# TLC27L4, TLC27L4A, TLC27L4B, TLC27L4Y, TLC27L9
## LinCMOS™ PRECISION QUAD OPERATIONAL AMPLIFIERS
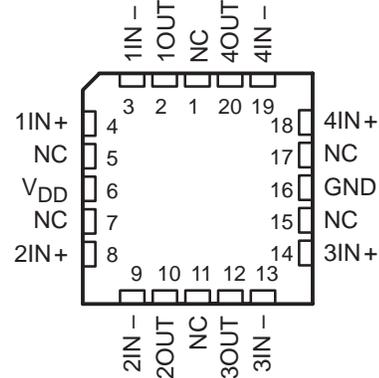
- **Trimmed Offset Voltage:**
  **TLC27L9 . . . 900 µV Max at 25°C,**
  **$V_{DD}$ = 5 V**
- **Input Offset Voltage Drift . . . Typically 0.1 µV/Month, Including the First 30 Days**
- **Wide Range of Supply Voltages Over Specified Temperature Range:**
  **0°C to 70°C . . . 3 V to 16 V**
  **−40°C to 85°C . . . 4 V to 16 V**
  **−55°C to 125°C . . . 4 V to 16 V**
- **Single-Supply Operation**
- **Common-Mode Input Voltage Range Extends Below the Negative Rail (C-Suffix, I-Suffix Types)**
- **Ultra-Low Power . . . Typically 195 µW at 25°C, $V_{DD}$ = 5 V**
- **Output Voltage Range includes Negative Rail**
- **High Input Impedance . . . $10^{12}$ Ω Typ**
- **ESD-Protection Circuitry**
- **Small-Outline Package Option Also Available in Tape and Reel**
- **Designed-In Latch-Up Immunity**

**D, J, N, OR PW PACKAGE**
**(TOP VIEW)**

```
        ___ ___
1OUT [  1      14 ] 4OUT
1IN− [  2      13 ] 4IN−
1IN+ [  3      12 ] 4IN+
 VDD [  4      11 ] GND
2IN+ [  5      10 ] 3IN+
2IN− [  6       9 ] 3IN−
2OUT [  7       8 ] 3OUT
```

**FK PACKAGE**
**(TOP VIEW)**

```
          1IN−  1OUT  NC  4OUT  4IN−
            3    2    1   20   19
1IN+ [ 4                        18 ] 4IN+
 NC  [ 5                        17 ] NC
 VDD [ 6                        16 ] GND
 NC  [ 7                        15 ] NC
2IN+ [ 8                        14 ] 3IN+
            9   10   11   12   13
          2IN−  2OUT  NC  3OUT  3IN−
```
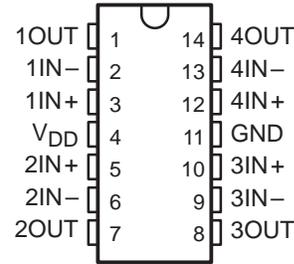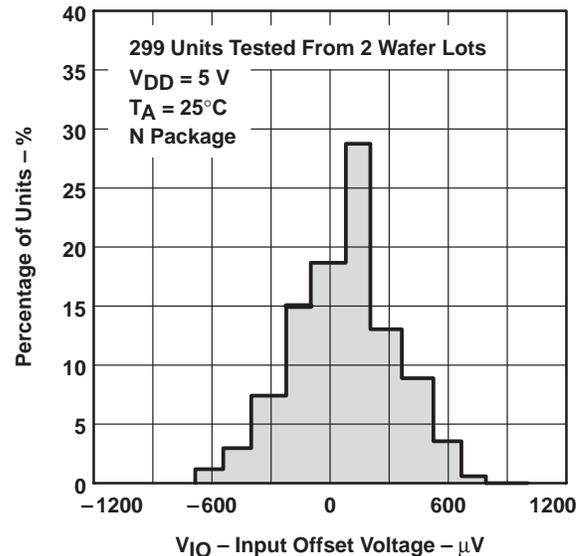
NC – No internal connection

## description

The TLC27L4 and TLC27L9 quad operational amplifiers combine a wide range of input offset voltage grades with low offset voltage drift, high input impedance, extremely low power, and high gain.

These devices use Texas instruments silicon-gate LinCMOS™ technology, which provides offset voltage stability far exceeding the stability available with conventional metal-gate processes.

The extremely high input impedance, low bias currents, and low-power consumption make these cost-effective devices ideal for high-gain, low- frequency, low-power applications. Four offset voltage grades are available (C-suffix and I-suffix types), ranging from the low-cost TLC27L4 (10 mV) to the high-precision TLC27L9 (900 µV). These advantages, in combination with good common-mode rejection and supply voltage rejection, make these devices a good choice for new state-of-the-art designs as well as for upgrading existing designs.

**DISTRIBUTION OF TLC27L9**
**INPUT OFFSET VOLTAGE**



299 Units Tested From 2 Wafer Lots
$V_{DD}$ = 5 V
$T_A$ = 25°C
N Package

Percentage of Units – %

$V_{IO}$ – Input Offset Voltage – µV

**TEXAS INSTRUMENTS**

## description (continued)

In general, many features associated with bipolar technology are available on LinCMOS™ operational amplifiers, without the power penalties of bipolar technology. General applications such as transducer interfacing, analog calculations, amplifier blocks, active filters, and signal buffering are easily designed with the TLC27L4 and TLC27L9. The devices also exhibit low voltage single-supply operation and ultra-low power consumption, making them ideally suited for remote and inaccessible battery-powered applications. The common-mode input voltage range includes the negative rail.

A wide range of packaging options is available, including small-outline and chip-carrier versions for high-density system applications.

The device inputs and outputs are designed to withstand –100-mA surge currents without sustaining latch-up.

The TLC27L4 and TLC27L9 incorporate internal ESD-protection circuits that prevent functional failures at voltages up to 2000 V as tested under MIL-STD-883C, Method 3015.2; however, care should be exercised in handling these devices, as exposure to ESD may result in the degradation of the device parametric performance.

The C-suffix devices are characterized for operation from 0°C to 70°C. The I-suffix devices are characterized for operation from –40°C to 85°C. The M-suffix devices are characterized for operation from –55°C to 125°C.

**AVAILABLE OPTIONS**

| | | PACKAGED DEVICES | | | | | CHIP FORM (Y) |
|---|---|---|---|---|---|---|---|
| $T_A$ | $V_{IO}$max AT 25°C | SMALL OUTLINE (D) | CHIP CARRIER (FK) | CERAMIC DIP (J) | PLASTIC DIP (N) | TSSOP (PW) | |
| 0°C to 70°C | 900 µV | TLC27L9CD | — | — | TLC27L9CN | — | — |
| | 2 mV | TLC27L4BCD | — | — | TLC27L4BCN | — | — |
| | 5 mV | TLC27L4ACD | — | — | TLC27L4ACN | — | — |
| | 10 mV | TLC27L4CD | — | — | TLC27L4CN | TLC27L4CPW | TLC27L4Y |
| –40°C to 85°C | 900 µV | TLC27L9ID | — | — | TLC27L9IN | — | — |
| | 2 mV | TLC27L4BID | — | — | TLC27L4BIN | — | — |
| | 5 mV | TLC27L4AID | — | — | TLC27L4AIN | — | — |
| | 10 mV | TLC27L4ID | — | — | TLC27L4IN | — | — |
| –55°C to 125°C | 900 µV | TLC27L9MD | TLC27L9MFK | TLC27L9MJ | TLC27L9MN | — | — |
| | 10 mV | TLC27L4MD | TLC27L4MFK | TLC27L4MJ | TLC27L4MN | — | — |

The D package is available taped and reeled. Add R suffix to the device type (e.g., TLC27L9CDR).

**TEXAS INSTRUMENTS**

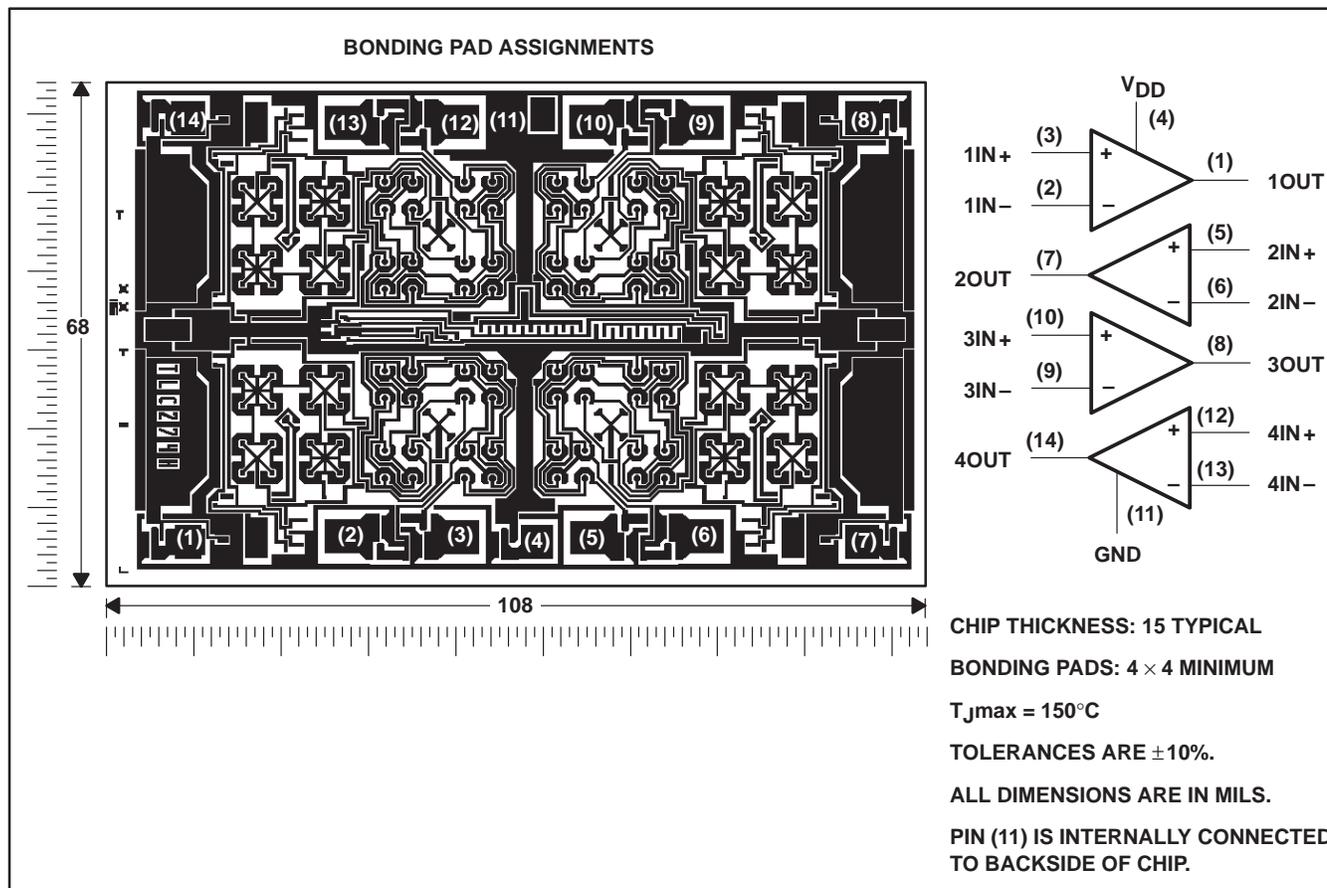## equivalent schematic (each amplifier)

# TLC27L4, TLC27L4A, TLC27L4B, TLC27L4Y, TLC27L9
## LinCMOS™ PRECISION QUAD OPERATIONAL AMPLIFIERS

SLOS053C – OCTOBER 1987 – REVISED AUGUST 1994

## TLC27L4Y chip information

These chips, when properly assembled, display characteristics similar to the TLC27L4C. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. Chips may be mounted with conductive epoxy or a gold-silicon preform.

**BONDING PAD ASSIGNMENTS**



CHIP THICKNESS: 15 TYPICAL

BONDING PADS: 4 × 4 MINIMUM

$T_J$max = 150°C

TOLERANCES ARE ±10%.

ALL DIMENSIONS ARE IN MILS.

PIN (11) IS INTERNALLY CONNECTED TO BACKSIDE OF CHIP.

TEXAS
INSTRUMENTS

4

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

## absolute maximum ratings over operating free-air temperature (unless otherwise noted)†

| | |
|---|---|
| Supply voltage, $V_{DD}$ (see Note 1) | 18 V |
| Differential input voltage, $V_{ID}$ (see Note 2) | $\pm V_{DD}$ |
| Input voltage range, $V_I$ (any input) | −0.3 V to $V_{DD}$ |
| Input current, $I_I$ | $\pm 5$ mA |
| Output current, $I_O$ (each output) | $\pm 30$ mA |
| Total current into $V_{DD}$ | 45 mA |
| Total current out of GND | 45 mA |
| Duration of short-circuit current at (or below) 25°C (see Note 3) | unlimited |
| Continuous total dissipation | See Dissipation Rating Table |
| Operating free-air temperature, $T_A$:  C suffix | 0°C to 70°C |
| I suffix | −40°C to 85°C |
| M suffix | −55°C to 125°C |
| Storage temperature range | −65°C to 150°C |
| Case temperature for 60 seconds: FK package | 260°C |
| Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D, N, or PW package | 260°C |
| Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: J package | 300°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.

NOTES:  1.  All voltage values, except differential voltages, are with respect to network ground.
2.  Differential voltages are at IN+ with respect to IN–.
3.  The output may be shorted to either supply. Temperature and/or supply voltages must be limited to ensure that the maximum dissipation rating is not exceeded (see application section).

### DISSIPATION RATING TABLE

| PACKAGE | $T_A \leq 25°C$ POWER RATING | DERATING FACTOR ABOVE $T_A = 25°C$ | $T_A = 70°C$ POWER RATING | $T_A = 85°C$ POWER RATING | $T_A = 125°C$ POWER RATING |
|---|---|---|---|---|---|
| D | 950 mW | 7.6 mW/°C | 608 mW | 494 mW | — |
| FK | 1375 mW | 11.0 mW/°C | 880 mW | 715 mW | 275 mW |
| J | 1375 mW | 11.0 mW/°C | 880 mW | 715 mW | 275 mW |
| N | 1575 mW | 12.6 mW/°C | 1008 mW | 819 mW | — |
| PW | 700 mW | 5.6 mW/°C | 448 mW | — | — |

## recommended operating conditions

| | | C SUFFIX | | I SUFFIX | | M SUFFIX | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | MIN | MAX | MIN | MAX | MIN | MAX | |
| Supply voltage, $V_{DD}$ | | 3 | 16 | 4 | 16 | 4 | 16 | V |
| Common-mode input voltage, $V_{IC}$ | $V_{DD} = 5$ V | −0.2 | 3.5 | −0.2 | 3.5 | 0 | 3.5 | V |
| | $V_{DD} = 10$ V | −0.2 | 8.5 | −0.2 | 8.5 | 0 | 8.5 | |
| Operating free-air temperature, $T_A$ | | 0 | 70 | −40 | 85 | −55 | 125 | °C |

**TEXAS INSTRUMENTS**

## electrical characteristics at specified free-air temperature, $V_{DD}$ = 5 V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC27L4C TLC27L4AC TLC27L4BC TLC27L9C | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | |
| $V_{IO}$ Input offset voltage | TLC27L4C | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 1.1 | 10 | mV |
| | | | | Full range | | | 12 | |
| | TLC27L4AC | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 0.9 | 5 | mV |
| | | | | Full range | | | 6.5 | |
| | TLC27L4BC | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 240 | 2000 | μV |
| | | | | Full range | | | 3000 | |
| | TLC27L9C | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 200 | 900 | |
| | | | | Full range | | | 1500 | |
| $\alpha_{VIO}$ | Average temperature coefficient of input offset voltage | | | 25°C to 70°C | | 1.1 | | μV/°C |
| $I_{IO}$ | Input offset current (see Note 4) | $V_O$ = 2.5 V, | $V_{IC}$ = 2.5 V | 25°C | | 0.1 | | pA |
| | | | | 70°C | | 7 | 300 | |
| $I_{IB}$ | Input bias current (see Note 4) | $V_O$ = 2.5 V, | $V_{IC}$ = 2.5 V | 25°C | | 0.6 | | pA |
| | | | | 70°C | | 40 | 600 | |
| $V_{ICR}$ | Common mode input voltage range (see Note 5) | | | 25°C | −0.2 to 4 | −0.3 to 4.2 | | V |
| | | | | Full range | −0.2 to 3.5 | | | V |
| $V_{OH}$ | High-level output voltage | $V_{ID}$ = 100 mV, | $R_L$ = 1 MΩ | 25°C | 3.2 | 4.1 | | V |
| | | | | 0°C | 3 | 4.1 | | |
| | | | | 70°C | 3 | 4.2 | | |
| $V_{OL}$ | Low-level output voltage | $V_{ID}$ = −100 mV, | $I_{OL}$ = 0 | 25°C | | 0 | 50 | mV |
| | | | | 0°C | | 0 | 50 | |
| | | | | 70°C | | 0 | 50 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = 2.5 V to 2 V, | $R_L$ = 1 MΩ | 25°C | 50 | 520 | | V/mV |
| | | | | 0°C | 50 | 680 | | |
| | | | | 70°C | 50 | 380 | | |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min | | 25°C | 65 | 94 | | dB |
| | | | | 0°C | 60 | 95 | | |
| | | | | 70°C | 60 | 95 | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$) | $V_{DD}$ = 5 V to 10 V, | $V_O$ = 1.4 V | 25°C | 70 | 97 | | dB |
| | | | | 0°C | 60 | 97 | | |
| | | | | 70°C | 60 | 98 | | |
| $I_{DD}$ | Supply current (four amplifiers) | $V_O$ = 2.5 V, No load | $V_{IC}$ = 2.5 V, | 25°C | | 40 | 68 | μA |
| | | | | 0°C | | 48 | 84 | |
| | | | | 70°C | | 31 | 56 | |

† Full range is 0°C to 70°C.
NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.
      5. This range also applies to each input individually.

