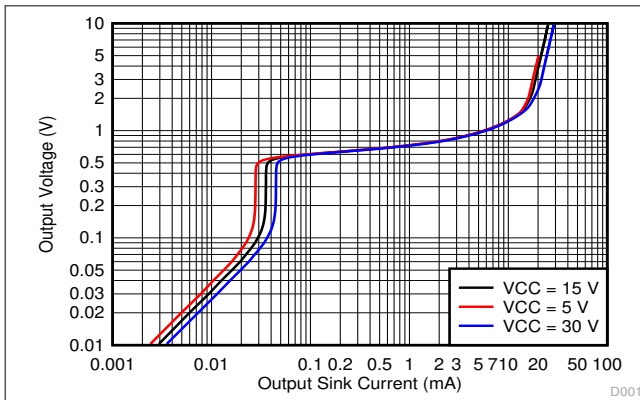


Figure 6-1. Output Sinking Characteristics

D001

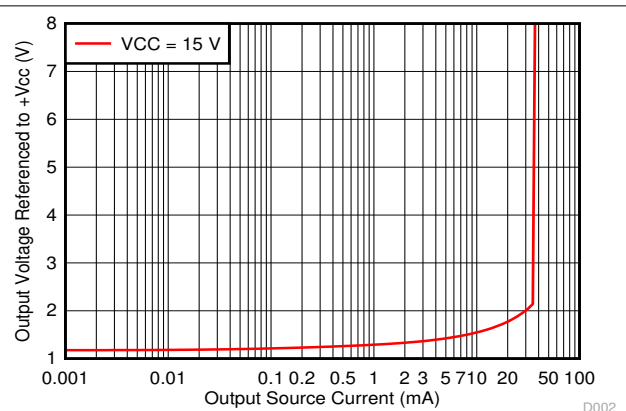


Figure 6-2. Output Sourcing Characteristics

D002

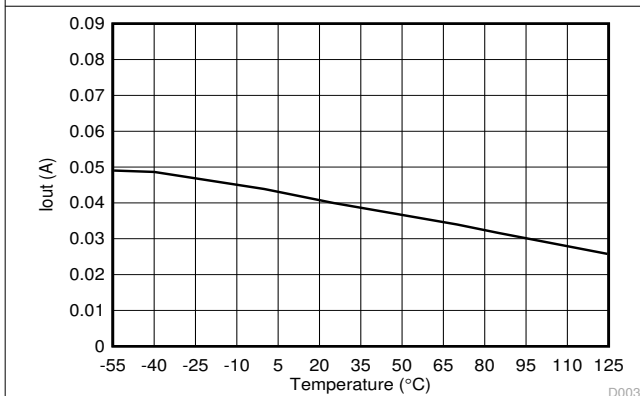


Figure 6-3. Source Current Limiting

D003

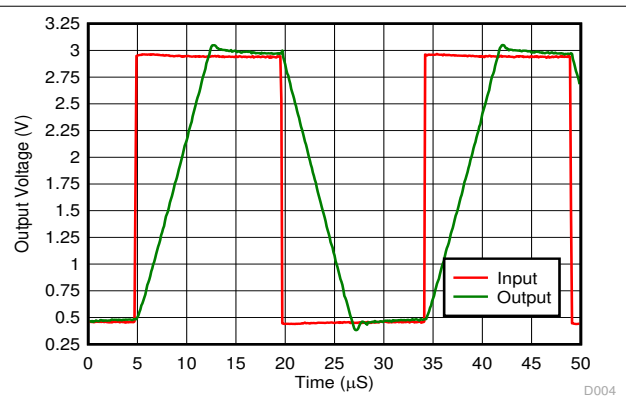


Figure 6-4. Voltage Follower Large Signal Response (50 pF)

D004

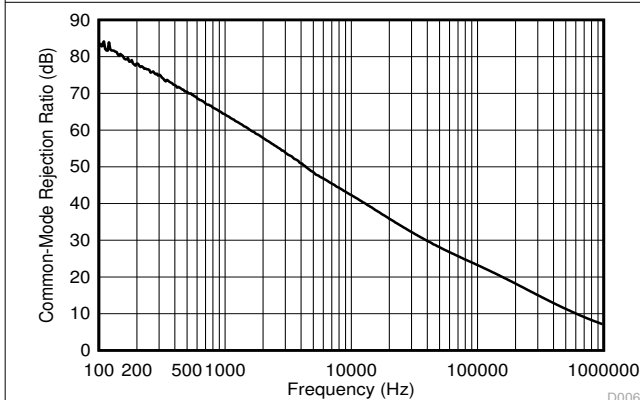


Figure 6-5. Common-Mode Rejection Ratio

D006

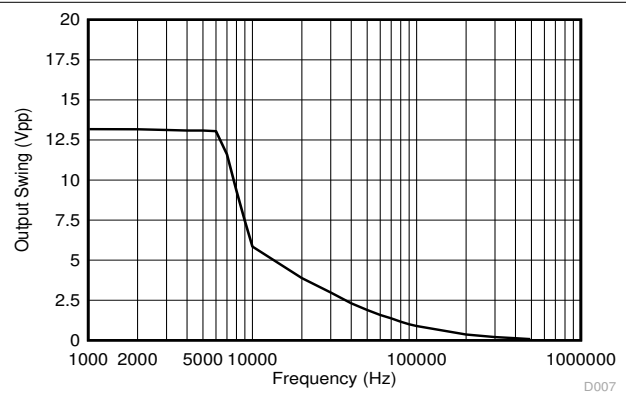


Figure 6-6. Maximum Output Swing vs. Frequency (VCC = 15 V)