## electrical characteristics at specified free-air temperature, $V_{DD}$ = 10 V (unless otherwise noted)

| PARAMETER | | | TEST CONDITIONS | | $T_A$† | TLC27L4C TLC27L4AC TLC27L4BC TLC27L9C | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | TLC27L4C | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 1.1 | 10 | mV |
| | | | | | Full range | | | 12 | |
| | | TLC27L4AC | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 0.9 | 5 | |
| | | | | | Full range | | | 6.5 | |
| | | TLC27L4BC | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 260 | 2000 | μV |
| | | | | | Full range | | | 3000 | |
| | | TLC27L9C | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 210 | 1200 | |
| | | | | | Full range | | | 1900 | |
| $\alpha_{VIO}$ | Average temperature coefficient of input offset voltage | | | | 25°C to 70°C | | 1 | | μV/°C |
| $I_{IO}$ | Input offset current (see Note 4) | | $V_O$ = 5 V, | $V_{IC}$ = 5 V | 25°C | | 0.1 | | pA |
| | | | | | 70°C | | 7 | 300 | |
| $I_{IB}$ | Input bias current (see Note 4) | | $V_O$ = 5 V, | $V_{IC}$ = 5 V | 25°C | | 0.7 | | pA |
| | | | | | 70°C | | 50 | 600 | |
| $V_{ICR}$ | Common-mode input voltage range (see Note 5) | | | | 25°C | −0.2 to 9 | −0.3 to 9.2 | | V |
| | | | | | Full range | −0.2 to 8.5 | | | V |
| $V_{OH}$ | High-level output voltage | | $V_{ID}$ = 100 mV, | $R_L$ = 1 MΩ | 25°C | 8 | 8.9 | | V |
| | | | | | 0°C | 7.8 | 8.9 | | |
| | | | | | 70°C | 7.8 | 8.9 | | |
| $V_{OL}$ | Low-level output voltage | | $V_{ID}$ = −100 mV, | $I_{OL}$ = 0 | 25°C | | 0 | 50 | mV |
| | | | | | 0°C | | 0 | 50 | |
| | | | | | 70°C | | 0 | 50 | |
| $A_{VD}$ | Large-signal differential voltage amplification | | $V_O$ = 1 V to 6 V, | $R_L$ = 1 MΩ | 25°C | 50 | 870 | | V/mV |
| | | | | | 0°C | 50 | 1020 | | |
| | | | | | 70°C | 50 | 660 | | |
| CMRR | Common-mode rejection ratio | | $V_{IC}$ = $V_{ICR}$min | | 25°C | 65 | 97 | | dB |
| | | | | | 0°C | 60 | 97 | | |
| | | | | | 70°C | 60 | 97 | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$) | | $V_{DD}$ = 5 V to 10 V, | $V_O$ = 1.4 V | 25°C | 70 | 97 | | dB |
| | | | | | 0°C | 60 | 97 | | |
| | | | | | 70°C | 60 | 98 | | |
| $I_{DD}$ | Supply current (four amplifiers) | | $V_O$ = 5 V, No load | $V_{IC}$ = 5 V, | 25°C | | 57 | 92 | μA |
| | | | | | 0°C | | 72 | 132 | |
| | | | | | 70°C | | 44 | 80 | |

† Full range is 0°C to 70°C.
NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.
5. This range also applies to each input individually.

## electrical characteristics at specified free-air temperature, $V_{DD}$ = 5 V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC27L4I TLC27L4AI TLC27L4BI TLC27L9I | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | |
| $V_{IO}$ Input offset voltage | TLC27L4I | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 1.1 | 10 | mV |
| | | | | Full range | | | 13 | |
| | TLC27L4AI | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 0.9 | 5 | |
| | | | | Full range | | | 7 | |
| | TLC27L4BI | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 240 | 2000 | μV |
| | | | | Full range | | | 3500 | |
| | TLC27L9I | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 200 | 900 | |
| | | | | Full range | | | 2000 | |
| $\alpha_{VIO}$ | Average temperature coefficient of input offset voltage | | | 25°C to 85°C | | 1.1 | | μV/°C |
| $I_{IO}$ | Input offset current (see Note 4) | $V_O$ = 2.5 V, | $V_{IC}$ = 2.5 V | 25°C | | 0.1 | | pA |
| | | | | 85°C | | 24 | 1000 | |
| $I_{IB}$ | Input bias current (see Note 4) | $V_O$ = 2.5 V, | $V_{IC}$ = 2.5 V | 25°C | | 0.6 | | pA |
| | | | | 85°C | | 200 | 2000 | |
| $V_{ICR}$ | Common-mode input voltage range (see Note 5) | | | 25°C | −0.2 to 4 | −0.3 to 4.2 | | V |
| | | | | Full range | −0.2 to 3.5 | | | V |
| $V_{OH}$ | High-level output voltage | $V_{ID}$ = 100 mV, | $R_L$ = 1 MΩ | 25°C | 3.2 | 4.1 | | V |
| | | | | −40°C | 3 | 4.1 | | |
| | | | | 85°C | 3 | 4.2 | | |
| $V_{OL}$ | Low-level output voltage | $V_{ID}$ = −100 mV, | $I_{OL}$ = 0 | 25°C | | 0 | 50 | mV |
| | | | | −40°C | | 0 | 50 | |
| | | | | 85°C | | 0 | 50 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = 0.25 V to 2 V, | $R_L$ = 1 MΩ | 25°C | 50 | 480 | | V/mV |
| | | | | −40°C | 50 | 900 | | |
| | | | | 85°C | 50 | 330 | | |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min | | 25°C | 65 | 94 | | dB |
| | | | | −40°C | 60 | 95 | | |
| | | | | 85°C | 60 | 95 | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$) | $V_{DD}$ = 5 V to 10 V, | $V_O$ = 1.4 V | 25°C | 70 | 97 | | dB |
| | | | | −40°C | 60 | 97 | | |
| | | | | 85°C | 60 | 98 | | |
| $I_{DD}$ | Supply current (four amplifiers) | $V_O$ = 2.5 V, No load | $V_{IC}$ = 2.5 V, | 25°C | | 39 | 68 | μA |
| | | | | −40°C | | 62 | 108 | |
| | | | | 85°C | | 29 | 52 | |

† Full range is −40°C to 85°C.
NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.
      5. This range also applies to each input individually.

## electrical characteristics at specified free-air temperature, $V_{DD}$ = 10 V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC27L4I TLC27L4AI TLC27L4BI TLC27L9I | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | |
| $V_{IO}$ Input offset voltage | TLC27L4I | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 1.1 | 10 | mV |
| | | | | Full range | | | 13 | |
| | TLC27L4AI | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 0.9 | 5 | mV |
| | | | | Full range | | | 7 | |
| | TLC27L4BI | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 260 | 2000 | μV |
| | | | | Full range | | | 3500 | |
| | TLC27L9I | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 210 | 1200 | μV |
| | | | | Full range | | | 2900 | |
| $\alpha_{VIO}$ | Average temperature coefficient of input offset voltage | | | 25°C to 85°C | | 1 | | μV/°C |
| $I_{IO}$ | Input offset current (see Note 4) | $V_O$ = 5 V, | $V_{IC}$ = 5 V | 25°C | | 0.1 | | pA |
| | | | | 85°C | | 26 | 1000 | |
| $I_{IB}$ | Input bias current (see Note 4) | $V_O$ = 5 V, | $V_{IC}$ = .5 V | 25°C | | 0.7 | | pA |
| | | | | 85°C | | 220 | 2000 | |
| $V_{ICR}$ | Common-mode input voltage range (see Note 5) | | | 25°C | −0.2 to 9 | −0.3 to 9.2 | | V |
| | | | | Full range | −0.2 to 8.5 | | | V |
| $V_{OH}$ | High-level output voltage | $V_{ID}$ = 100 mV, | $R_L$ = 1 MΩ | 25°C | 8 | 8.9 | | V |
| | | | | −40°C | 7.8 | 8.9 | | |
| | | | | 85°C | 7.8 | 8.9 | | |
| $V_{OL}$ | Low-level output voltage | $V_{ID}$ = −100 mV, | $I_{OL}$ = 0 | 25°C | | 0 | 50 | mV |
| | | | | −40°C | | 0 | 50 | |
| | | | | 85°C | | 0 | 50 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = 1 V to 6 V, | $R_L$ = 1 MΩ | 25°C | 50 | 800 | | V/mV |
| | | | | −40°C | 50 | 1550 | | |
| | | | | 85°C | 50 | 585 | | |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min | | 25°C | 65 | 97 | | dB |
| | | | | −40°C | 60 | 97 | | |
| | | | | 85°C | 60 | 98 | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$) | $V_{DD}$ = 5 V to 10 V, | $V_O$ = 1.4 V | 25°C | 70 | 97 | | dB |
| | | | | −40°C | 60 | 97 | | |
| | | | | 85°C | 60 | 98 | | |
| $I_{DD}$ | Supply current (four amplifiers) | $V_O$ = 5 V, No load | $V_{IC}$ = 5 V, | 25°C | | 57 | 92 | μA |
| | | | | −40°C | | 98 | 172 | |
| | | | | 85°C | | 40 | 72 | |

† Full range is −40°C to 85°C.
NOTES:  4.  The typical values of input bias current and input offset current below 5 pA were determined mathematically.
          5.  This range also applies to each input individually.

## electrical characteristics at specified free-air temperature, $V_{DD}$ = 5 V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC27L4M TLC27L9M | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | |
| $V_{IO}$ Input offset voltage | TLC27L4M | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 1.1 | 10 | mV |
| | | | | Full range | | | 12 | |
| | TLC27L9M | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 200 | 900 | μV |
| | | | | Full range | | | 3750 | |
| $α_{VIO}$ | Average temperature coefficient of input offset voltage | | | 25°C to 125°C | | 1.4 | | μV/°C |
| $I_{IO}$ | Input offset current (see Note 4) | $V_O$ = 2.5 V, | $V_{IC}$ = 2.5 V | 25°C | | 0.1 | | pA |
| | | | | 125°C | | 1.4 | 15 | nA |
| $I_{IB}$ | Input bias current (see Note 4) | $V_O$ = 2.5 V, | $V_{IC}$ = 2.5 V | 25°C | | 0.6 | | pA |
| | | | | 125°C | | 9 | 35 | nA |
| $V_{ICR}$ | Common-mode input voltage range (see Note 5) | | | 25°C | −0.2 to 4 | −0.3 to 4.2 | | V |
| | | | | Full range | −0.2 to 3.5 | | | V |
| $V_{OH}$ | High-level output voltage | $V_{ID}$ = 100 mV, | $R_L$ = 1 MΩ | 25°C | 3.2 | 4.1 | | V |
| | | | | −55°C | 3 | 4.1 | | |
| | | | | 125°C | 3 | 4.2 | | |
| $V_{OL}$ | Low-level output voltage | $V_{ID}$ = −100 mV, | $I_{OL}$ = 0 | 25°C | | 0 | 50 | mV |
| | | | | −55°C | | 0 | 50 | |
| | | | | 125°C | | 0 | 50 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = 0.25 V to 2 V, | $R_L$ = 1 MΩ | 25°C | 50 | 480 | | V/mV |
| | | | | −55°C | 25 | 950 | | |
| | | | | 125°C | 25 | 200 | | |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min | | 25°C | 65 | 94 | | dB |
| | | | | −55°C | 60 | 95 | | |
| | | | | 125°C | 60 | 85 | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($ΔV_{DD}/ΔV_{IO}$) | $V_{DD}$ = 5 V to 10 V, | $V_O$ = 1.4 V | 25°C | 70 | 97 | | dB |
| | | | | −55°C | 60 | 97 | | |
| | | | | 125°C | 60 | 98 | | |
| $I_{DD}$ | Supply current (four amplifiers) | $V_O$ = 2.5 V, No load | $V_{IC}$ = 2.5 V, | 25°C | | 39 | 68 | μA |
| | | | | −55°C | | 69 | 120 | |
| | | | | 125°C | | 27 | 48 | |

† Full range is −55°C to 125°C.

NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.
5. This range also applies to each input individually.

## electrical characteristics at specified free-air temperature, $V_{DD}$ = 10 V (unless otherwise noted)

| PARAMETER | | | TEST CONDITIONS | | $T_A$† | TLC27L4M TLC27L9M | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | TLC27L4M | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 1.1 | 10 | mV |
| | | | | | Full range | | | 12 | |
| | | TLC27L9M | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | 25°C | | 210 | 1200 | µV |
| | | | | | Full range | | | 4300 | |
| $\alpha_{VIO}$ | Average temperature coefficient of input offset voltage | | | | 25°C to 125°C | | 1.4 | | µV/°C |
| $I_{IO}$ | Input offset current (see Note 4) | | $V_O$ = 5 V, | $V_{IC}$ = 5 V | 25°C | | 0.1 | | pA |
| | | | | | 125°C | | 1.8 | 15 | nA |
| $I_{IB}$ | Input bias current (see Note 4) | | $V_O$ = 5 V, | $V_{IC}$ = 5 V | 25°C | | 0.7 | | pA |
| | | | | | 125°C | | 10 | 35 | nA |
| $V_{ICR}$ | Common-mode input voltage range (see Note 5) | | | | 25°C | 0 to 9 | −0.3 to 9.2 | | V |
| | | | | | Full range | 0 to 8.5 | | | V |
| $V_{OH}$ | High-level output voltage | | $V_{ID}$ = 100 mV, | $R_L$ = 1 MΩ | 25°C | 8 | 8.9 | | V |
| | | | | | −55°C | 7.8 | 8.8 | | |
| | | | | | 125°C | 7.8 | 9 | | |
| $V_{OL}$ | Low-level output voltage | | $V_{ID}$ = −100 mV, | $I_{OL}$ = 0 | 25°C | | 0 | 50 | mV |
| | | | | | −55°C | | 0 | 50 | |
| | | | | | 125°C | | 0 | 50 | |
| $A_{VD}$ | Large-signal differential voltage amplification | | $V_O$ = 1 V to 6 V, | $R_L$ = 1 MΩ | 25°C | 50 | 800 | | V/mV |
| | | | | | −55°C | 25 | 1750 | | |
| | | | | | 125°C | 25 | 380 | | |
| CMRR | Common-mode rejection ratio | | $V_{IC}$ = $V_{ICR}$min | | 25°C | 65 | 97 | | dB |
| | | | | | −55°C | 60 | 97 | | |
| | | | | | 125°C | 60 | 91 | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$) | | $V_{DD}$ = 5 V to 10 V, | $V_O$ = 1.4 V | 25°C | 70 | 97 | | dB |
| | | | | | −55°C | 60 | 97 | | |
| | | | | | 125°C | 60 | 98 | | |
| $I_{DD}$ | Supply current (four amplifiers) | | $V_O$ = 5 V, No load | $V_{IC}$ = 5 V, | 25°C | | 57 | 92 | µA |
| | | | | | −55°C | | 111 | 192 | |
| | | | | | 125°C | | 35 | 60 | |

† Full range is −55°C to 125°C.
NOTES: 4. The typical values of input bias current and Input offset current below 5 pA were determined mathematically.
5. This range also applies to each input individually.

## electrical characteristics at specified free-air temperature, $V_{DD}$ = 5 V, $T_A$ = 25°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | TLC27L4Y | | | UNIT |
|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | | 1.1 | 10 | mV |
| $\alpha_{VIO}$ | Average temperature coefficient of input offset voltage | $T_A$ = 25°C to 70°C | | | 1.1 | | μV/°C |
| $I_{IO}$ | Input offset current (see Note 4) | $V_O$ = 2.5 V, | $V_{IC}$ = 2.5 V | | 0.1 | | pA |
| $I_{IB}$ | Input bias current (see Note 4) | $V_O$ = 2.5 V, | $V_{IC}$ = 2.5 V | | 0.6 | | pA |
| $V_{ICR}$ | Common-mode input voltage range (see Note 5) | | | −0.2 to 4 | −0.3 to 4.2 | | V |
| $V_{OH}$ | High-level output voltage | $V_{ID}$ = 100 mV, | $R_L$ = 1 MΩ | 3.2 | 4.1 | | V |
| $V_{OL}$ | Low-level output voltage | $V_{ID}$ = −100 mV, | $I_{OL}$ = 0 | | 0 | 50 | mV |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = 0.25 V to 2 V, | $R_L$ = 1 MΩ | 50 | 520 | | V/mV |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min | | 65 | 94 | | dB |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$) | $V_{DD}$ = 5 V to 10 V, | $V_O$ = 1.4 V | 70 | 97 | | dB |
| $I_{DD}$ | Supply current (four amplifiers) | $V_O$ = 2.5 V, No load | $V_{IC}$ = 2.5 V, | | 40 | 68 | μA |

## electrical characteristics at specified free-air temperature, $V_{DD}$ = 10 V, $T_A$ = 25°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | TLC27L4Y | | | UNIT |
|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_O$ = 1.4 V, $R_S$ = 50 Ω, | $V_{IC}$ = 0, $R_L$ = 1 MΩ | | 1.1 | 10 | mV |
| $\alpha_{VIO}$ | Average temperature coefficient of input offset voltage | $T_A$ = 25°C to 70°C | | | 1 | | μV/°C |
| $I_{IO}$ | Input offset current (see Note 4) | $V_O$ = 5 V, | $V_{IC}$ = 5 V | | 0.1 | | pA |
| $I_{IB}$ | Input bias current (see Note 4) | $V_O$ = 5 V, | $V_{IC}$ = 5 V | | 0.7 | | pA |
| $V_{ICR}$ | Common-mode input voltage range (see Note 5) | | | −0.2 to 9 | −0.3 to 9.2 | | V |
| $V_{OH}$ | High-level output voltage | $V_{ID}$ = 100 mV, | $R_L$ = 1 MΩ | 8 | 8.9 | | V |
| $V_{OL}$ | Low-level output voltage | $V_{ID}$ = −100 mV, | $I_{OL}$ = 0 | | 0 | 50 | mV |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = 1 V to 6 V, | $R_L$ = 1 MΩ | 50 | 870 | | V/mV |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min | | 65 | 97 | | dB |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$) | $V_{DD}$ = 5 V to 10 V, | $V_O$ = 1.4 V | 70 | 97 | | dB |
| $I_{DD}$ | Supply current (four amplifiers) | $V_O$ = 5 V, No load | $V_{IC}$ = 5 V, | | 57 | 92 | μA |

NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.
5. This range also applies to each input individually.

**TEXAS INSTRUMENTS**

## operating characteristics at specified free-air temperature, $V_{DD}$ = 5 V

| PARAMETER | | TEST CONDITIONS | | $T_A$ | TLC27L4C TLC27L4AC TLC27L4BC TLC27L9C | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $R_L$ = 1 MΩ, $C_L$ = 20 pF, See Figure 1 | $V_{IPP}$ = 1 V | 25°C | | 0.03 | | V/μs |
| | | | | 0°C | | 0.04 | | |
| | | | | 70°C | | 0.03 | | |
| | | | $V_{IPP}$ = 2.5 V | 25°C | | 0.03 | | |
| | | | | 0°C | | 0.03 | | |
| | | | | 70°C | | 0.02 | | |
| $V_n$ | Equivalent input noise voltage | f = 1 kHZ, See Figure 2 | $R_S$ = 20 Ω, | 25°C | | 70 | | nV/√$\overline{Hz}$ |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_O$ = $V_{OH}$, $R_L$ = 1 MΩ, | $C_L$ = 20 pF, See Figure 1 | 25°C | | 5 | | kHz |
| | | | | 0°C | | 6 | | |
| | | | | 70°C | | 4.5 | | |
| $B_1$ | Unity-gain bandwidth | $V_I$ = 10 mV, See Figure 3 | $C_L$ = 20 pF, | 25°C | | 85 | | kHz |
| | | | | 0°C | | 100 | | |
| | | | | 70°C | | 65 | | |
| $\phi_m$ | Phase margin | $V_I$ = 10 mV, $C_L$ = 20 pF, | f = $B_1$, See Figure 3 | 25°C | | 34° | | |
| | | | | 0°C | | 36° | | |
| | | | | 70°C | | 30° | | |

## operating characteristics at specified free-air temperature, $V_{DD}$ = 10 V

| PARAMETER | | TEST CONDITIONS | | $T_A$ | TLC27L4C TLC27L4AC TLC27L4BC TLC27L9C | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $R_L$ = 1 MΩ, $C_L$ = 20 pF, See Figure 1 | $V_{IPP}$ = 1 V | 25°C | | 0.05 | | V/μs |
| | | | | 0°C | | 0.05 | | |
| | | | | 70°C | | 0.04 | | |
| | | | $V_{IPP}$ = 5.5 V | 25°C | | 0.04 | | |
| | | | | 0°C | | 0.05 | | |
| | | | | 70°C | | 0.04 | | |
| $V_n$ | Equivalent input noise voltage | f = 1 kHz, See Figure 2 | $R_S$ = 20 Ω, | 25°C | | 70 | | nV/√$\overline{Hz}$ |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_O$ = $V_{OH}$, $R_L$ = 1 MΩ, | $C_L$ = 20 pF, See Figure 1 | 25°C | | 1 | | kHz |
| | | | | 0°C | | 1.3 | | |
| | | | | 70°C | | 0.9 | | |
| $B_1$ | Unity-gain bandwidth | $V_I$ = 10 mV, See Figure 3 | $C_L$ = 20 pF, | 25°C | | 110 | | kHz |
| | | | | 0°C | | 125 | | |
| | | | | 70°C | | 90 | | |
| $\phi_m$ | Phase margin | $V_I$ = 10 mV, $C_L$ = 20 pF, | f = $B_1$, See Figure 3 | 25°C | | 38° | | |
| | | | | 0°C | | 40° | | |
| | | | | 70°C | | 34° | | |

**TEXAS INSTRUMENTS**

## operating characteristics at specified free-air temperature, $V_{DD}$ = 5 V

| PARAMETER | | TEST CONDITIONS | | $T_A$ | TLC27L4I TLC27L4AI TLC27L4BI TLC27L9I | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $R_L$ = 1 MΩ, $C_L$ = 20 pF, See Figure 1 | $V_{IPP}$ = 1 V | 25°C | | 0.03 | | V/μs |
| | | | | −40°C | | 0.04 | | |
| | | | | 85°C | | 0.03 | | |
| | | | $V_{IPP}$ = 2.5 V | 25°C | | 0.03 | | |
| | | | | −40°C | | 0.04 | | |
| | | | | 85°C | | 0.02 | | |
| $V_n$ | Equivalent input noise voltage | f = 1 HZ, See Figure 2 | $R_S$ = 20 Ω, | 25°C | | 70 | | nV/√Hz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_O$ = $V_{OH}$, $R_L$ = 1 MΩ, | $C_L$ = 20 pF, See Figure 1 | 25°C | | 5 | | kHz |
| | | | | −40°C | | 7 | | |
| | | | | 85°C | | 4 | | |
| $B_1$ | Unity-gain bandwidth | $V_I$ = 10 mV, See Figure 3 | $C_L$ = 20 pF, | 25°C | | 85 | | kHz |
| | | | | −40°C | | 130 | | |
| | | | | 85°C | | 55 | | |
| $\phi_m$ | Phase margin | $V_I$ = 10 mV, $C_L$ = 20 pF, | f = $B_1$, See Figure 3 | 25°C | | 34° | | |
| | | | | −40°C | | 38° | | |
| | | | | 85°C | | 28° | | |

## operating characteristics at specified free-air temperature, $V_{DD}$ = 10 V

| PARAMETER | | TEST CONDITIONS | | $T_A$ | TLC27L4I TLC27L4AI TLC27L4BI TLC27L9I | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $R_L$ = 1 MΩ, $C_L$ = 20 pF, See Figure 1 | $V_{IPP}$ = 1 V | 25°C | | 0.05 | | V/μs |
| | | | | −40°C | | 0.06 | | |
| | | | | 85°C | | 0.03 | | |
| | | | $V_{IPP}$ = 2.5 V | 25°C | | 0.04 | | |
| | | | | −40°C | | 0.05 | | |
| | | | | 85°C | | 0.03 | | |
| $V_n$ | Equivalent input noise voltage | f = 1 HZ, See Figure 2 | $R_S$ = 20 Ω, | 25°C | | 70 | | nV/√Hz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_O$ = $V_{OH}$, $R_L$ = 1 MΩ, | $C_L$ = 20 pF, See Figure 1 | 25°C | | 1 | | kHz |
| | | | | −40°C | | 1.4 | | |
| | | | | 85°C | | 0.8 | | |
| $B_1$ | Unity-gain bandwidth | $V_I$ = 10 mV, See Figure 3 | $C_L$ = 20 pF, | 25°C | | 110 | | kHz |
| | | | | −40°C | | 155 | | |
| | | | | 85°C | | 80 | | |
| $\phi_m$ | Phase margin | $V_I$ = 10 mV, $C_L$ = 20 pF, | f = $B_1$, See Figure 3 | 25°C | | 38° | | |
| | | | | −40°C | | 42° | | |
| | | | | 85°C | | 32° | | |

## operating characteristics at specified free-air temperature, $V_{DD}$ = 5 V

| PARAMETER | | TEST CONDITIONS | | $T_A$ | TLC27L4M TLC27L9M | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $R_L$ = 1 MΩ, $C_L$ = 20 pF, See Figure 1 | $V_{IPP}$ = 1 V | 25°C | | 0.03 | | V/μs |
| | | | | −55°C | | 0.04 | | |
| | | | | 125°C | | 0.02 | | |
| | | | $V_{IPP}$ = 2.5 V | 25°C | | 0.03 | | |
| | | | | −55°C | | 0.04 | | |
| | | | | 125°C | | 0.02 | | |
| $V_n$ | Equivalent input noise voltage | f = 1 kHz, See Figure 2 | $R_S$ = 20 Ω, | 25°C | | 70 | | nV/√Hz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_O$ = $V_{OH}$, $R_L$ = 1 MΩ, | $C_L$ = 20 pF, See Figure 1 | 25°C | | 5 | | kHz |
| | | | | −55°C | | 8 | | |
| | | | | 125°C | | 3 | | |
| $B_1$ | Unity-gain bandwidth | $V_I$ = 10 mV, See Figure 3 | $C_L$ = 20 pF, | 25°C | | 85 | | kHz |
| | | | | −55°C | | 140 | | |
| | | | | 125°C | | 45 | | |
| $\phi_m$ | Phase margin | $V_I$ = 10 mV, $C_L$ = 20 pF, | f = $B_1$, See Figure 3 | 25°C | | 34° | | |
| | | | | −55°C | | 39° | | |
| | | | | 125°C | | 25° | | |

## operating characteristics at specified free-air temperature, $V_{DD}$ = 10 V

| PARAMETER | | TEST CONDITIONS | | $T_A$ | TLC27L4M TLC27L9M | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $R_L$ = 1 MΩ, $C_L$ = 20 pF, See Figure 1 | $V_{IPP}$ = 1 V | 25°C | | 0.05 | | V/μs |
| | | | | −55°C | | 0.06 | | |
| | | | | 125°C | | 0.03 | | |
| | | | $V_{IPP}$ = 5.5 V | 25°C | | 0.04 | | |
| | | | | −55°C | | 0.06 | | |
| | | | | 125°C | | 0.03 | | |
| $V_n$ | Equivalent input noise voltage | f = 1 kHz, See Figure 2 | $R_S$ = 20 Ω, | 25°C | | 70 | | nV/√Hz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_O$ = $V_{OH}$, $R_L$ = 1 MΩ, | $C_L$ = 20 pF, See Figure 1 | 25°C | | 1 | | kHz |
| | | | | −55°C | | 1.5 | | |
| | | | | 125°C | | 0.7 | | |
| $B_1$ | Unity-gain bandwidth | $V_I$ = 10 mV, See Figure 3 | $C_L$ = 20 pF, | 25°C | | 110 | | kHz |
| | | | | −55°C | | 165 | | |
| | | | | 125°C | | 70 | | |
| $\phi_m$ | Phase margin | $V_I$ = 10 mV, $C_L$ = 20 pF, | f = $B_1$, See Figure 3 | 25°C | | 38° | | |
| | | | | −55°C | | 43° | | |
| | | | | 125°C | | 29° | | |

## operating characteristics, $V_{DD}$ = 5 V, $T_A$ = 25°C

| PARAMETER | | TEST CONDITIONS | | TLC27L4Y | | | UNIT |
|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $R_L$ = 1 MΩ, $C_L$ = 20 pF, See Figure 1 | $V_{IPP}$ = 1 V | | 0.03 | | V/µs |
| | | | $V_{IPP}$ = 2.5 V | | 0.03 | | |
| $V_n$ | Equivalent input noise voltage | f = 1 kHz, See Figure 2 | $R_S$ = 20 Ω, | | 70 | | nV/√$\overline{Hz}$ |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_O$ = $V_{OH}$, $R_L$ = 1 MΩ, | $C_L$ = 20 pF, See Figure 1 | | 5 | | kHz |
| $B_1$ | Unity-gain bandwidth | $V_I$ = 10 mV, See Figure 3 | $C_L$ = 20 pF, | | 85 | | kHz |
| $\phi_m$ | Phase margin | $V_I$ = 10 mV, $C_L$ = 20 pF, | f = $B_1$, See Figure 3 | | 34° | | |

## operating characteristics, $V_{DD}$ = 10 V, $T_A$ = 25°C

| PARAMETER | | TEST CONDITIONS | | TLC27L4Y | | | UNIT |
|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $R_L$ = 1 MΩ, $C_L$ = 20 pF, See Figure 1 | $V_{IPP}$ = 1 V | | 0.05 | | V/µs |
| | | | $V_{IPP}$ = 5.5 V | | 0.04 | | |
| $V_n$ | Equivalent input noise voltage | f = 1 kHz, See Figure 2 | $R_S$ = 20 Ω, | | 70 | | nV/√$\overline{Hz}$ |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_O$ = $V_{OH}$, $R_L$ = 1 MΩ, | $C_L$ = 20 pF, See Figure 1 | | 1 | | kHz |
| $B_1$ | Unity-gain bandwidth | $V_I$ = 10 mV, See Figure 3 | $C_L$ = 20 pF, | | 110 | | kHz |
| $\phi_m$ | Phase margin | $V_I$ = 10 mV, $C_L$ = 20 pF, | f = $B_1$, See Figure 3 | | 38° | | |

## PARAMETER MEASUREMENT INFORMATION

### single-supply versus split-supply test circuits

Because the TLC27L4 and TLC27L9 are optimized for single-supply operation, circuit configurations used for the various tests often present some inconvenience since the input signal, in many cases, must be offset from ground. This inconvenience can be avoided by testing the device with split supplies and the output load tied to the negative rail. A comparison of single-supply versus split-supply test circuits is shown below. The use of either circuit gives the same result.

**(a) SINGLE SUPPLY**     **(b) SPLIT SUPPLY**
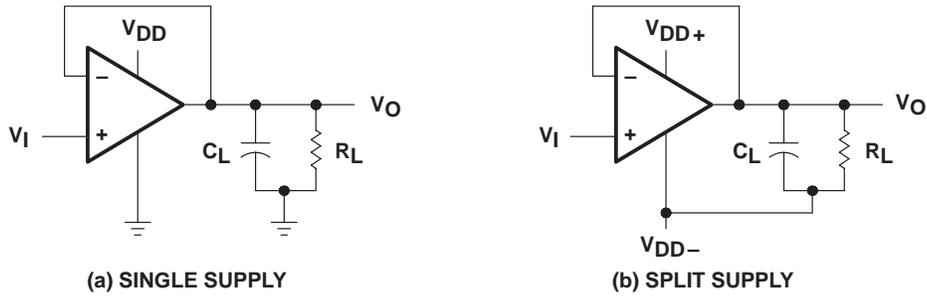
**Figure 1. Unity-Gain Amplifier**

**(a) SINGLE SUPPLY**     **(b) SPLIT SUPPLY**
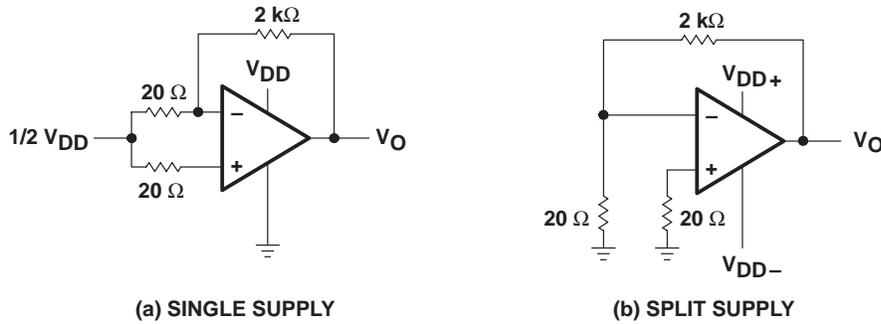
**Figure 2. Noise-Test Circuit**

**(a) SINGLE SUPPLY**     **(b) SPLIT SUPPLY**
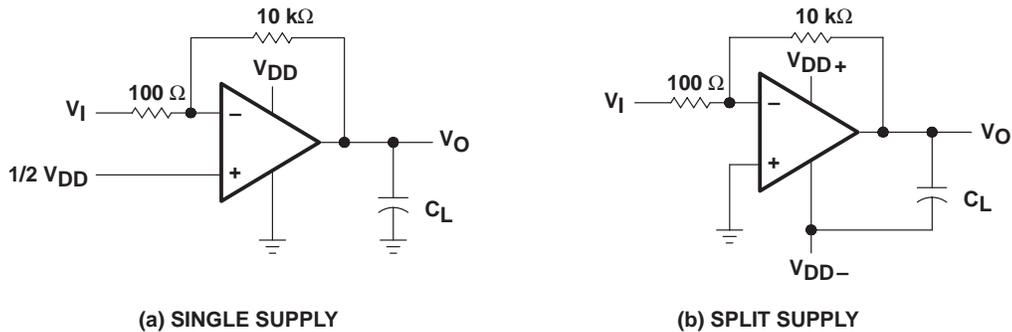
**Figure 3. Gain-of-100 Inverting Amplifier**

## PARAMETER MEASUREMENT INFORMATION

### input bias current

Because of the high input impedance of the TLC27L4 and TLC27L9 operational amplifiers, attempts to measure the input bias current can result in erroneous readings. The bias current at normal room ambient temperature is typically less than 1 pA, a value that is easily exceeded by leakages on the test socket. Two suggestions are offered to avoid erroneous measurements:

1. Isolate the device from other potential leakage sources. Use a grounded shield around and between the device inputs (see Figure 4). Leakages that would otherwise flow to the inputs are shunted away.