D007

7 Parameter Measurement Information

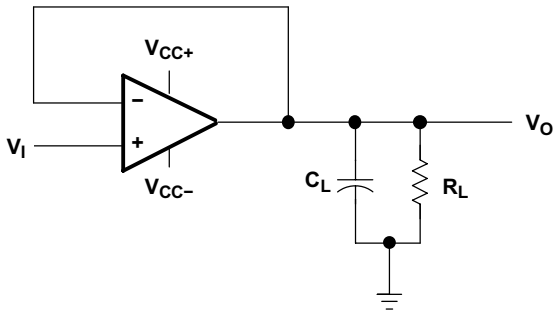


Figure 7-1. Unity-Gain Amplifier

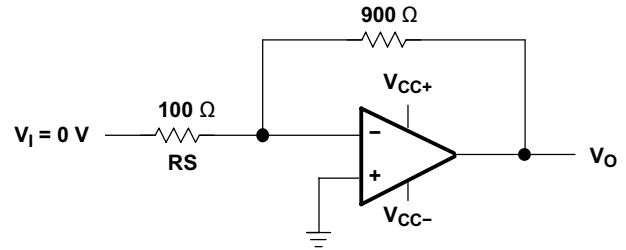


Figure 7-2. Noise-Test Circuit

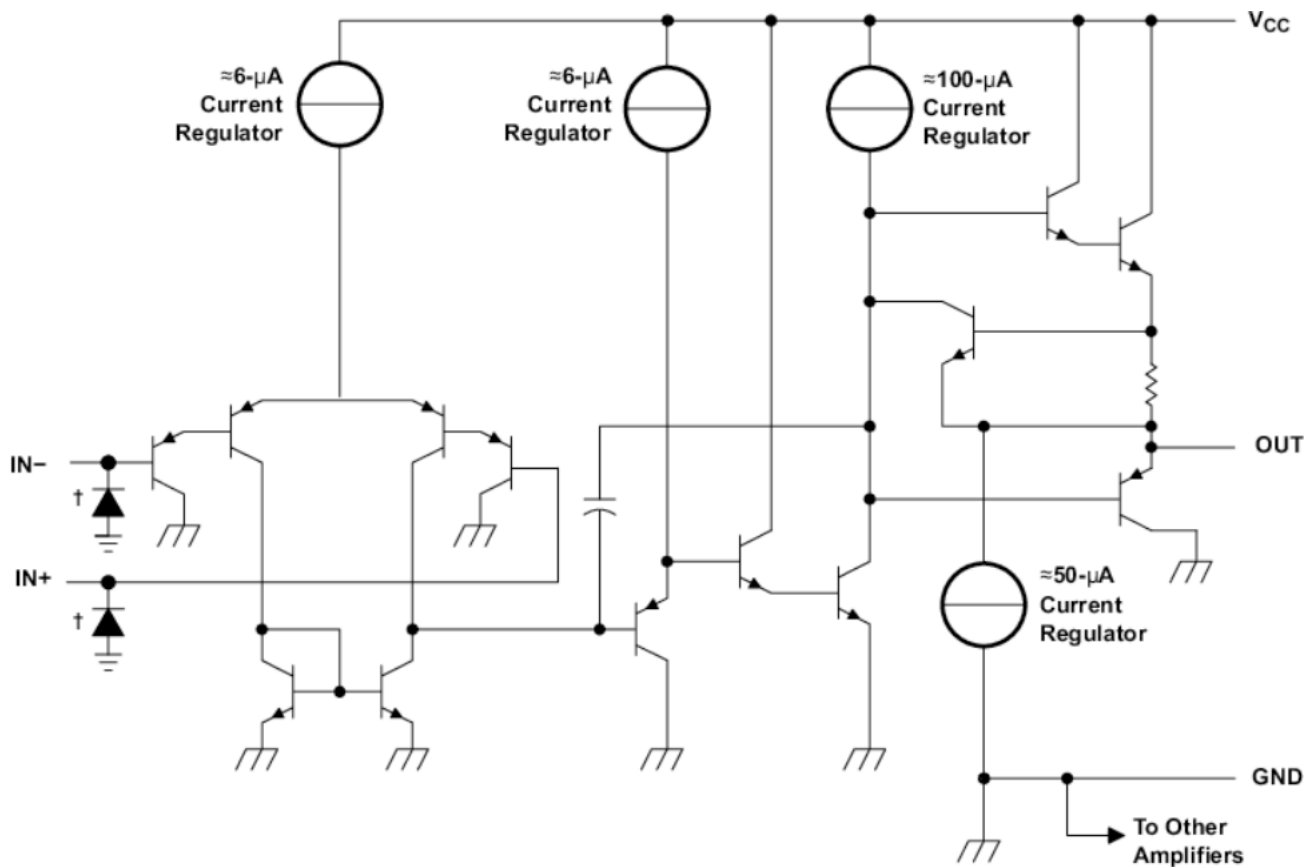
8 Detailed Description

8.1 Overview

These devices consist of four independent high-gain frequency-compensated operational amplifiers that are designed specifically to operate from a single supply over a wide range of voltages. Operation from split supplies also is possible if the difference between the two supplies is 3 V to 36 V (B and BA versions), 3 V to 26 V (for LM2902 devices) or 3 V to 30V (for all other devices), and V_{CC} is at least 1.5 V more positive than the input common-mode voltage. The low supply-current drain is independent of the magnitude of the supply voltage.

Applications include transducer amplifiers, DC amplification blocks, and all the conventional operational-amplifier circuits that now can be more easily implemented in single-supply-voltage systems. For example, the LM124 device can be operated directly from the standard 5-V supply that is used in digital systems and provides the required interface electronics, without requiring additional ± 15 -V supplies.

8.2 Functional Block Diagram



| COMPONENT COUNT (total device) | |
|-----------------------------------|----|
| Epi-FET | 1 |
| Transistors | 95 |
| Diodes | 4 |
| Resistors | 11 |
| Capacitors | 4 |

ESD protection cells - available on B, BA, and K versions only

8.3 Feature Description

8.3.1 Unity-Gain Bandwidth

Gain bandwidth product is found by multiplying the measured bandwidth of an amplifier by the gain at which that bandwidth was measured. These devices have a high gain bandwidth of 1.2 MHz.

8.3.2 Slew Rate

The slew rate is the rate at which an operational amplifier can change its output when there is a change on the input. These devices have a 0.5-V/ μ s slew rate.

8.3.3 Input Common Mode Range

The valid common mode range is from device ground to $V_{CC} - 1.5$ V ($V_{CC} - 2$ V across temperature). Inputs may exceed V_{CC} up to the maximum V_{CC} without device damage. At least one input must be in the valid input common mode range for output to be correct phase. If both inputs exceed valid range then output phase is undefined. If either input is less than -0.3 V then input current should be limited to 1 mA and output phase is undefined.

8.4 Device Functional Modes

These devices are powered on when the supply is connected. This device can be operated as a single supply operational amplifier or dual supply amplifier depending on the application.

9 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, as well as validating and testing their design implementation to confirm system functionality.

9.1 Application Information

The LMx24 and LM2902 operational amplifiers are useful in a wide range of signal conditioning applications. Inputs can be powered before VCC for flexibility in multiple supply circuits.

9.2 Typical Application

A typical application for an operational amplifier is an inverting amplifier. This amplifier takes a positive voltage on the input, and makes it a negative voltage of the same magnitude. In the same manner, it also makes negative voltages positive.

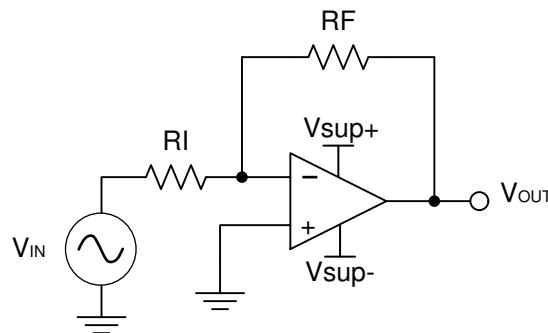


Figure 9-1. Application Schematic

9.2.1 Design Requirements

The supply voltage must be chosen such that it is larger than the input voltage range and output range. For instance, this application will scale a signal of ± 0.5 V to ± 1.8 V. Setting the supply at ± 12 V is sufficient to accommodate this application.

9.2.2 Detailed Design Procedure

Determine the gain required by the inverting amplifier using [Equation 1](#) and [Equation 2](#):

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

$$A_v = \frac{1.8}{-0.5} = -3.6 \quad (2)$$

Once the desired gain is determined, choose a value for R_I or R_F . Choosing a value in the kilohm range is desirable because the amplifier circuit will use currents in the milliamp range. This ensures the part will not draw too much current. This example will choose 10 k Ω for R_I which means 36 k Ω will be used for R_F . This was determined by [Equation 3](#).

$$A_v = -\frac{R_F}{R_I} \quad (3)$$

9.2.3 Application Curve

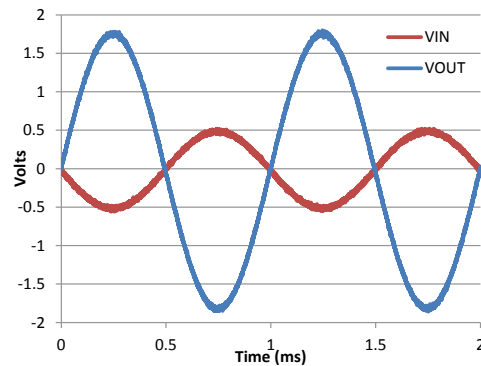


Figure 9-2. Input and Output Voltages of the Inverting Amplifier

10 Power Supply Recommendations

CAUTION

Supply voltages larger than 32 V for a single supply, or outside the range of ± 16 V for a dual supply can permanently damage the device (see the [Section 6.1](#)).

Place 0.1- μ 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, refer to the [Section 11](#).

11 Layout

11.1 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, as well as 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- μ 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 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 it is not possible to keep them separate, it is much better to cross the sensitive trace perpendicular as opposed to in parallel with the noisy trace.
- Place the external components as close to the device as possible. Keeping RF and RG close to the inverting input minimizes parasitic capacitance, as shown in [Section 11.2](#).
- 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.

11.2 Layout Examples

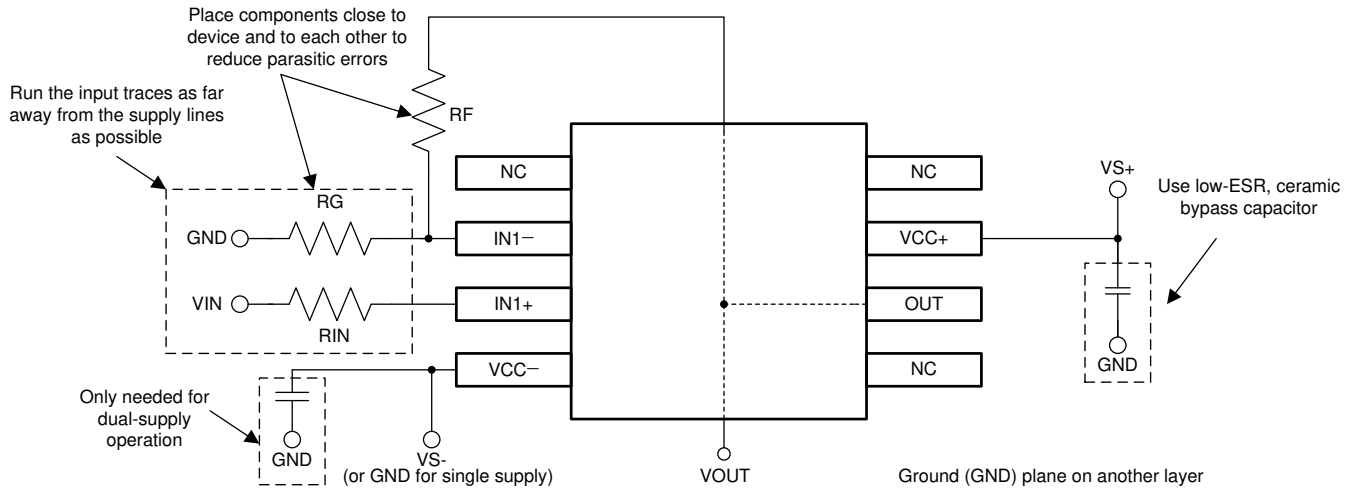


Figure 11-1. Operational Amplifier Board Layout for Noninverting Configuration

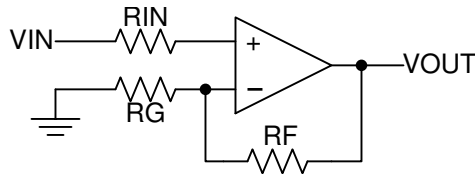


Figure 11-2. Operational Amplifier Schematic for Noninverting Configuration

12 Device and Documentation Support

12.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

12.2 Support Resources

TI E2E™ [support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

12.3 Trademarks

TI E2E™ is a trademark of Texas Instruments.
All trademarks are the property of their respective owners.