2. Compensate for the leakage of the test socket by actually performing an input bias current test (using a picoammeter) with no device in the test socket. The actual input bias current can then be calculated by subtracting the open-socket leakage readings from the readings obtained with a device in the test socket.

One word of caution: many automatic testers as well as some bench-top operational amplifier testers use the servo-loop technique with a resistor in series with the device input to measure the input bias current (the voltage drop across the series resistor is measured and the bias current is calculated). This method requires that a device be inserted into the test socket to obtain a correct reading; therefore, an open-socket reading is not feasible using this method.
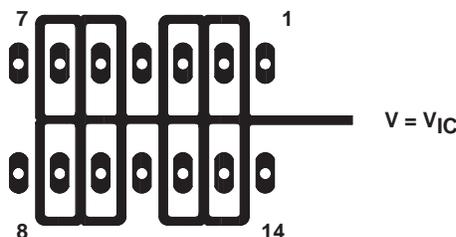


**Figure 4. Isolation Metal Around Device Inputs (J and N packages)**

### low-level output voltage

To obtain low-supply-voltage operation, some compromise was necessary in the input stage. This compromise results in the device low-level output being dependent on both the common-mode input voltage level as well as the differential input voltage level. When attempting to correlate low-level output readings with those quoted in the electrical specifications, these two conditions should be observed. If conditions other than these are to be used, please refer to Figures 14 through 19 in the Typical Characteristics of this data sheet.

### input offset voltage temperature coefficient

Erroneous readings often result from attempts to measure temperature coefficient of input offset voltage. This parameter is actually a calculation using input offset voltage measurements obtained at two different temperatures. When one (or both) of the temperatures is below freezing, moisture can collect on both the device and the test socket. This moisture results in leakage and contact resistance, which can cause erroneous input offset voltage readings. The isolation techniques previously mentioned have no effect on the leakage since the moisture also covers the isolation metal itself, thereby rendering it useless. It is suggested that these measurements be performed at temperatures above freezing to minimize error.

**PARAMETER MEASUREMENT INFORMATION**

**full-power response**

Full-power response, the frequency above which the operational amplifier slew rate limits the output voltage swing, is often specified two ways: full-linear response and full-peak response. The full-linear response is generally measured by monitoring the distortion level of the output while increasing the frequency of a sinusoidal input signal until the maximum frequency is found above which the output contains significant distortion. The full-peak response is defined as the maximum output frequency, without regard to distortion, above which full peak-to-peak output swing cannot be maintained.

Because there is no industry-wide accepted value for significant distortion, the full-peak response is specified in this data sheet and is measured using the circuit of Figure 1. The initial setup involves the use of a sinusoidal input to determine the maximum peak-to-peak output of the device (the amplitude of the sinusoidal wave is increased until clipping occurs). The sinusoidal wave is then replaced with a square wave of the same amplitude. The frequency is then increased until the maximum peak-to-peak output can no longer be maintained (Figure 5). A square wave is used to allow a more accurate determination of the point at which the maximum peak-to-peak output is reached.



(a) f = 100 Hz    (b) $B_{OM} > f > 100$ Hz    (c) $f = B_{OM}$    (d) $f > B_{OM}$
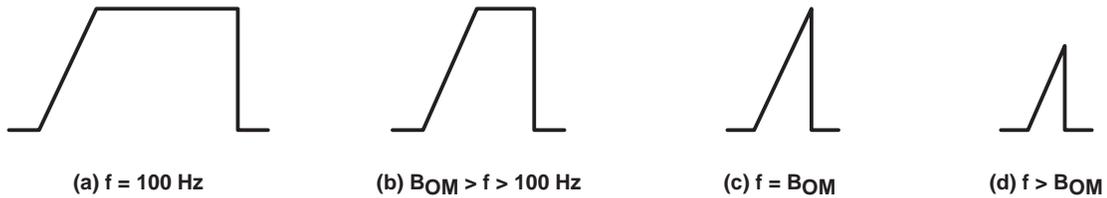
**Figure 5. Full-Power-Response Output Signal**

**test time**

Inadequate test time is a frequent problem, especially when testing CMOS devices in a high-volume, short-test-time environment. Internal capacitances are inherently higher in CMOS than in bipolar and BiFET devices and require longer test times than their bipolar and BiFET counterparts. The problem becomes more pronounced with reduced supply levels and lower temperatures.

## TYPICAL CHARACTERISTICS

**Table of Graphs**

| | | | FIGURE |
|---|---|---|---|
| $V_{IO}$ | Input offset voltage | Distribution | 6, 7 |
| $\alpha_{VIO}$ | Temperature coefficient | Distribution | 8, 9 |
| $V_{OH}$ | High-level output voltage | vs High-level output current<br>vs Supply voltage<br>vs Free-air temperature | 10, 11<br>12<br>13 |
| $V_{OL}$ | Low-level output voltage | vs Common-mode input voltage<br>vs Differential input voltage<br>vs Free-air temperature<br>vs Low-level output current | 14, 15<br>16<br>17<br>18, 19 |
| $A_{VD}$ | Differential voltage amplification | vs Supply voltage<br>vs Free-air temperature<br>vs Frequency | 20<br>21<br>32, 33 |
| $I_{IB}/I_{IO}$ | Input bias and input offset current | vs Free-air temperature | 22 |
| $V_{IC}$ | Common-mode input voltage | vs Supply voltage | 23 |
| $I_{DD}$ | Supply current | vs Supply voltage<br>vs Free-air temperature | 24<br>25 |
| SR | Slew rate | vs Supply voltage<br>vs Free-air temperature | 26<br>27 |
| | Normalized slew rate | vs Free-air temperature | 28 |
| $V_{O(PP)}$ | Maximum peak-to-peak output voltage | vs Frequency | 29 |
| $B_1$ | Unity-gain bandwidth | vs Free-air temperature<br>vs Supply voltage | 30<br>31 |
| $\phi_m$ | Phase margin | vs Supply voltage<br>vs Free-air temperature<br>vs Capacitive loads | 34<br>35<br>36 |
| $V_n$ | Equivalent input noise voltage | vs Frequency | 37 |
| $\phi$ | Phase shift | vs Frequency | 32, 33 |

![Texas Instruments logo]

**TEXAS**
**INSTRUMENTS**

POST OFFICE BOX 655303 ● DALLAS, TEXAS 75265

## TYPICAL CHARACTERISTICS

DISTRIBUTION OF TLC27L4
INPUT OFFSET VOLTAGE



905 Amplifiers Tested From 6 Wafer Lots
$V_{DD}$ = 5 V
$T_A$ = 25°C
N Package
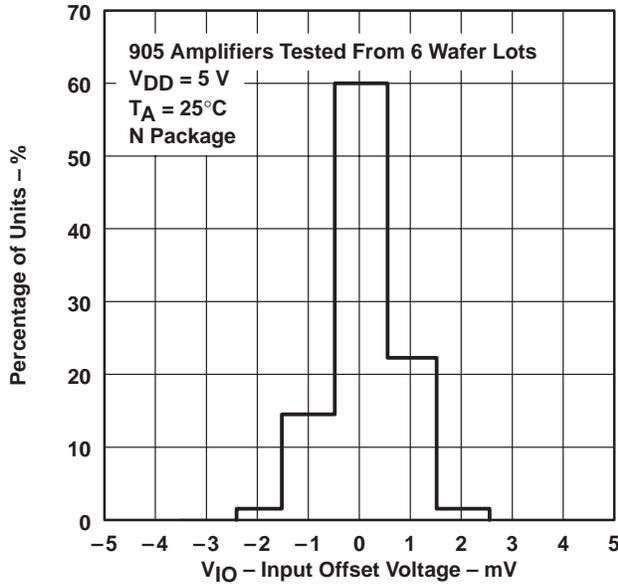
**Figure 6**

DISTRIBUTION OF TLC27L4
INPUT OFFSET VOLTAGE



905 Amplifiers Tested From 6 Wafer Lots
$V_{DD}$ = 10 V
$T_A$ = 25°C
N Package
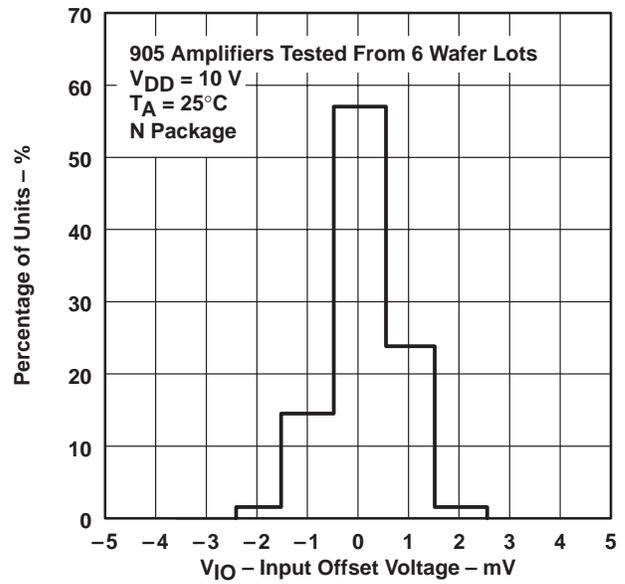
**Figure 7**

DISTRIBUTION OF TLC27L4 AND TLC27L9
INPUT OFFSET VOLTAGE
TEMPERATURE COEFFICIENT



356 Amplifiers Tested From 8 Wafer Lots
$V_{DD}$ = 5 V
$T_A$ = 25°C to 125°C
N Package
Outliers:
(1) 19.2 μV/°C
(1) 12.1 μV/°C
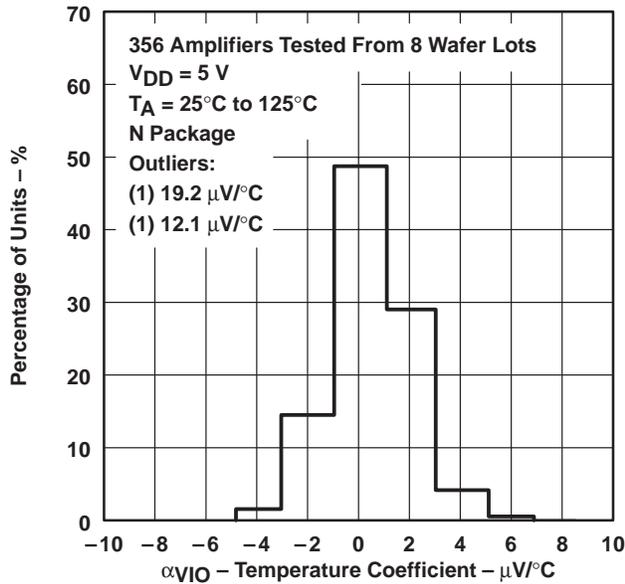
**Figure 8**

DISTRIBUTION OF TLC27L4 AND TLC27L9
INPUT OFFSET VOLTAGE
TEMPERATURE COEFFICIENT



356 Amplifiers Tested From 6 Wafer Lots
$V_{DD}$ = 10 V
$T_A$ = 25°C to 125°C
N Package
Outliers:
(1) 18.7 μV/°C
(1) 11.6 μV/°C

**Figure 9**

TEXAS
INSTRUMENTS

## TYPICAL CHARACTERISTICS†

HIGH-LEVEL OUTPUT VOLTAGE
vs
HIGH-LEVEL OUTPUT CURRENT



**Figure 10**

HIGH-LEVEL OUTPUT VOLTAGE
vs
HIGH-LEVEL OUTPUT CURRENT



**Figure 11**

HIGH-LEVEL OUTPUT VOLTAGE
vs
SUPPLY VOLTAGE



**Figure 12**
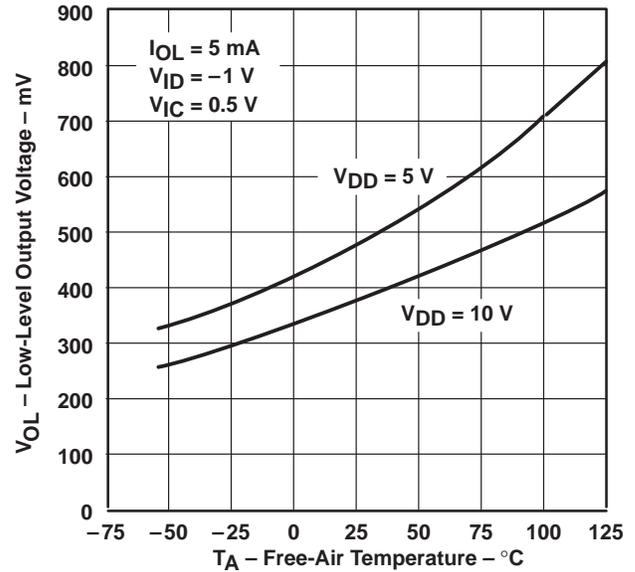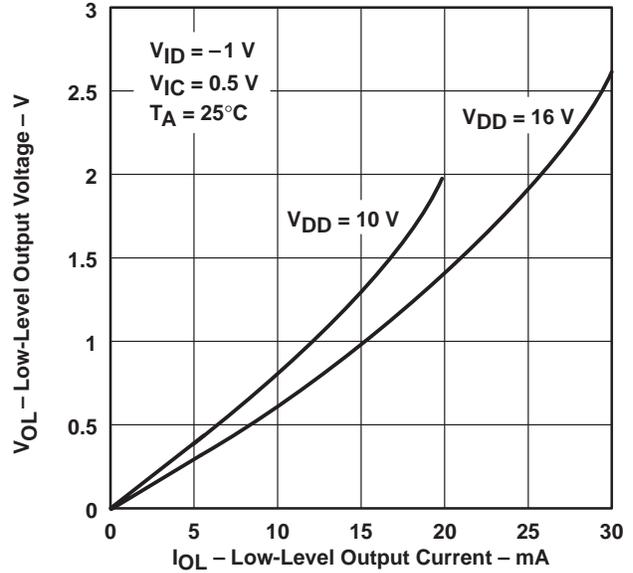
HIGH-LEVEL OUTPUT VOLTAGE
vs
FREE-AIR TEMPERATURE
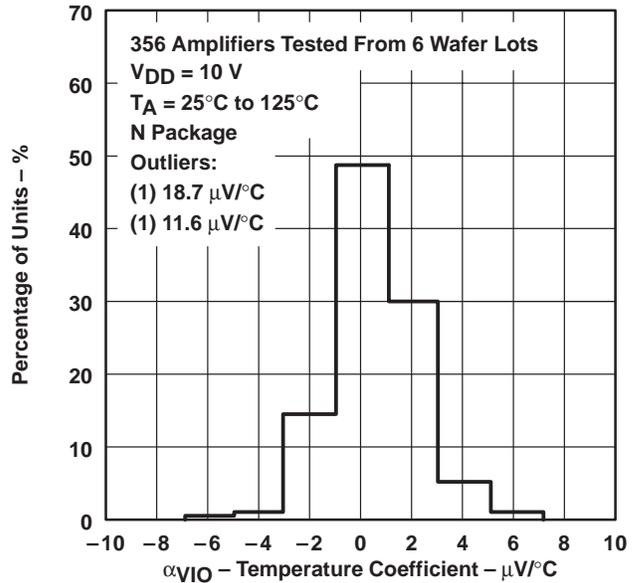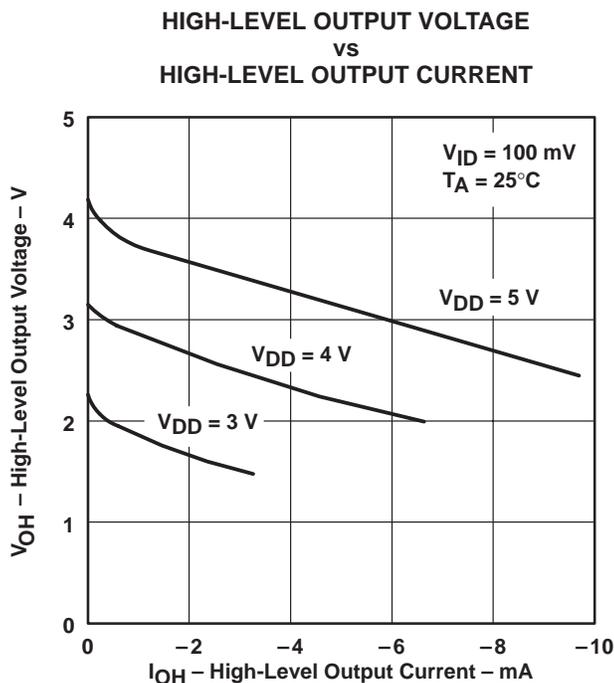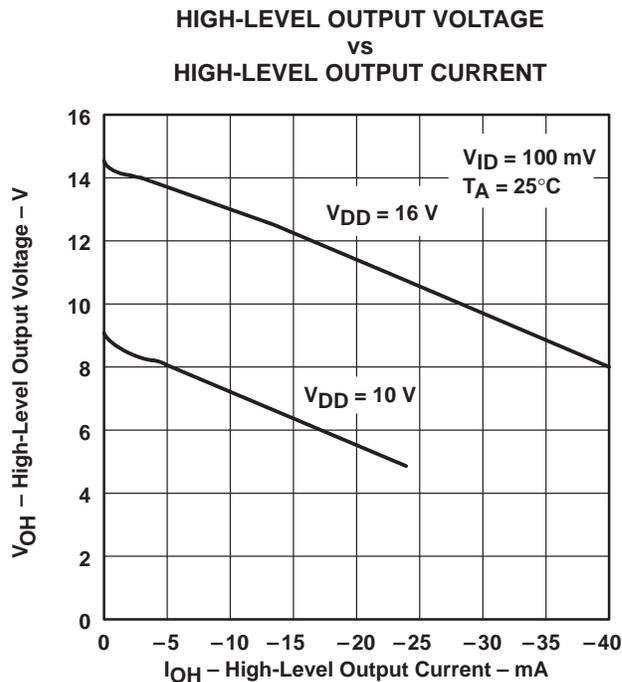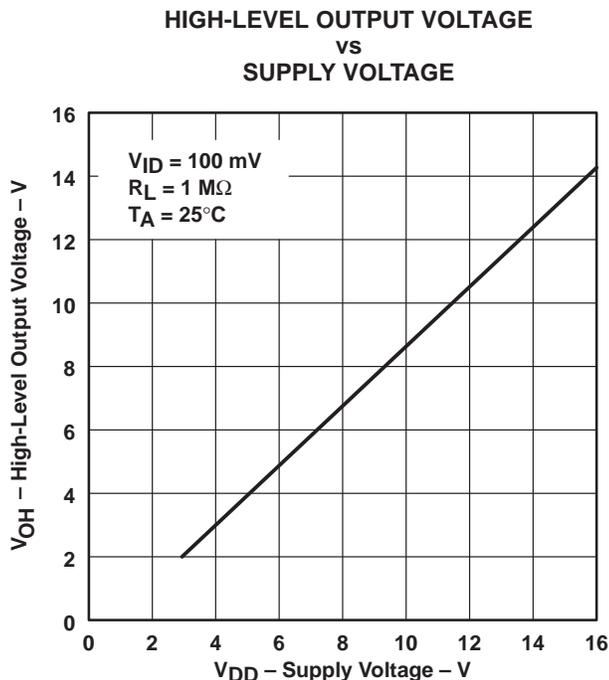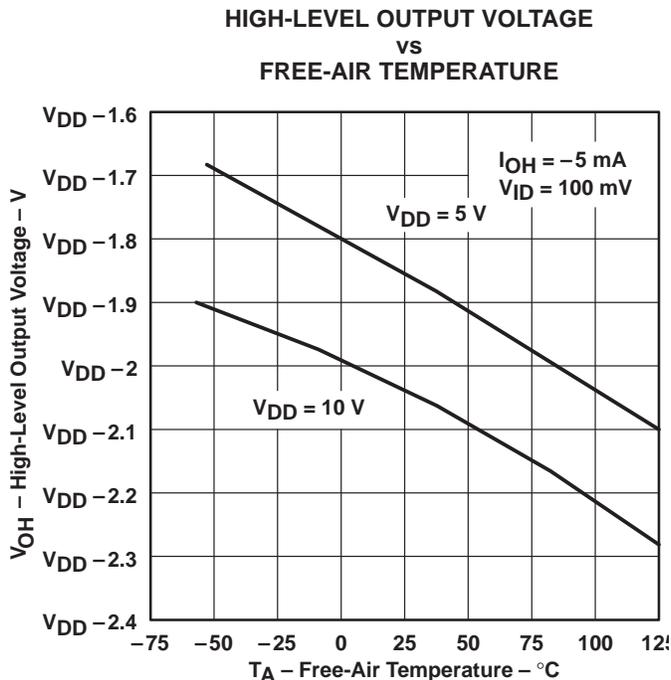