12.4 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

12.5 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

13 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 (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|------------------|--------------------------------------|----------------------|--------------|------------------------------------|-------------------------|
| 5962-7704301VCA | ACTIVE | CDIP | J | 14 | 1 | Non-RoHS & Green | SNPB | N / A for Pkg Type | -55 to 125 | 5962-7704301VC A LM124JQMLV | Samples |
| 5962-9950403V9B | ACTIVE | XCEPT | KGD | 0 | 100 | RoHS & Green | Call TI | N / A for Pkg Type | -55 to 125 | | Samples |
| 5962-9950403VCA | ACTIVE | CDIP | J | 14 | 1 | Non-RoHS & Green | SNPB | N / A for Pkg Type | -55 to 125 | 5962-9950403VC A LM124AJQMLV | Samples |
| 77043012A | ACTIVE | LCCC | FK | 20 | 1 | Non-RoHS & Green | SNPB | N / A for Pkg Type | -55 to 125 | 77043012A LM124FKB | Samples |
| 7704301CA | ACTIVE | CDIP | J | 14 | 1 | Non-RoHS & Green | SNPB | N / A for Pkg Type | -55 to 125 | 7704301CA LM124JB | Samples |
| 7704301DA | ACTIVE | CFP | W | 14 | 1 | Non-RoHS & Green | SNPB | N / A for Pkg Type | -55 to 125 | 7704301DA LM124WB | Samples |
| 77043022A | ACTIVE | LCCC | FK | 20 | 1 | Non-RoHS & Green | SNPB | N / A for Pkg Type | -55 to 125 | 77043022A LM124AFKB | Samples |
| 7704302CA | ACTIVE | CDIP | J | 14 | 1 | Non-RoHS & Green | SNPB | N / A for Pkg Type | -55 to 125 | 7704302CA LM124AJB | Samples |
| 7704302DA | ACTIVE | CFP | W | 14 | 1 | Non-RoHS & Green | SNPB | N / A for Pkg Type | -55 to 125 | 7704302DA LM124AWB | Samples |
| JM38510/11005BCA | ACTIVE | CDIP | J | 14 | 1 | Non-RoHS & Green | SNPB | N / A for Pkg Type | -55 to 125 | JM38510 /11005BCA | Samples |
| LM124AFKB | ACTIVE | LCCC | FK | 20 | 1 | Non-RoHS & Green | SNPB | N / A for Pkg Type | -55 to 125 | 77043022A LM124AFKB | Samples |
| LM124AJ | ACTIVE | CDIP | J | 14 | 1 | Non-RoHS & Green | SNPB | N / A for Pkg Type | -55 to 125 | LM124AJ | Samples |
| LM124AJB | ACTIVE | CDIP | J | 14 | 1 | Non-RoHS & Green | SNPB | N / A for Pkg Type | -55 to 125 | 7704302CA LM124AJB | Samples |
| LM124AWB | ACTIVE | CFP | W | 14 | 1 | Non-RoHS & Green | SNPB | N / A for Pkg Type | -55 to 125 | 7704302DA LM124AWB | Samples |
| LM124D | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -55 to 125 | LM124 | Samples |
| LM124DG4 | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -55 to 125 | LM124 | Samples |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|------------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| LM124DR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -55 to 125 | LM124 | Samples |
| LM124DRG4 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -55 to 125 | LM124 | Samples |
| LM124FKB | ACTIVE | LCCC | FK | 20 | 1 | Non-RoHS & Green | SNPB | N / A for Pkg Type | -55 to 125 | 77043012A LM124FKB | Samples |
| LM124J | ACTIVE | CDIP | J | 14 | 1 | Non-RoHS & Green | SNPB | N / A for Pkg Type | -55 to 125 | LM124J | Samples |
| LM124JB | ACTIVE | CDIP | J | 14 | 1 | Non-RoHS & Green | SNPB | N / A for Pkg Type | -55 to 125 | 7704301CA LM124JB | Samples |
| LM124W | ACTIVE | CFP | W | 14 | 1 | Non-RoHS & Green | SNPB | N / A for Pkg Type | -55 to 125 | LM124W | Samples |
| LM124WB | ACTIVE | CFP | W | 14 | 1 | Non-RoHS & Green | SNPB | N / A for Pkg Type | -55 to 125 | 7704301DA LM124WB | Samples |
| LM224AD | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -25 to 85 | LM224A | Samples |
| LM224ADR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU SN | Level-1-260C-UNLIM | -25 to 85 | LM224A | Samples |
| LM224ADRE4 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -25 to 85 | LM224A | Samples |
| LM224ADRG4 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -25 to 85 | LM224A | Samples |
| LM224AN | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | -25 to 85 | LM224AN | Samples |
| LM224D | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -25 to 85 | LM224 | Samples |
| LM224DG4 | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -25 to 85 | LM224 | Samples |
| LM224DR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU SN | Level-1-260C-UNLIM | -25 to 85 | LM224 | Samples |
| LM224DRG3 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | SN | Level-1-260C-UNLIM | -25 to 85 | LM224 | Samples |
| LM224DRG4 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -25 to 85 | LM224 | Samples |
| LM224KAD | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -25 to 85 | LM224KA | Samples |
| LM224KADG4 | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -25 to 85 | LM224KA | Samples |
| LM224KADR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -25 to 85 | LM224KA | Samples |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| LM224KADRG4 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -25 to 85 | LM224KA | Samples |
| LM224KAN | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | -25 to 85 | LM224KAN | Samples |
| LM224KDR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -25 to 85 | LM224K | Samples |
| LM224KDRG4 | ACTIVE | SOIC | D | 14 | 2500 | TBD | Call TI | Call TI | -25 to 85 | | Samples |
| LM224KN | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | -25 to 85 | LM224KN | Samples |
| LM224N | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | -25 to 85 | LM224N | Samples |
| LM224NE4 | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | -25 to 85 | LM224N | Samples |
| LM2902D | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | LM2902 | Samples |
| LM2902DR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU SN | Level-1-260C-UNLIM | -40 to 125 | LM2902 | Samples |
| LM2902DRE4 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | LM2902 | Samples |
| LM2902DRG3 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | SN | Level-1-260C-UNLIM | -40 to 125 | LM2902 | Samples |
| LM2902DRG4 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | LM2902 | Samples |
| LM2902KAVQDR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | L2902KA | Samples |
| LM2902KAVQDRG4 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | L2902KA | Samples |
| LM2902KAVQPWR | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | L2902KA | Samples |
| LM2902KAVQPWRG4 | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | L2902KA | Samples |
| LM2902KD | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | LM2902K | Samples |
| LM2902KDB | ACTIVE | SSOP | DB | 14 | 80 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | L2902K | Samples |
| LM2902KDG4 | ACTIVE | SOIC | D | 14 | 50 | TBD | Call TI | Call TI | -40 to 125 | | Samples |
| LM2902KDR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | LM2902K | Samples |
| LM2902KN | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | -40 to 125 | LM2902KN | Samples |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| LM2902KNSR | ACTIVE | SO | NS | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | LM2902K | Samples |
| LM2902KNSRG4 | ACTIVE | SO | NS | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | LM2902K | Samples |
| LM2902KPW | ACTIVE | TSSOP | PW | 14 | 90 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | L2902K | Samples |
| LM2902KPWE4 | ACTIVE | TSSOP | PW | 14 | 90 | TBD | Call TI | Call TI | -40 to 125 | | Samples |
| LM2902KPWR | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | L2902K | Samples |
| LM2902KVQDR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | L2902KV | Samples |
| LM2902KVQDRG4 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | L2902KV | Samples |
| LM2902KVQPWR | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | L2902KV | Samples |
| LM2902KVQPWRG4 | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | L2902KV | Samples |
| LM2902N | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU SN | N / A for Pkg Type | -40 to 125 | LM2902N | Samples |
| LM2902NE4 | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | -40 to 125 | LM2902N | Samples |
| LM2902NSR | ACTIVE | SO | NS | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | LM2902 | Samples |
| LM2902PW | ACTIVE | TSSOP | PW | 14 | 90 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | L2902 | Samples |
| LM2902PWR | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU SN | Level-1-260C-UNLIM | -40 to 125 | L2902 | Samples |
| LM2902PWRE4 | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | L2902 | Samples |
| LM2902PWRG3 | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | SN | Level-1-260C-UNLIM | -40 to 125 | L2902 | Samples |
| LM2902PWRG4 | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | L2902 | Samples |
| LM324AD | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324A | Samples |
| LM324ADBR | ACTIVE | SSOP | DB | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324A | Samples |
| LM324ADE4 | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324A | Samples |
| LM324ADR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU SN | Level-1-260C-UNLIM | 0 to 70 | LM324A | Samples |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| LM324ADRE4 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324A | Samples |
| LM324ADRG4 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324A | Samples |
| LM324AN | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | 0 to 70 | LM324AN | Samples |
| LM324ANSR | ACTIVE | SO | NS | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324A | Samples |
| LM324ANSRG4 | ACTIVE | SO | NS | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324A | Samples |
| LM324APW | ACTIVE | TSSOP | PW | 14 | 90 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | L324A | Samples |
| LM324APWE4 | ACTIVE | TSSOP | PW | 14 | 90 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | L324A | Samples |
| LM324APWR | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU SN | Level-1-260C-UNLIM | 0 to 70 | L324A | Samples |
| LM324APWRG4 | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | L324A | Samples |
| LM324D | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324 | Samples |
| LM324DE4 | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324 | Samples |
| LM324DG4 | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324 | Samples |
| LM324DR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU SN | Level-1-260C-UNLIM | 0 to 70 | LM324 | Samples |
| LM324DRE4 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324 | Samples |
| LM324DRG3 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | SN | Level-1-260C-UNLIM | 0 to 70 | LM324 | Samples |
| LM324DRG4 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324 | Samples |
| LM324KAD | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324KA | Samples |
| LM324KADR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324KA | Samples |
| LM324KADRG4 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324KA | Samples |
| LM324KAN | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | 0 to 70 | LM324KAN | Samples |
| LM324KANSR | ACTIVE | SO | NS | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324KA | Samples |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|------------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| LM324KAPW | ACTIVE | TSSOP | PW | 14 | 90 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | L324KA | Samples |
| LM324KAPWR | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | L324KA | Samples |
| LM324KAPWRG4 | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | L324KA | Samples |
| LM324KDR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324K | Samples |
| LM324KN | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | 0 to 70 | LM324KN | Samples |
| LM324KNSR | ACTIVE | SO | NS | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324K | Samples |
| LM324KPW | ACTIVE | TSSOP | PW | 14 | 90 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | L324K | Samples |
| LM324KPWR | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | L324K | Samples |
| LM324N | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU SN | N / A for Pkg Type | 0 to 70 | LM324N | Samples |
| LM324NE3 | ACTIVE | PDIP | N | 14 | 25 | RoHS & Non-Green | SN | N / A for Pkg Type | 0 to 70 | LM324N | Samples |
| LM324NE4 | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | 0 to 70 | LM324N | Samples |
| LM324NSR | ACTIVE | SO | NS | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324 | Samples |
| LM324NSRE4 | ACTIVE | SO | NS | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324 | Samples |
| LM324NSRG4 | ACTIVE | SO | NS | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | LM324 | Samples |
| LM324PW | ACTIVE | TSSOP | PW | 14 | 90 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | L324 | Samples |
| LM324PWR | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU SN | Level-1-260C-UNLIM | 0 to 70 | L324 | Samples |
| LM324PWRE4 | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | L324 | Samples |
| LM324PWRG3 | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | SN | Level-1-260C-UNLIM | 0 to 70 | L324 | Samples |
| LM324PWRG4 | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | L324 | Samples |
| M38510/11005BCA | ACTIVE | CDIP | J | 14 | 1 | Non-RoHS & Green | SNPB | N / A for Pkg Type | -55 to 125 | JM38510 /11005BCA | Samples |
| PLM2902BIPWR | ACTIVE | TSSOP | PW | 14 | 3000 | TBD | Call TI | Call TI | -40 to 125 | | Samples |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|---------|
| PLM324BIPWR | ACTIVE | TSSOP | PW | 14 | 3000 | TBD | Call TI | Call TI | -40 to 85 | | Samples |

(1) 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.