**Figure 13**

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

# TYPICAL CHARACTERISTICS†

**LOW-LEVEL OUTPUT VOLTAGE
vs
COMMON-MODE INPUT VOLTAGE**
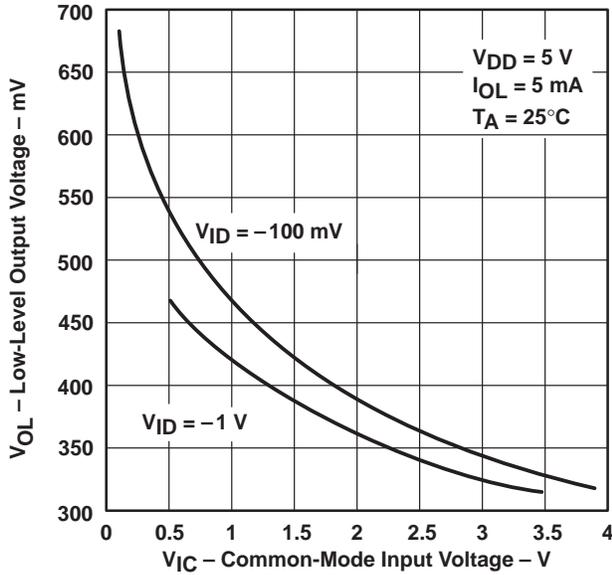


**Figure 14**

**LOW-LEVEL OUTPUT VOLTAGE
vs
COMMON-MODE INPUT VOLTAGE**
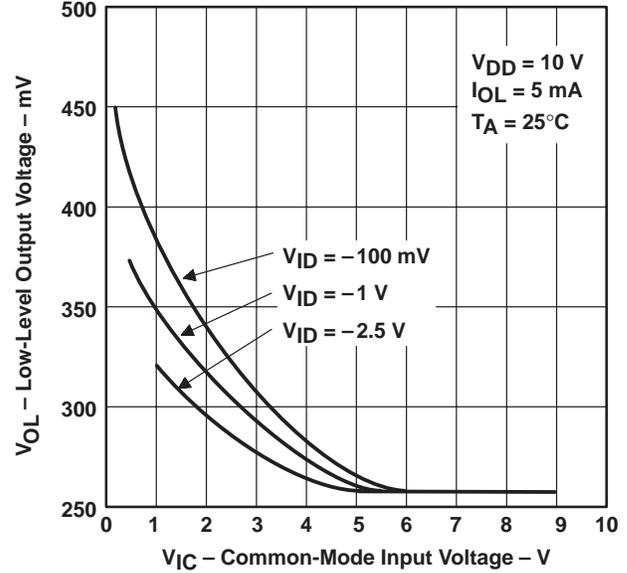


**Figure 15**

**LOW-LEVEL OUTPUT VOLTAGE
vs
DIFFERENTIAL INPUT VOLTAGE**
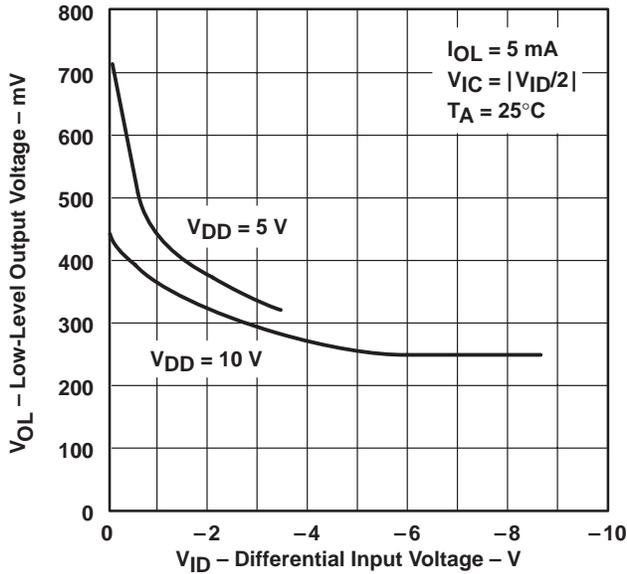


**Figure 16**
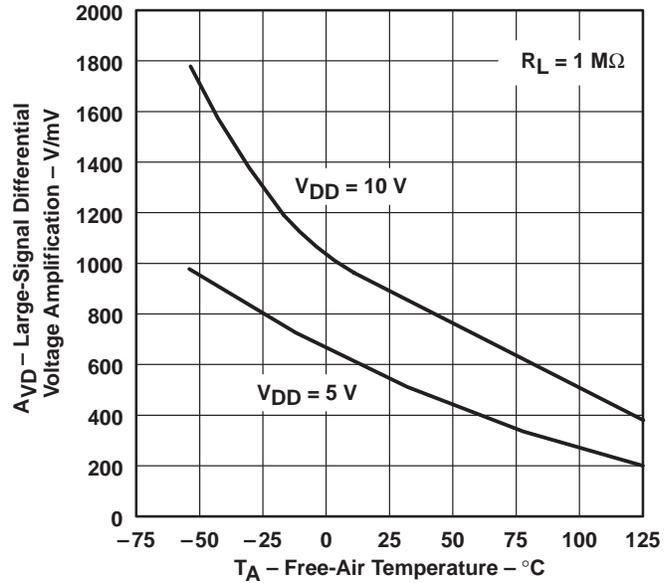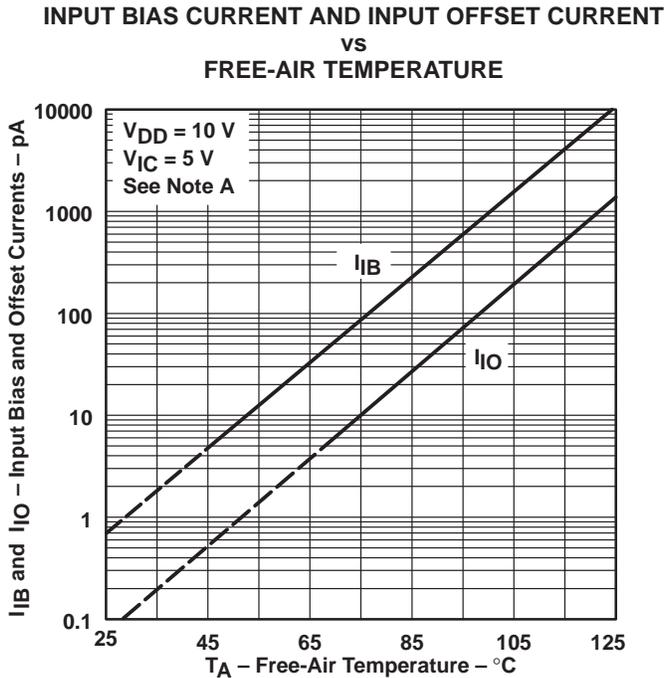
**LOW-LEVEL OUTPUT VOLTAGE
vs
FREE-AIR TEMPERATURE**



**Figure 17**

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

## TYPICAL CHARACTERISTICS†

### LOW-LEVEL OUTPUT VOLTAGE
### vs
### LOW-LEVEL OUTPUT CURRENT

$V_{ID} = -1$ V
$V_{IC} = 0.5$ V
$T_A = 25°C$

$V_{DD} = 5$ V
$V_{DD} = 4$ V
$V_{DD} = 3$ V
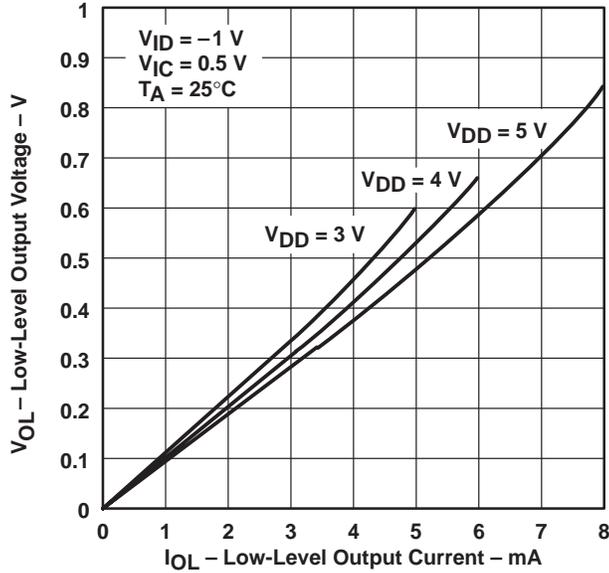
**Figure 18**

### LOW-LEVEL OUTPUT VOLTAGE
### vs
### LOW-LEVEL OUTPUT CURRENT

$V_{ID} = -1$ V
$V_{IC} = 0.5$ V
$T_A = 25°C$

$V_{DD} = 16$ V
$V_{DD} = 10$ V

**Figure 19**

### LARGE-SIGNAL
### DIFFERENTIAL VOLTAGE AMPLIFICATION
### vs
### SUPPLY VOLTAGE

$T_A = -55°C$
$R_L = 1$ MΩ
$T_A = -40°C$
$T_A = 0°C$
$T_A = 25°C$
$T_A = 70°C$
$T_A = 85°C$
$T_A = 125°C$
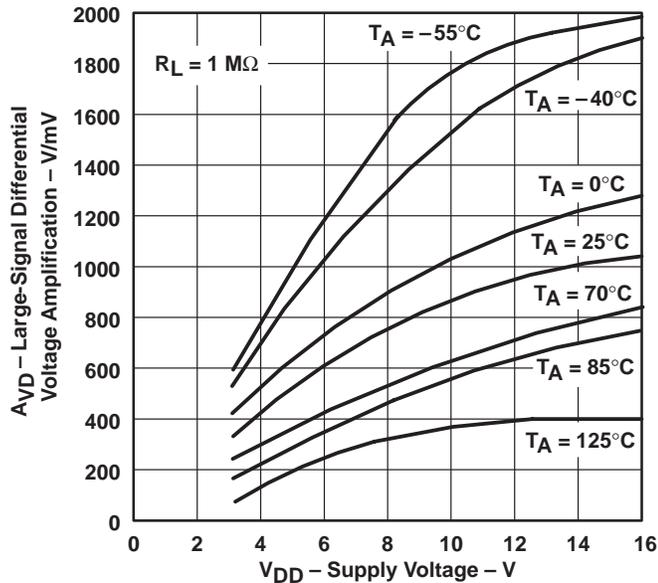
**Figure 20**

### LARGE-SIGNAL
### DIFFERENTIAL VOLTAGE AMPLIFICATION
### vs
### FREE-AIR TEMPERATURE

$R_L = 1$ MΩ
$V_{DD} = 10$ V
$V_{DD} = 5$ V

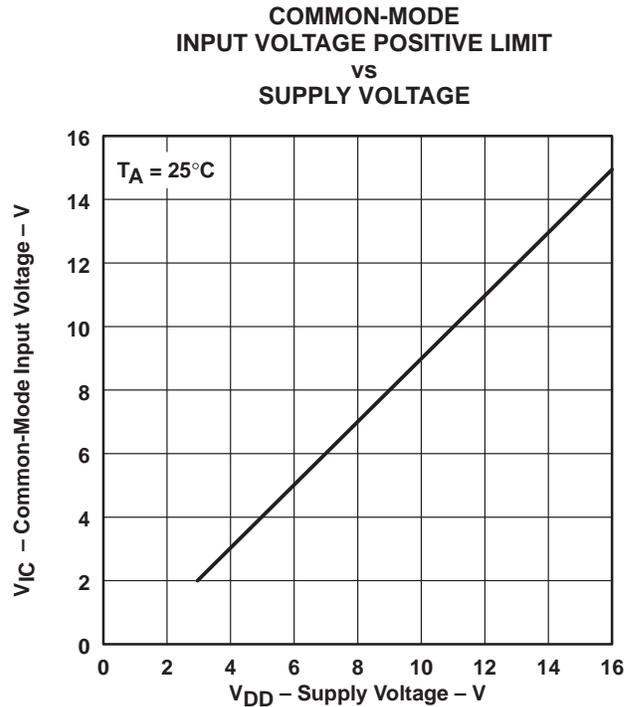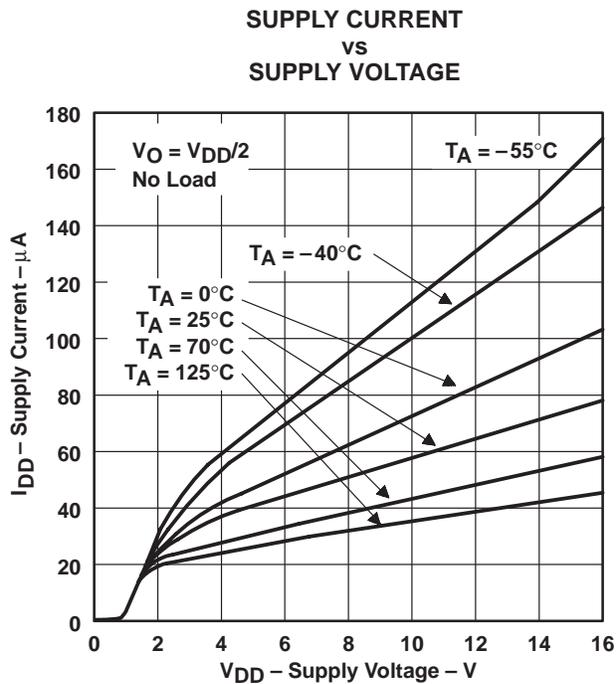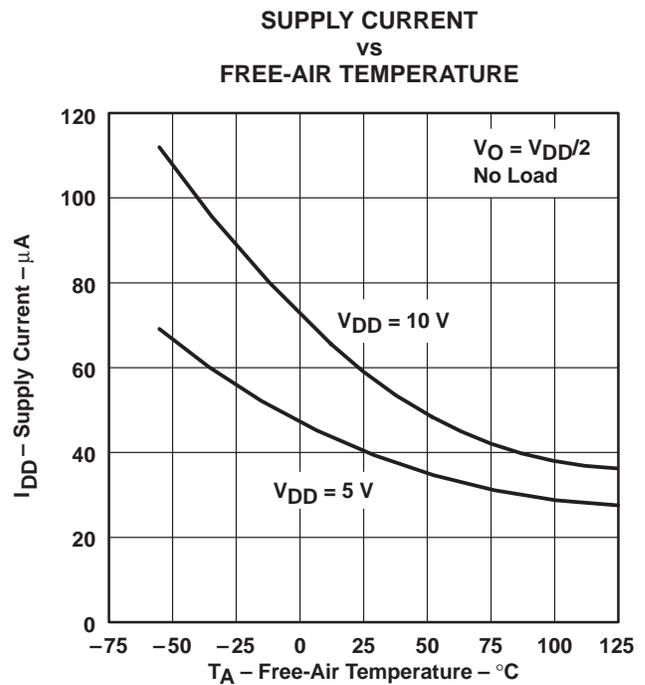**Figure 21**

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

![Texas Instruments logo] **TEXAS INSTRUMENTS**

POST OFFICE BOX 655303 ● DALLAS, TEXAS 75265

## TYPICAL CHARACTERISTICS†

**INPUT BIAS CURRENT AND INPUT OFFSET CURRENT**
**vs**
**FREE-AIR TEMPERATURE**



NOTE A: The typical values of input bias current and input offset current below 5 pA were determined mathematically.