OBSOLETE: TI has discontinued the production of the device.

(2) **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.

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

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

(5) 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.

(6) 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.

Important Information and Disclaimer:The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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 LM124, LM124-SP, LM124M, LM2902, LM2902B :

- Catalog : [LM124](#), [LM124](#)

- Automotive : [LM2902-Q1](#), [LM2902B-Q1](#)
- Enhanced Product : [LM2902-EP](#)
- Military : [LM124M](#), [LM124M](#)
- Space : [LM124-SP](#), [LM124-SP](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects
- Enhanced Product - Supports Defense, Aerospace and Medical Applications
- Military - QML certified for Military and Defense Applications
- Space - Radiation tolerant, ceramic packaging and qualified for use in Space-based application

TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*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 |
|------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LM124DR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM224ADR | SOIC | D | 14 | 2500 | 330.0 | 16.8 | 6.5 | 9.5 | 2.1 | 8.0 | 16.0 | Q1 |
| LM224ADR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM224ADRG4 | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM224ADRG4 | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM224DR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM224DR | SOIC | D | 14 | 2500 | 330.0 | 16.8 | 6.5 | 9.5 | 2.1 | 8.0 | 16.0 | Q1 |
| LM224DRG3 | SOIC | D | 14 | 2500 | 330.0 | 17.5 | 6.4 | 9.05 | 2.1 | 8.0 | 16.0 | Q1 |
| LM224DRG3 | SOIC | D | 14 | 2500 | 330.0 | 16.8 | 6.5 | 9.5 | 2.1 | 8.0 | 16.0 | Q1 |
| LM224DRG4 | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM224KADR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM224KADR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM2902DR | SOIC | D | 14 | 2500 | 330.0 | 16.8 | 6.5 | 9.5 | 2.1 | 8.0 | 16.0 | Q1 |
| LM2902DR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM2902DR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM2902DRG3 | SOIC | D | 14 | 2500 | 330.0 | 16.8 | 6.5 | 9.5 | 2.1 | 8.0 | 16.0 | Q1 |

| 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 |
|-----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LM2902DRG4 | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM2902DRG4 | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM2902KAVQPWR | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| LM2902KAVQPWRG4 | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| LM2902KDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM2902KNSR | SO | NS | 14 | 2000 | 330.0 | 16.4 | 8.2 | 10.5 | 2.5 | 12.0 | 16.0 | Q1 |
| LM2902KPWR | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| LM2902KVQPWR | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| LM2902KVQPWRG4 | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| LM2902NSR | SO | NS | 14 | 2000 | 330.0 | 16.4 | 8.2 | 10.5 | 2.5 | 12.0 | 16.0 | Q1 |
| LM2902PWR | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| LM2902PWR | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| LM2902PWRG3 | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| LM2902PWRG4 | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| LM324ADBR | SSOP | DB | 14 | 2000 | 330.0 | 16.4 | 8.35 | 6.6 | 2.4 | 12.0 | 16.0 | Q1 |
| LM324ADR | SOIC | D | 14 | 2500 | 330.0 | 16.8 | 6.5 | 9.5 | 2.1 | 8.0 | 16.0 | Q1 |
| LM324ADR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM324ADRG4 | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM324ANSR | SO | NS | 14 | 2000 | 330.0 | 16.4 | 8.2 | 10.5 | 2.5 | 12.0 | 16.0 | Q1 |
| LM324APWR | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| LM324APWR | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| LM324APWRG4 | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| LM324DR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM324DR | SOIC | D | 14 | 2500 | 330.0 | 16.8 | 6.5 | 9.5 | 2.1 | 8.0 | 16.0 | Q1 |
| LM324DRG3 | SOIC | D | 14 | 2500 | 330.0 | 17.5 | 6.4 | 9.05 | 2.1 | 8.0 | 16.0 | Q1 |
| LM324DRG3 | SOIC | D | 14 | 2500 | 330.0 | 16.8 | 6.5 | 9.5 | 2.1 | 8.0 | 16.0 | Q1 |
| LM324DRG4 | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM324DRG4 | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM324KADR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM324KANSR | SO | NS | 14 | 2000 | 330.0 | 16.4 | 8.2 | 10.5 | 2.5 | 12.0 | 16.0 | Q1 |
| LM324KAPWR | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| LM324KDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| LM324KNSR | SO | NS | 14 | 2000 | 330.0 | 16.4 | 8.2 | 10.5 | 2.5 | 12.0 | 16.0 | Q1 |
| LM324KPWR | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| LM324NSR | SO | NS | 14 | 2000 | 330.0 | 16.4 | 8.2 | 10.5 | 2.5 | 12.0 | 16.0 | Q1 |
| LM324PWR | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| LM324PWR | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| LM324PWRG3 | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| LM324PWRG4 | 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) |
|------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LM124DR | SOIC | D | 14 | 2500 | 350.0 | 350.0 | 43.0 |
| LM224ADR | SOIC | D | 14 | 2500 | 364.0 | 364.0 | 27.0 |
| LM224ADR | SOIC | D | 14 | 2500 | 356.0 | 356.0 | 35.0 |
| LM224ADRG4 | SOIC | D | 14 | 2500 | 356.0 | 356.0 | 35.0 |
| LM224ADRG4 | SOIC | D | 14 | 2500 | 340.5 | 336.1 | 32.0 |
| LM224DR | SOIC | D | 14 | 2500 | 356.0 | 356.0 | 35.0 |
| LM224DR | SOIC | D | 14 | 2500 | 364.0 | 364.0 | 27.0 |
| LM224DRG3 | SOIC | D | 14 | 2500 | 333.2 | 345.9 | 28.6 |
| LM224DRG3 | SOIC | D | 14 | 2500 | 364.0 | 364.0 | 27.0 |
| LM224DRG4 | SOIC | D | 14 | 2500 | 356.0 | 356.0 | 35.0 |
| LM224KADR | SOIC | D | 14 | 2500 | 356.0 | 356.0 | 35.0 |
| LM224KDR | SOIC | D | 14 | 2500 | 356.0 | 356.0 | 35.0 |
| LM2902DR | SOIC | D | 14 | 2500 | 364.0 | 364.0 | 27.0 |
| LM2902DR | SOIC | D | 14 | 2500 | 356.0 | 356.0 | 35.0 |
| LM2902DR | SOIC | D | 14 | 2500 | 340.5 | 336.1 | 32.0 |
| LM2902DRG3 | SOIC | D | 14 | 2500 | 364.0 | 364.0 | 27.0 |
| LM2902DRG4 | SOIC | D | 14 | 2500 | 340.5 | 336.1 | 32.0 |
| LM2902DRG4 | SOIC | D | 14 | 2500 | 356.0 | 356.0 | 35.0 |

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|-----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LM2902KAVQPWR | TSSOP | PW | 14 | 2000 | 356.0 | 356.0 | 35.0 |
| LM2902KAVQPWRG4 | TSSOP | PW | 14 | 2000 | 367.0 | 367.0 | 35.0 |
| LM2902KDR | SOIC | D | 14 | 2500 | 356.0 | 356.0 | 35.0 |
| LM2902KNSR | SO | NS | 14 | 2000 | 356.0 | 356.0 | 35.0 |
| LM2902KPWR | TSSOP | PW | 14 | 2000 | 356.0 | 356.0 | 35.0 |
| LM2902KVQPWR | TSSOP | PW | 14 | 2000 | 356.0 | 356.0 | 35.0 |
| LM2902KVQPWRG4 | TSSOP | PW | 14 | 2000 | 356.0 | 356.0 | 35.0 |
| LM2902NSR | SO | NS | 14 | 2000 | 356.0 | 356.0 | 35.0 |
| LM2902PWR | TSSOP | PW | 14 | 2000 | 364.0 | 364.0 | 27.0 |
| LM2902PWR | TSSOP | PW | 14 | 2000 | 356.0 | 356.0 | 35.0 |
| LM2902PWRG3 | TSSOP | PW | 14 | 2000 | 364.0 | 364.0 | 27.0 |
| LM2902PWRG4 | TSSOP | PW | 14 | 2000 | 356.0 | 356.0 | 35.0 |
| LM324ADBR | SSOP | DB | 14 | 2000 | 356.0 | 356.0 | 35.0 |
| LM324ADR | SOIC | D | 14 | 2500 | 364.0 | 364.0 | 27.0 |
| LM324ADR | SOIC | D | 14 | 2500 | 356.0 | 356.0 | 35.0 |
| LM324ADRG4 | SOIC | D | 14 | 2500 | 356.0 | 356.0 | 35.0 |
| LM324ANSR | SO | NS | 14 | 2000 | 356.0 | 356.0 | 35.0 |
| LM324APWR | TSSOP | PW | 14 | 2000 | 364.0 | 364.0 | 27.0 |
| LM324APWR | TSSOP | PW | 14 | 2000 | 356.0 | 356.0 | 35.0 |
| LM324APWRG4 | TSSOP | PW | 14 | 2000 | 356.0 | 356.0 | 35.0 |
| LM324DR | SOIC | D | 14 | 2500 | 356.0 | 356.0 | 35.0 |
| LM324DR | SOIC | D | 14 | 2500 | 364.0 | 364.0 | 27.0 |
| LM324DRG3 | SOIC | D | 14 | 2500 | 333.2 | 345.9 | 28.6 |
| LM324DRG3 | SOIC | D | 14 | 2500 | 364.0 | 364.0 | 27.0 |
| LM324DRG4 | SOIC | D | 14 | 2500 | 340.5 | 336.1 | 32.0 |
| LM324DRG4 | SOIC | D | 14 | 2500 | 356.0 | 356.0 | 35.0 |
| LM324KADR | SOIC | D | 14 | 2500 | 356.0 | 356.0 | 35.0 |
| LM324KANSR | SO | NS | 14 | 2000 | 356.0 | 356.0 | 35.0 |
| LM324KAPWR | TSSOP | PW | 14 | 2000 | 356.0 | 356.0 | 35.0 |
| LM324KDR | SOIC | D | 14 | 2500 | 356.0 | 356.0 | 35.0 |
| LM324KNSR | SO | NS | 14 | 2000 | 356.0 | 356.0 | 35.0 |
| LM324KPWR | TSSOP | PW | 14 | 2000 | 356.0 | 356.0 | 35.0 |
| LM324NSR | SO | NS | 14 | 2000 | 356.0 | 356.0 | 35.0 |
| LM324PWR | TSSOP | PW | 14 | 2000 | 364.0 | 364.0 | 27.0 |
| LM324PWR | TSSOP | PW | 14 | 2000 | 356.0 | 356.0 | 35.0 |
| LM324PWRG3 | TSSOP | PW | 14 | 2000 | 364.0 | 364.0 | 27.0 |
| LM324PWRG4 | TSSOP | PW | 14 | 2000 | 356.0 | 356.0 | 35.0 |