**Figure 22**

**COMMON-MODE**
**INPUT VOLTAGE POSITIVE LIMIT**
**vs**
**SUPPLY VOLTAGE**



**Figure 23**

**SUPPLY CURRENT**
**vs**
**SUPPLY VOLTAGE**



**Figure 24**

**SUPPLY CURRENT**
**vs**
**FREE-AIR TEMPERATURE**



**Figure 25**

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
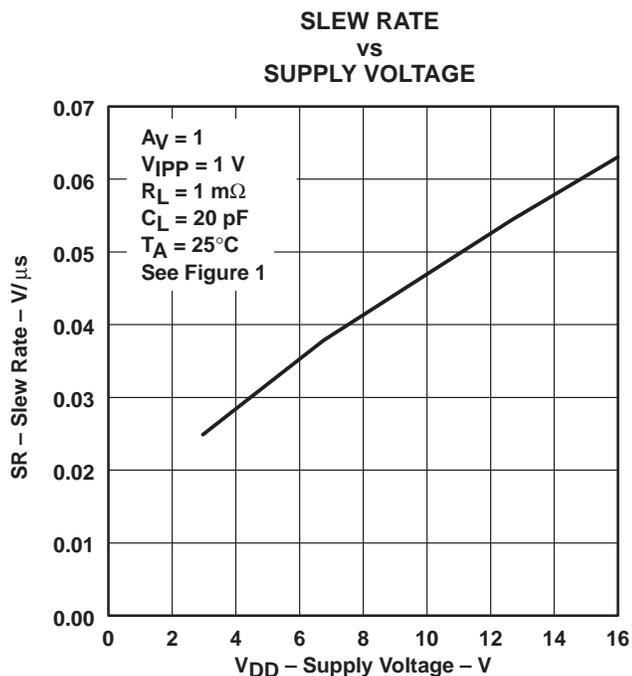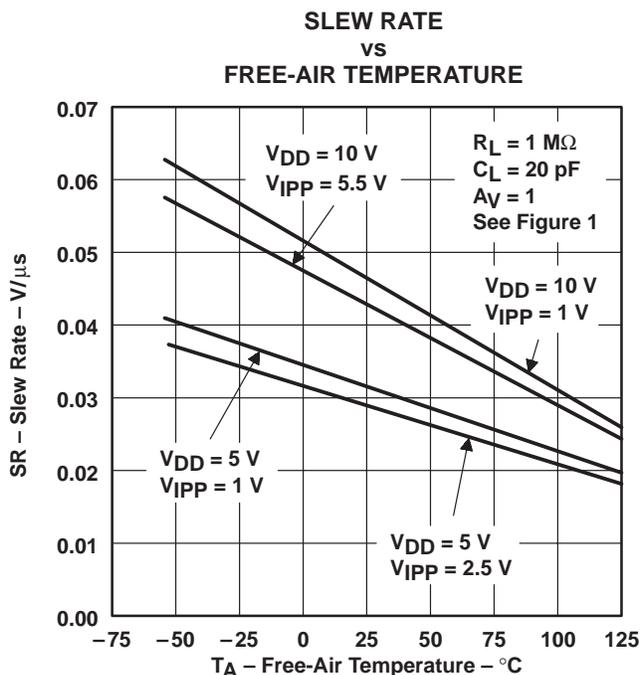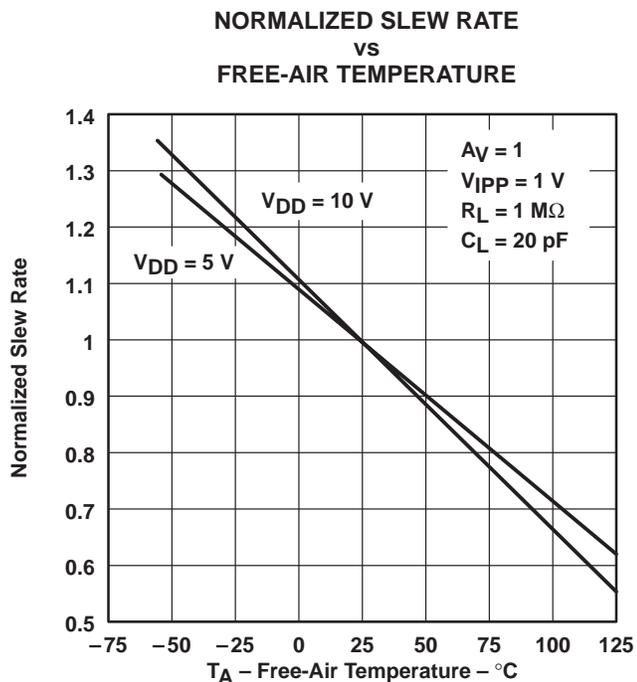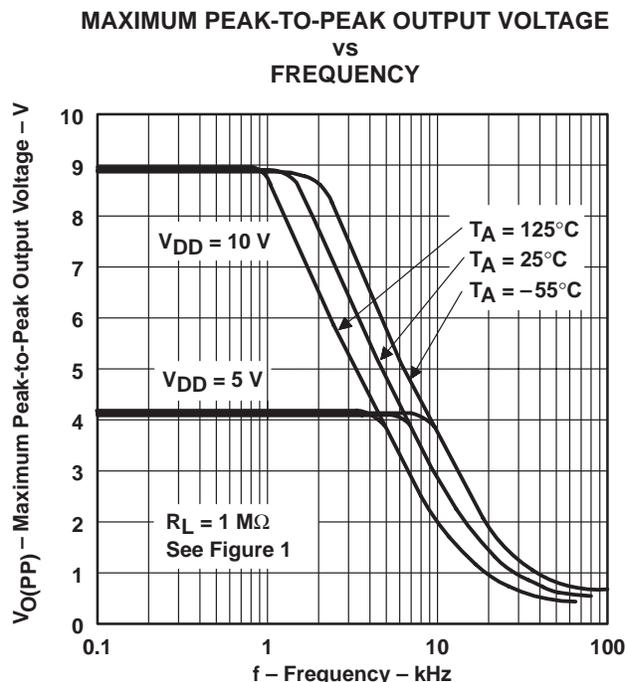
![Texas Instruments logo]
**TEXAS**
**INSTRUMENTS**

## TYPICAL CHARACTERISTICS†

SLEW RATE
vs
SUPPLY VOLTAGE



$A_V = 1$
$V_{IPP} = 1$ V
$R_L = 1$ mΩ
$C_L = 20$ pF
$T_A = 25°C$
See Figure 1

**Figure 26**

SLEW RATE
vs
FREE-AIR TEMPERATURE



$V_{DD} = 10$ V
$V_{IPP} = 5.5$ V

$R_L = 1$ MΩ
$C_L = 20$ pF
$A_V = 1$
See Figure 1

$V_{DD} = 10$ V
$V_{IPP} = 1$ V

$V_{DD} = 5$ V
$V_{IPP} = 1$ V

$V_{DD} = 5$ V
$V_{IPP} = 2.5$ V

**Figure 27**

NORMALIZED SLEW RATE
vs
FREE-AIR TEMPERATURE



$V_{DD} = 10$ V

$V_{DD} = 5$ V

$A_V = 1$
$V_{IPP} = 1$ V
$R_L = 1$ MΩ
$C_L = 20$ pF

**Figure 28**

MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE
vs
FREQUENCY



$V_{DD} = 10$ V

$T_A = 125°C$
$T_A = 25°C$
$T_A = -55°C$

$V_{DD} = 5$ V

$R_L = 1$ MΩ
See Figure 1

**Figure 29**

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
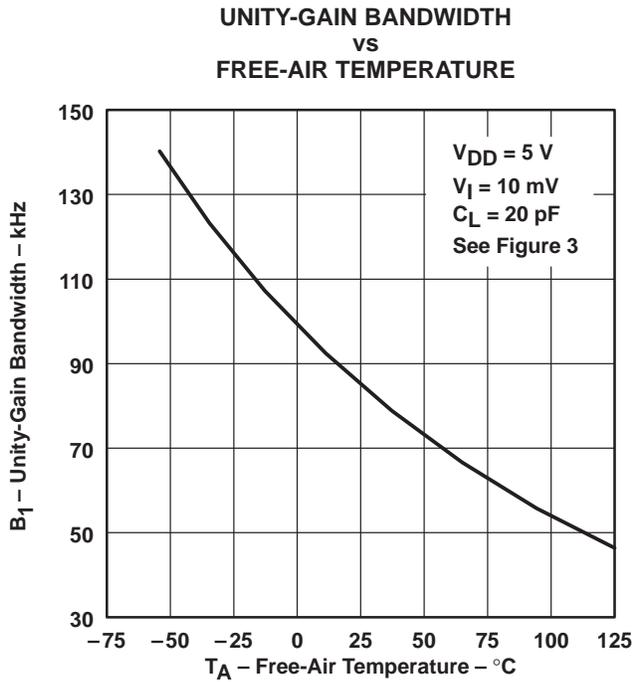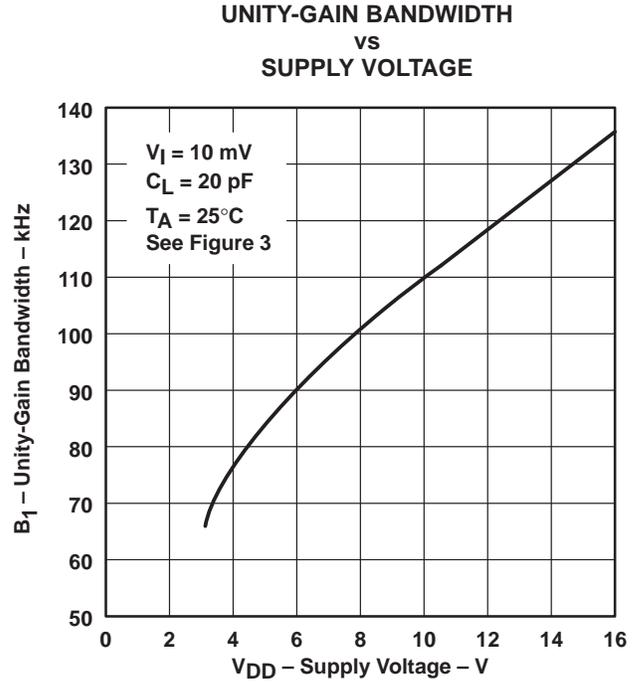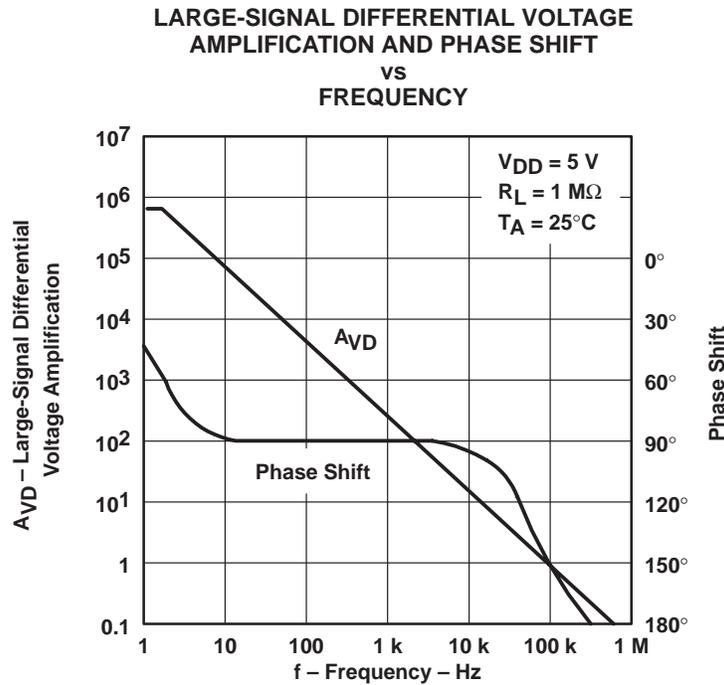
## TYPICAL CHARACTERISTICS†

**UNITY-GAIN BANDWIDTH
vs
FREE-AIR TEMPERATURE**

$V_{DD}$ = 5 V
$V_I$ = 10 mV
$C_L$ = 20 pF
See Figure 3

**Figure 30**

**UNITY-GAIN BANDWIDTH
vs
SUPPLY VOLTAGE**

$V_I$ = 10 mV
$C_L$ = 20 pF
$T_A$ = 25°C
See Figure 3

**Figure 31**

**LARGE-SIGNAL DIFFERENTIAL VOLTAGE
AMPLIFICATION AND PHASE SHIFT
vs
FREQUENCY**

$V_{DD}$ = 5 V
$R_L$ = 1 MΩ
$T_A$ = 25°C

$A_{VD}$

Phase Shift

**Figure 32**

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

**TEXAS
INSTRUMENTS**

## TYPICAL CHARACTERISTICS†

**LARGE-SIGNAL DIFFERENTIAL VOLTAGE
AMPLIFICATION AND PHASE SHIFT
vs
FREQUENCY**



$V_{DD} = 10\ V$
$R_L = 1\ M\Omega$
$T_A = 25°C$

$A_{VD}$

Phase Shift

$A_{VD}$ – Large-Signal Differential Voltage Amplification

Phase Shift

f – Frequency – Hz
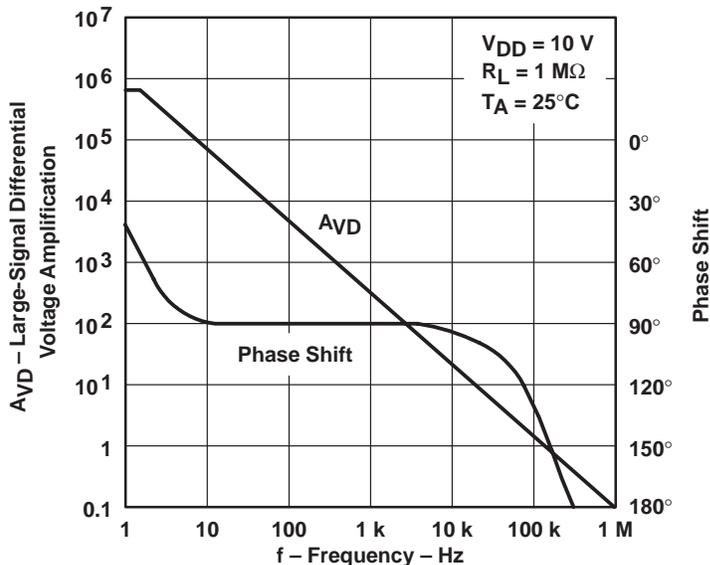
**Figure 33**

**PHASE MARGIN
vs
SUPPLY VOLTAGE**



$V_I = 10\ mV$
$C_L = 20\ pF$
$T_A = 25°C$
See Figure 3

$\phi_m$ – Phase Margin

$V_{DD}$ – Supply Voltage – V

**Figure 34**

**PHASE MARGIN
vs
FREE-AIR TEMPERATURE**



$V_{DD} = 5\ mV$
$V_I = 10\ mV$
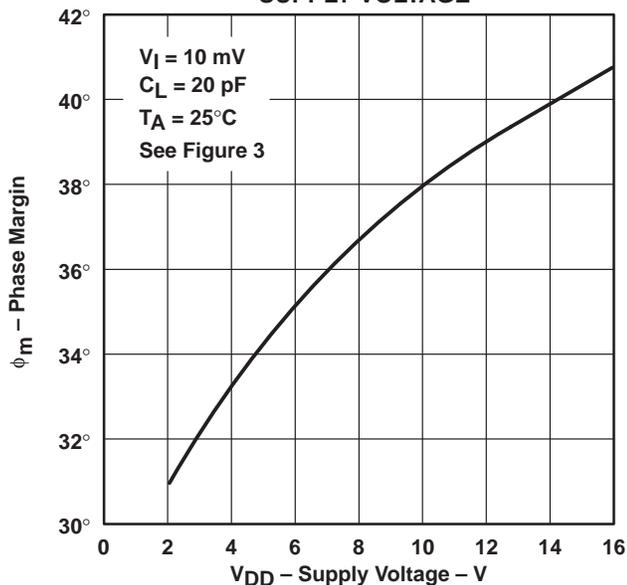$C_L = 20\ pF$
See Figure 3