TUBE


*All dimensions are nominal

| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (µm) | B (mm) |
|-----------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| 5962-9950403VCA | J | CDIP | 14 | 1 | 506.98 | 15.24 | 13440 | NA |
| 77043012A | FK | LCCC | 20 | 1 | 506.98 | 12.06 | 2030 | NA |
| 7704301DA | W | CFP | 14 | 1 | 506.98 | 26.16 | 6220 | NA |
| 77043022A | FK | LCCC | 20 | 1 | 506.98 | 12.06 | 2030 | NA |
| 7704302DA | W | CFP | 14 | 1 | 506.98 | 26.16 | 6220 | NA |
| LM124AFKB | FK | LCCC | 20 | 1 | 506.98 | 12.06 | 2030 | NA |
| LM124AWB | W | CFP | 14 | 1 | 506.98 | 26.16 | 6220 | NA |
| LM124D | D | SOIC | 14 | 50 | 505.46 | 6.76 | 3810 | 4 |
| LM124DG4 | D | SOIC | 14 | 50 | 505.46 | 6.76 | 3810 | 4 |
| LM124FKB | FK | LCCC | 20 | 1 | 506.98 | 12.06 | 2030 | NA |
| LM124W | W | CFP | 14 | 1 | 506.98 | 26.16 | 6220 | NA |
| LM124WB | W | CFP | 14 | 1 | 506.98 | 26.16 | 6220 | NA |
| LM224AD | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| LM224AN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| LM224D | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| LM224DG4 | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| LM224KAD | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| LM224KADG4 | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| LM224KAN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| LM224KN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| LM224N | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| LM224NE4 | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| LM2902D | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| LM2902KD | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| LM2902KDB | DB | SSOP | 14 | 80 | 530 | 10.5 | 4000 | 4.1 |
| LM2902KDG4 | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| LM2902KN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| LM2902KPW | PW | TSSOP | 14 | 90 | 530 | 10.2 | 3600 | 3.5 |
| LM2902KPWE4 | PW | TSSOP | 14 | 90 | 530 | 10.2 | 3600 | 3.5 |

| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (µm) | B (mm) |
|------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| LM2902N | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| LM2902N | N | PDIP | 14 | 25 | 506.1 | 9 | 600 | 5.4 |
| LM2902NE4 | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| LM2902PW | PW | TSSOP | 14 | 90 | 530 | 10.2 | 3600 | 3.5 |
| LM324AD | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| LM324ADE4 | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| LM324AN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| LM324AN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| LM324APW | PW | TSSOP | 14 | 90 | 530 | 10.2 | 3600 | 3.5 |
| LM324APWE4 | PW | TSSOP | 14 | 90 | 530 | 10.2 | 3600 | 3.5 |
| LM324D | D | SOIC | 14 | 50 | 507 | 8 | 3940 | 4.32 |
| LM324D | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| LM324DE4 | D | SOIC | 14 | 50 | 507 | 8 | 3940 | 4.32 |
| LM324DE4 | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| LM324DG4 | D | SOIC | 14 | 50 | 507 | 8 | 3940 | 4.32 |
| LM324DG4 | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| LM324KAD | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| LM324KAN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| LM324KAN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| LM324KAPW | PW | TSSOP | 14 | 90 | 530 | 10.2 | 3600 | 3.5 |
| LM324KN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| LM324KN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| LM324KPW | PW | TSSOP | 14 | 90 | 530 | 10.2 | 3600 | 3.5 |
| LM324N | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| LM324N | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| LM324N | N | PDIP | 14 | 25 | 506.1 | 9 | 600 | 5.4 |
| LM324NE3 | N | PDIP | 14 | 25 | 506.1 | 9 | 600 | 5.4 |
| LM324NE4 | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| LM324NE4 | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| LM324PW | PW | TSSOP | 14 | 90 | 530 | 10.2 | 3600 | 3.5 |

W (R-GDFP-F14)

CERAMIC DUAL FLATPACK



- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. This package can be hermetically sealed with a ceramic lid using glass frit.
 - D. Index point is provided on cap for terminal identification only.
 - E. Falls within MIL STD 1835 GDFP1-F14

J 14

GENERIC PACKAGE VIEW
CDIP - 5.08 mm max height
CERAMIC DUAL IN LINE PACKAGE



Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

4040083-5/G

J0014A



PACKAGE OUTLINE

CDIP - 5.08 mm max height

CERAMIC DUAL IN LINE PACKAGE



4214771/A 05/2017

NOTES:

1. All controlling linear dimensions are in inches. Dimensions in brackets are in millimeters. Any dimension in brackets or parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This package is hermetically sealed with a ceramic lid using glass frit.
4. Index point is provided on cap for terminal identification only and on press ceramic glass frit seal only.
5. Falls within MIL-STD-1835 and GDIP1-T14.

EXAMPLE BOARD LAYOUT

J0014A

CDIP - 5.08 mm max height

CERAMIC DUAL IN LINE PACKAGE



LAND PATTERN EXAMPLE
NON-SOLDER MASK DEFINED
SCALE: 5X



4214771/A 05/2017

D (R-PDSO-G14)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
 - Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
 - E. Reference JEDEC MS-012 variation AB.

D (R-PDSO-G14)

PLASTIC SMALL OUTLINE



4211283-3/E 08/12



- 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.

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



4040064-3/G 02/11

- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - B. This drawing is subject to change without notice.
 -  Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
 -  Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
 - E. Falls within JEDEC MO-153

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



4211284-2/G 08/15

- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Publication IPC-7351 is recommended for alternate designs.
 - 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.
 - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

N (R-PDIP-T**)

PLASTIC DUAL-IN-LINE PACKAGE

16 PINS SHOWN



- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
 - The 20 pin end lead shoulder width is a vendor option, either half or full width.

DB (R-PDSO-G**)

PLASTIC SMALL-OUTLINE

28 PINS SHOWN



- NOTES: A. All linear dimensions are in millimeters.
 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
 D. Falls within JEDEC MO-150

FK (S-CQCC-N**)

LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



| NO. OF TERMINALS ** | A | | B | |
|---------------------|------------------|------------------|------------------|------------------|
| | MIN | MAX | MIN | MAX |
| 20 | 0.342 (8,69) | 0.358 (9,09) | 0.307 (7,80) | 0.358 (9,09) |
| 28 | 0.442 (11,23) | 0.458 (11,63) | 0.406 (10,31) | 0.458 (11,63) |
| 44 | 0.640 (16,26) | 0.660 (16,76) | 0.495 (12,58) | 0.560 (14,22) |
| 52 | 0.740 (18,78) | 0.761 (19,32) | 0.495 (12,58) | 0.560 (14,22) |
| 68 | 0.938 (23,83) | 0.962 (24,43) | 0.850 (21,6) | 0.858 (21,8) |
| 84 | 1.141 (28,99) | 1.165 (29,59) | 1.047 (26,6) | 1.063 (27,0) |



4040140/D 01/11

- NOTES:
- All linear dimensions are in inches (millimeters).
 - This drawing is subject to change without notice.
 - This package can be hermetically sealed with a metal lid.
 - Falls within JEDEC MS-004

MECHANICAL DATA

NS (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14-PINS SHOWN



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

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