$\phi_m$ – Phase Margin

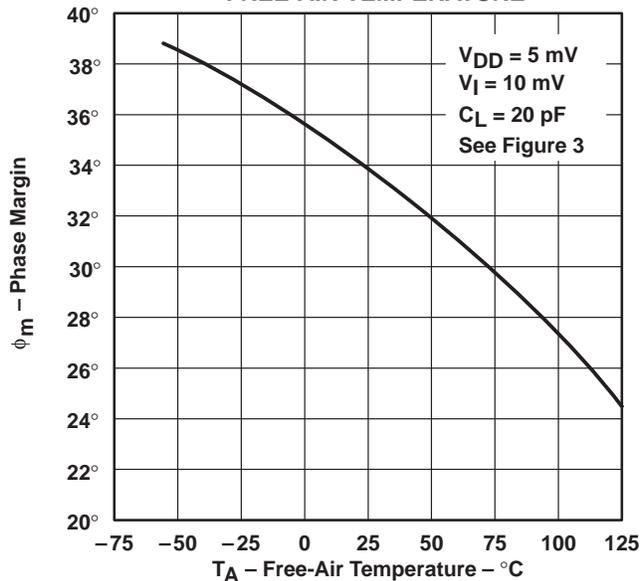$T_A$ – Free-Air Temperature – °C

**Figure 35**

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

![Texas Instruments logo] **TEXAS INSTRUMENTS**

POST OFFICE BOX 655303 ● DALLAS, TEXAS 75265

## TYPICAL CHARACTERISTICS

### PHASE MARGIN
### vs
### CAPACITIVE LOAD



$V_{DD}$ = 5 mV
$V_I$ = 10 mV
$T_A$ = 25°C
See Figure 3

$\phi_m$ – Phase Margin

$C_L$ – Capacitive Load – pF
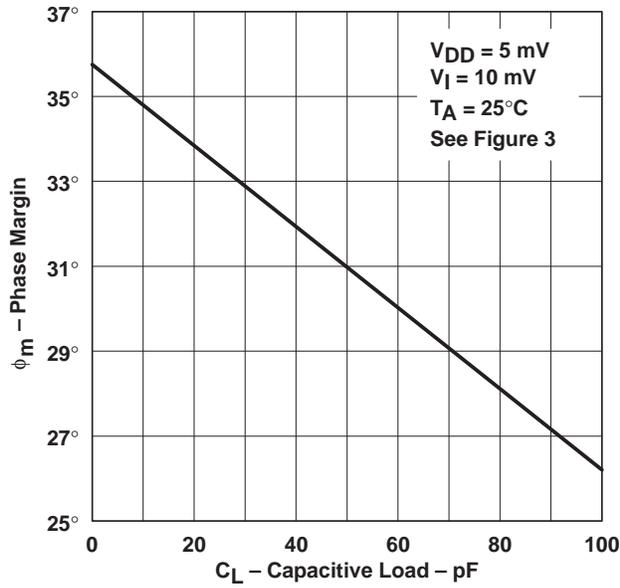
**Figure 36**

### EQUIVALENT INPUT NOISE VOLTAGE
### vs
### FREQUENCY



$V_{DD}$ = 5 V
$R_S$ = 20 Ω
$T_A$ = 25°C
See Figure 2

$V_n$ – Equivalent Input Noise Voltage – nV/√Hz

f – Frequency – Hz

**Figure 37**

TEXAS
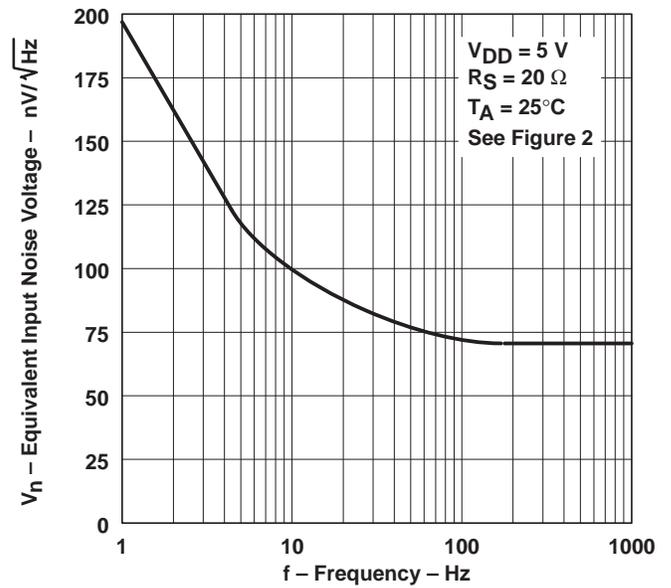INSTRUMENTS

POST OFFICE BOX 655303 ● DALLAS, TEXAS 75265

## APPLICATION INFORMATION

### single-supply operation

While the TLC27L4 and TLC27L9 perform well using dual power supplies (also called balanced or split supplies), the design is optimized for single-supply operation. This design includes an input common-mode voltage range that encompasses ground as well as an output voltage range that pulls down to ground. The supply voltage range extends down to 3 V (C-suffix types), thus allowing operation with supply levels commonly available for TTL and HCMOS; however, for maximum dynamic range, 16-V single-supply operation is recommended.

Many single-supply applications require that a voltage be applied to one input to establish a reference level that is above ground. A resistive voltage divider is usually sufficient to establish this reference level (see Figure 38). The low input bias current of the TLC27L4 and TLC27L9 permits the use of very large resistive values to implement the voltage divider, thus minimizing power consumption.

The TLC27L4 and TLC27L9 work well in conjunction with digital logic; however, when powering both linear devices and digital logic from the same power supply, the following precautions are recommended:

1. Power the linear devices from separate bypassed supply lines (see Figure 39); otherwise, the linear device supply rails can fluctuate due to voltage drops caused by high switching currents in the digital logic.

2. Use proper bypass techniques to reduce the probability of noise-induced errors. Single capacitive decoupling is often adequate; however, high-frequency applications may require RC decoupling.
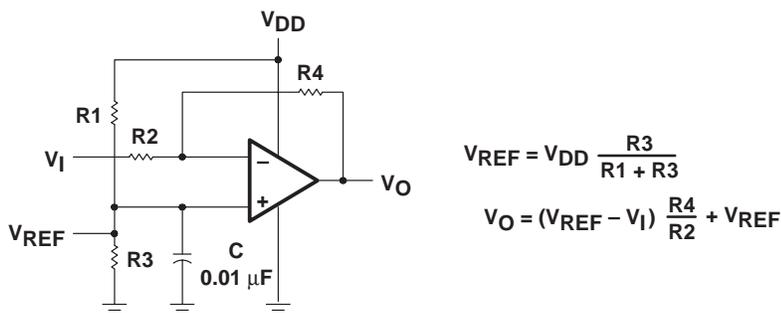


$$V_{REF} = V_{DD} \frac{R3}{R1 + R3}$$

$$V_O = (V_{REF} - V_I) \frac{R4}{R2} + V_{REF}$$

**Figure 38. Inverting Amplifier With Voltage Reference**

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

## APPLICATION INFORMATION

### single-supply operation (continued)



(a) COMMON SUPPLY RAILS



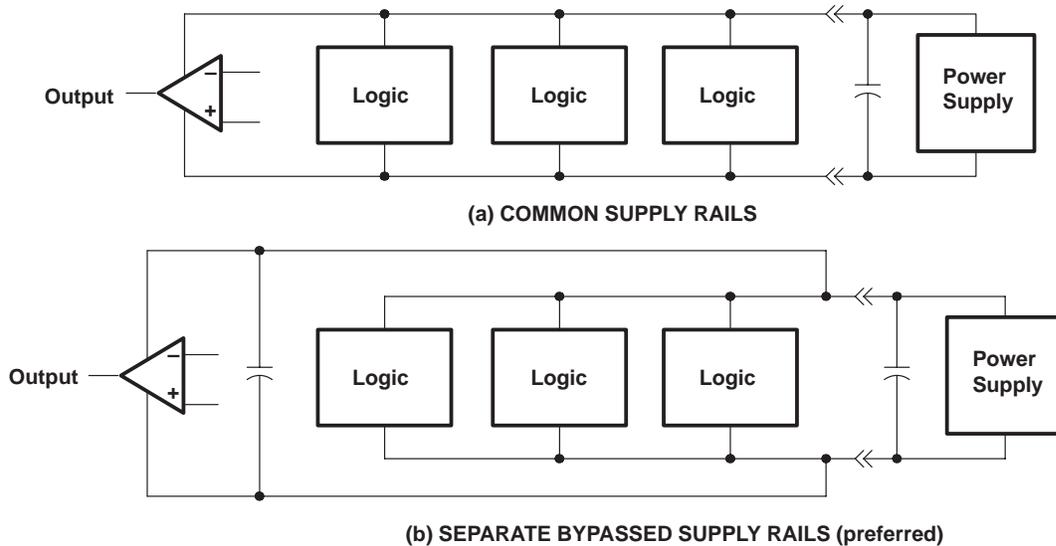(b) SEPARATE BYPASSED SUPPLY RAILS (preferred)

**Figure 39. Common Versus Separate Supply Rails**

### input characteristics

The TLC27L4 and TLC27L9 are specified with a minimum and a maximum input voltage that, if exceeded at either input, could cause the device to malfunction. Exceeding this specified range is a common problem, especially in single-supply operation. Note that the lower range limit includes the negative rail, while the upper range limit is specified at $V_{DD} - 1$ V at $T_A = 25°C$ and at $V_{DD} - 1.5$ V at all other temperatures.

The use of the polysilicon-gate process and the careful input circuit design gives the TLC27L4 and TLC27L9 very good input offset voltage drift characteristics relative to conventional metal-gate processes. Offset voltage drift in CMOS devices is highly influenced by threshold voltage shifts caused by polarization of the phosphorus dopant implanted in the oxide. Placing the phosphorus dopant in a conductor (such as a polysilicon gate) alleviates the polarization problem, thus reducing threshold voltage shifts by more than an order of magnitude. The offset voltage drift with time has been calculated to be typically 0.1 µV/month, including the first month of operation.

Because of the extremely high input impedance and resulting low bias current requirements, the TLC27L4 and TLC27L9 are well suited for low-level signal processing; however, leakage currents on printed circuit boards and sockets can easily exceed bias current requirements and cause a degradation in device performance. It is good practice to include guard rings around inputs (similar to those of Figure 4 in the Parameter Measurement Information section). These guards should be driven from a low-impedance source at the same voltage level as the common-mode input (see Figure 40).

The inputs of any unused amplifiers should be tied to ground to avoid possible oscillation.

### noise performance

The noise specifications in operational amplifier circuits are greatly dependent on the current in the first-stage differential amplifier. The low input bias current requirements of the TLC27L4 and TLC27L9 result in a very low noise current, which is insignificant in most applications. This feature makes the devices especially favorable over bipolar devices when using values of circuit impedance greater than 50 kΩ, since bipolar devices exhibit greater noise currents.

![Texas Instruments logo]

## APPLICATION INFORMATION

### noise performance (continued)



**(a) NONINVERTING AMPLIFIER**    **(b) INVERTING AMPLIFIER**    **(c) UNITY-GAIN AMPLIFIER**
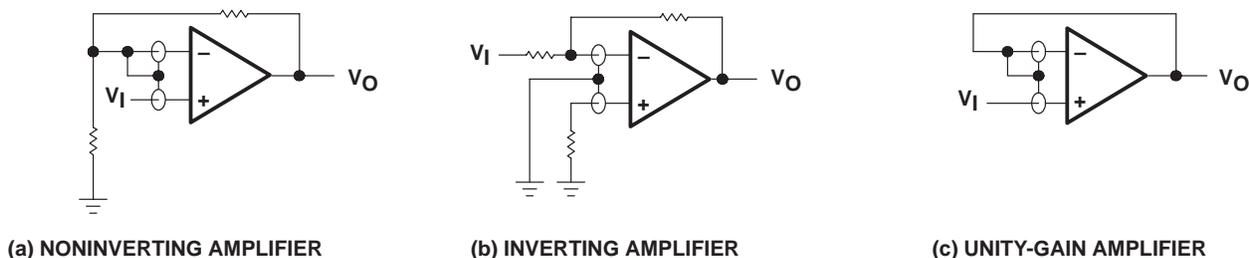
**Figure 40. Guard-Ring Schemes**

### output characteristics

The output stage of the TLC27L4 and TLC27L9 is designed to sink and source relatively high amounts of current (see typical characteristics). If the output is subjected to a short-circuit condition, this high current capability can cause device damage under certain conditions. Output current capability increases with supply voltage.

All operating characteristics of the TLC27L4 and TLC27L9 were measured using a 20-pF load. The devices drive higher capacitive loads; however, as output load capacitance increases, the resulting response pole occurs at lower frequencies, thereby causing ringing, peaking, or even oscillation (see Figure 41). In many cases, adding a small amount of resistance in series with the load capacitance alleviates the problem.
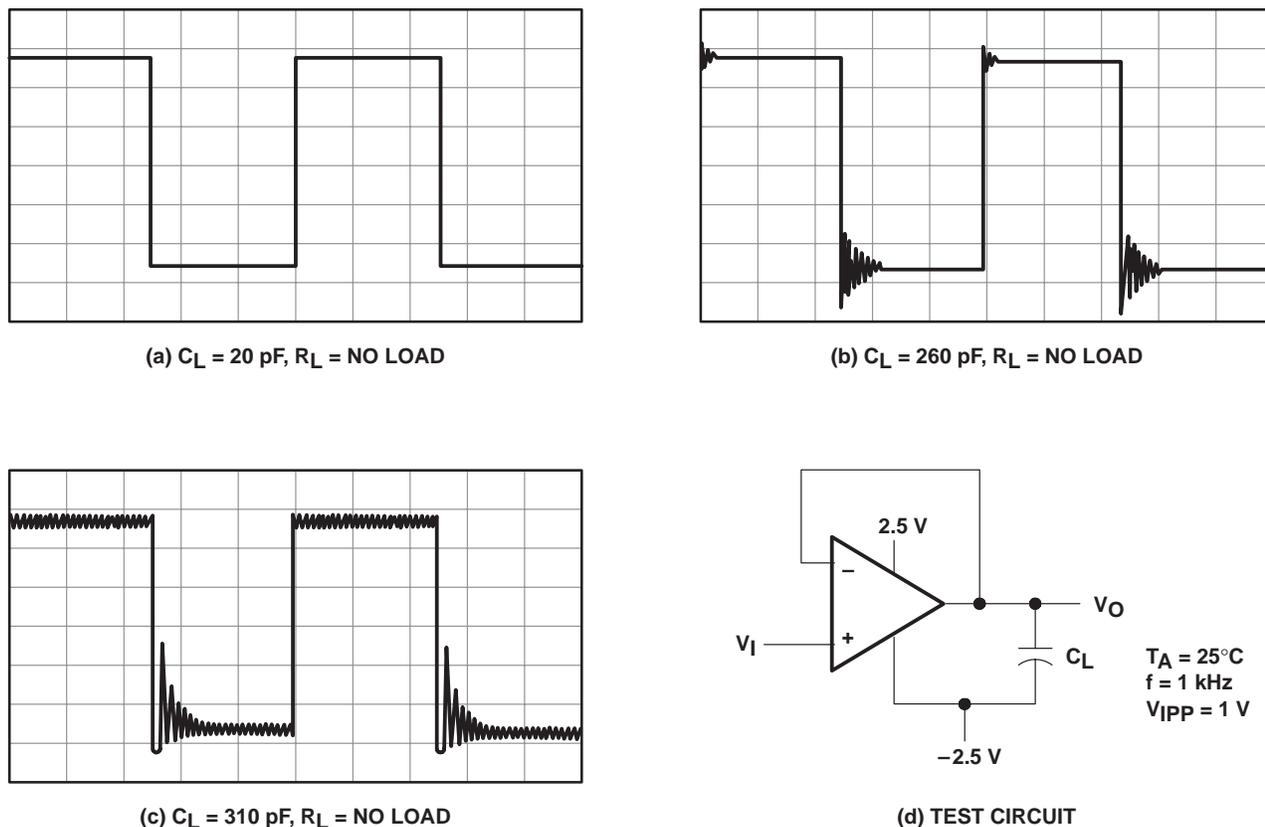


**(a) $C_L$ = 20 pF, $R_L$ = NO LOAD**



**(b) $C_L$ = 260 pF, $R_L$ = NO LOAD**



**(c) $C_L$ = 310 pF, $R_L$ = NO LOAD**



**(d) TEST CIRCUIT**

$T_A$ = 25°C
f = 1 kHz
$V_{IPP}$ = 1 V

**Figure 41. Effect of Capacitive Loads and Test Circuit**

## TEXAS INSTRUMENTS

## APPLICATION INFORMATION

### output characteristics (continued)

Although the TLC27L4 and TLC27L9 possess excellent high-level output voltage and current capability, methods for boosting this capability are available, if needed. The simplest method involves the use of a pullup resistor (Rb) connected from the output to the positive supply rail (see Figure 42). There are two disadvantages to the use of this circuit. First, the NMOS pulldown transistor N4 (see equivalent schematic) must sink a comparatively large amount of current. In this circuit, N4 behaves like a linear resistor with an on-resistance between approximately 60 $\Omega$ and 180 $\Omega$, depending on how hard the operational amplifier input is driven. With very low values of $R_P$, a voltage offset from 0 V at the output occurs. Second, pullup resistor $R_P$ acts as a drain load to N4 and the gain of the operational amplifier is reduced at output voltage levels where N5 is not supplying the output current.
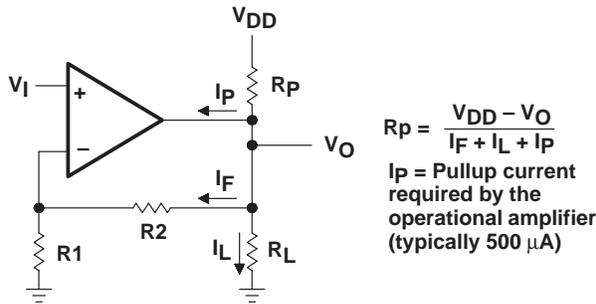


$$Rp = \frac{V_{DD} - V_O}{I_F + I_L + I_P}$$

$I_P$ = Pullup current required by the operational amplifier (typically 500 $\mu$A)

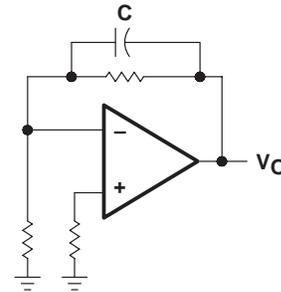**Figure 42. Resistive Pullup to Increase V$_{OH}$**



**Figure 43. Compensation for Input Capacitance**

### feedback

Operational amplifier circuits nearly always employ feedback, and since feedback is the first prerequisite for oscillation, some caution is appropriate. Most oscillation problems result from driving capacitive loads (discussed previously) and ignoring stray input capacitance. A small-value capacitor connected in parallel with the feedback resistor is an effective remedy (see Figure 43). The value of this capacitor is optimized empirically.

### electrostatic discharge protection

The TLC27L4 and TLC27L9 incorporate an internal electrostatic discharge (ESD) protection circuit that prevents functional failures at voltages up to 2000 V as tested under MIL-STD-883C, Method 3015.2. Care should be exercised, however, when handling these devices, as exposure to ESD may result in the degradation of the device parametric performance. The protection circuit also causes the input bias currents to be temperature dependent and have the characteristics of a reverse-biased diode.

### latch-up

Because CMOS devices are susceptible to latch-up due to their inherent parasitic thyristors, the TLC27L4 and TLC27L9 inputs and outputs were designed to withstand –100-mA surge currents without sustaining latch-up; however, techniques should be used to reduce the chance of latch-up whenever possible. Internal protection diodes should not, by design, be forward biased. Applied input and output voltage should not exceed the supply voltage by more than 300 mV. Care should be exercised when using capacitive coupling on pulse generators. Supply transients should be shunted by the use of decoupling capacitors (0.1 $\mu$F typical) located across the supply rails as close to the device as possible.

TEXAS
INSTRUMENTS

## APPLICATION INFORMATION

### latch-up (continued)

The current path established if latch-up occurs is usually between the positive supply rail and ground and can be triggered by surges on the supply lines and/or voltages on either the output or inputs that exceed the supply voltage. Once latch-up occurs, the current flow is limited only by the impedance of the power supply and the forward resistance of the parasitic thyristor and usually results in the destruction of the device. The chance of latch-up occurring increases with increasing temperature and supply voltages.
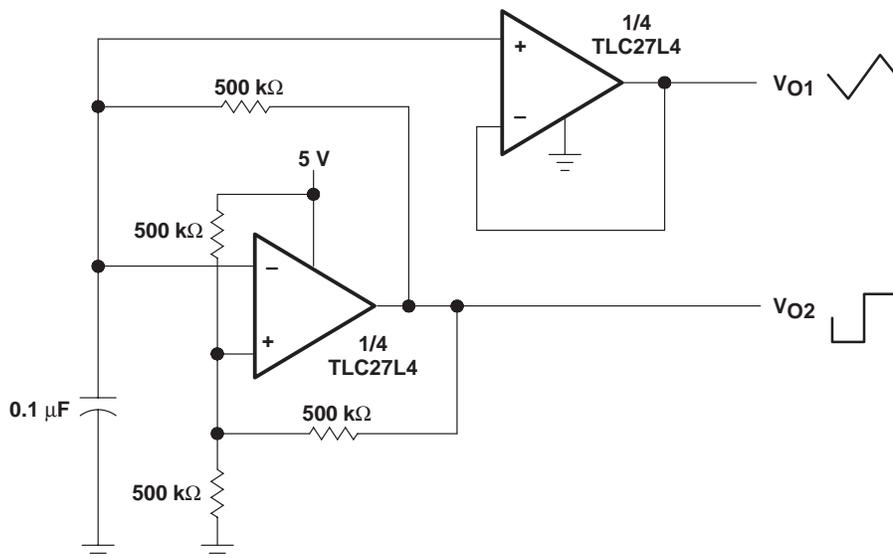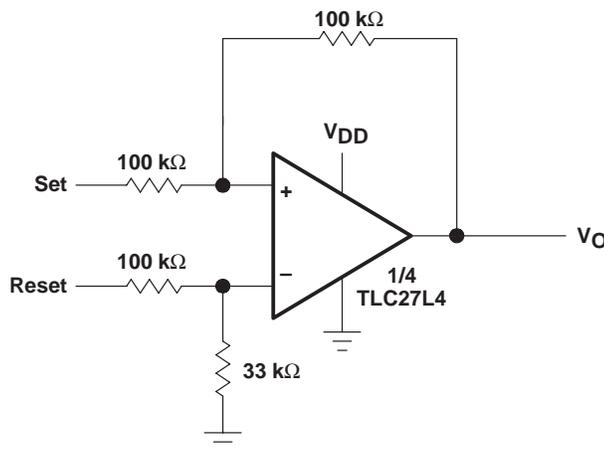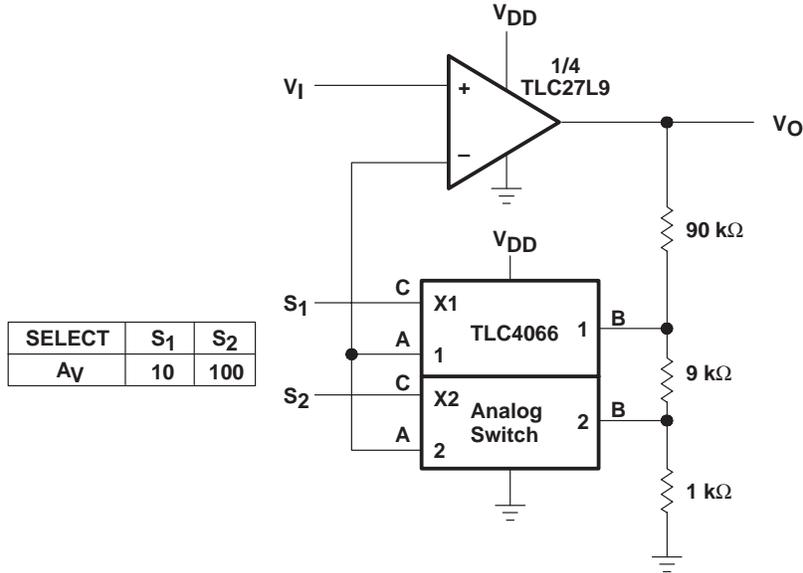


**Figure 44. Multivibrator**



NOTE: $V_{DD}$ = 5 V to 16 V

**Figure 45. Set/Reset Flip-Flop**

![TEXAS INSTRUMENTS]

## APPLICATION INFORMATION

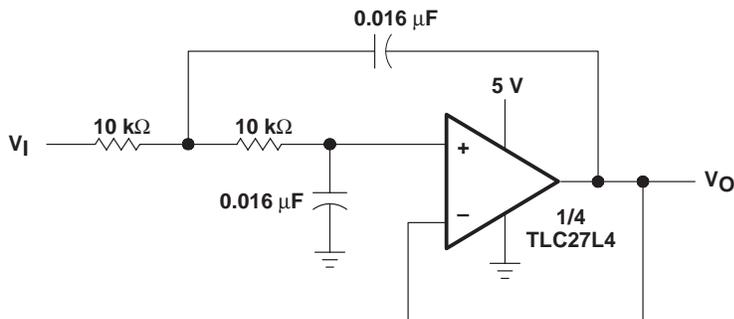| SELECT | $S_1$ | $S_2$ |
|--------|-------|-------|
| $A_V$  | 10    | 100   |

NOTE: $V_{DD}$ = 5 V to 12 V

**Figure 46. Amplifier With Digital Gain Selection**
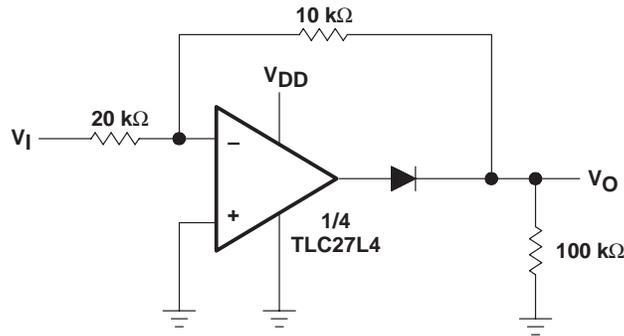
NOTE: $V_{DD}$ = 5 V to 16 V

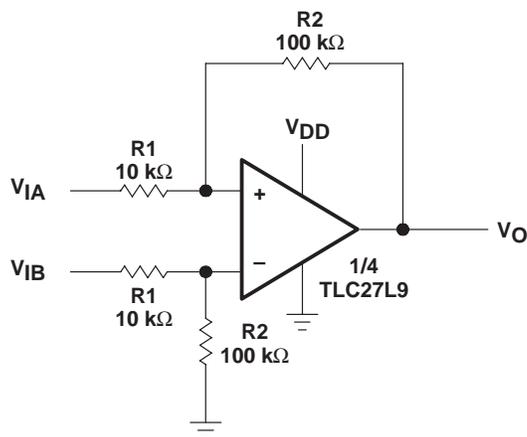**Figure 47. Full-Wave Rectifier**

## APPLICATION INFORMATION



NOTE: Normalized to $F_C$ = 1 kHz and $R_L$ = 10 kΩ

**Figure 48. Two-Pole Low-Pass Butterworth Filter**



NOTE: $V_{DD}$ = 5 V to 16 V

$$V_O = \frac{R2}{R1}\left(V_{IB} - V_{IA}\right)$$

**Figure 49. Difference Amplifier**

TEXAS
INSTRUMENTS

POST OFFICE BOX 655303 ● DALLAS, TEXAS 75265

## 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TLC27L4ACD | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 27L4AC | Samples |
| TLC27L4ACDR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 27L4AC | Samples |
| TLC27L4ACN | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | 0 to 70 | TLC27L4ACN | Samples |
| TLC27L4ACNE4 | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | 0 to 70 | TLC27L4ACN | Samples |
| TLC27L4AID | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 27L4AI | Samples |
| TLC27L4AIDG4 | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 27L4AI | Samples |
| TLC27L4AIDR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 27L4AI | Samples |
| TLC27L4AIN | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | -40 to 85 | TLC27L4AIN | Samples |
| TLC27L4BCD | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 27L4BC | Samples |
| TLC27L4BCDR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 27L4BC | Samples |
| TLC27L4BCN | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | 0 to 70 | TLC27L4BCN | Samples |
| TLC27L4BID | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 27L4BI | Samples |
| TLC27L4BIDG4 | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 27L4BI | Samples |
| TLC27L4BIDR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 27L4BI | Samples |
| TLC27L4BIDRG4 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | 27L4BI | Samples |
| TLC27L4BIN | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | -40 to 85 | TLC27L4BIN | Samples |
| TLC27L4CD | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | TLC27L4C | Samples |
| TLC27L4CDR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | TLC27L4C | Samples |
| TLC27L4CN | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | 0 to 70 | TLC27L4CN | Samples |
| TLC27L4CNS | ACTIVE | SO | NS | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | TLC27L4 | 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TLC27L4CNSR | ACTIVE | SO | NS | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | TLC27L4 | Samples |
| TLC27L4CPW | ACTIVE | TSSOP | PW | 14 | 90 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | P27L4C | Samples |
| TLC27L4CPWR | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | P27L4C | Samples |
| TLC27L4CPWRG4 | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | P27L4C | Samples |
| TLC27L4ID | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | TLC27L4I | Samples |
| TLC27L4IDG4 | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | TLC27L4I | Samples |
| TLC27L4IDR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | TLC27L4I | Samples |
| TLC27L4IN | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | -40 to 85 | TLC27L4IN | Samples |
| TLC27L4INE4 | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | -40 to 85 | TLC27L4IN | Samples |
| TLC27L4IPW | ACTIVE | TSSOP | PW | 14 | 90 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | P27L4I | Samples |
| TLC27L4IPWR | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | P27L4I | Samples |
| TLC27L4IPWRG4 | ACTIVE | TSSOP | PW | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | P27L4I | Samples |
| TLC27L9CD | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | TLC27L9C | Samples |
| TLC27L9CDR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | TLC27L9C | Samples |
| TLC27L9CDRG4 | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | TLC27L9C | Samples |
| TLC27L9CN | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | 0 to 70 | TLC27L9CN | Samples |
| TLC27L9CNSR | ACTIVE | SO | NS | 14 | 2000 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | TLC27L9 | Samples |
| TLC27L9ID | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | TLC27L9I | Samples |
| TLC27L9IDG4 | ACTIVE | SOIC | D | 14 | 50 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | TLC27L9I | Samples |
| TLC27L9IDR | ACTIVE | SOIC | D | 14 | 2500 | RoHS & Green | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | TLC27L9I | Samples |
| TLC27L9IN | ACTIVE | PDIP | N | 14 | 25 | RoHS & Green | NIPDAU | N / A for Pkg Type | -40 to 85 | TLC27L9IN | 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.
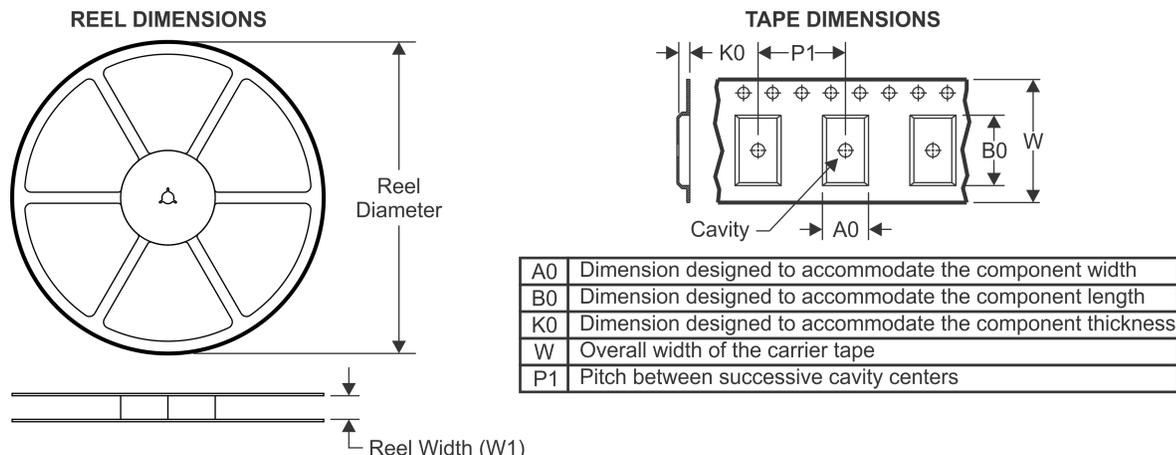
**(5)** Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

**(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.
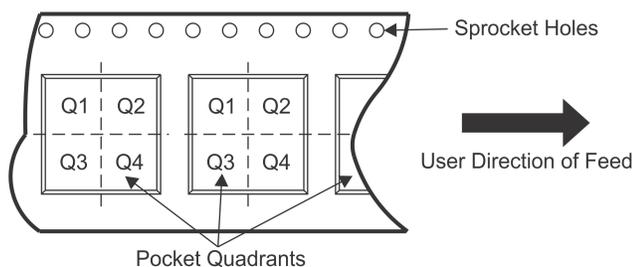
**Important Information and Disclaimer:**The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. 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.

# PACKAGE MATERIALS INFORMATION

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

**TAPE DIMENSIONS**



| A0 | Dimension designed to accommodate the component width |
| B0 | Dimension designed to accommodate the component length |
| K0 | Dimension designed to accommodate the component thickness |
| W | Overall width of the carrier tape |
| P1 | Pitch between successive cavity centers |

**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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TLC27L4ACDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| TLC27L4ACDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| TLC27L4ACDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| TLC27L4AIDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| TLC27L4BCDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| TLC27L4BIDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| TLC27L4CDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| TLC27L4CDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| TLC27L4CDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| TLC27L4CNSR | SO | NS | 14 | 2000 | 330.0 | 16.4 | 8.2 | 10.5 | 2.5 | 12.0 | 16.0 | Q1 |
| TLC27L4CPWR | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| TLC27L4IDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| TLC27L4IPWR | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| TLC27L9CDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| TLC27L9CNSR | SO | NS | 14 | 2000 | 330.0 | 16.4 | 8.2 | 10.5 | 2.5 | 12.0 | 16.0 | Q1 |
| TLC27L9IDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |

**TAPE AND REEL BOX  DIMENSIONS**
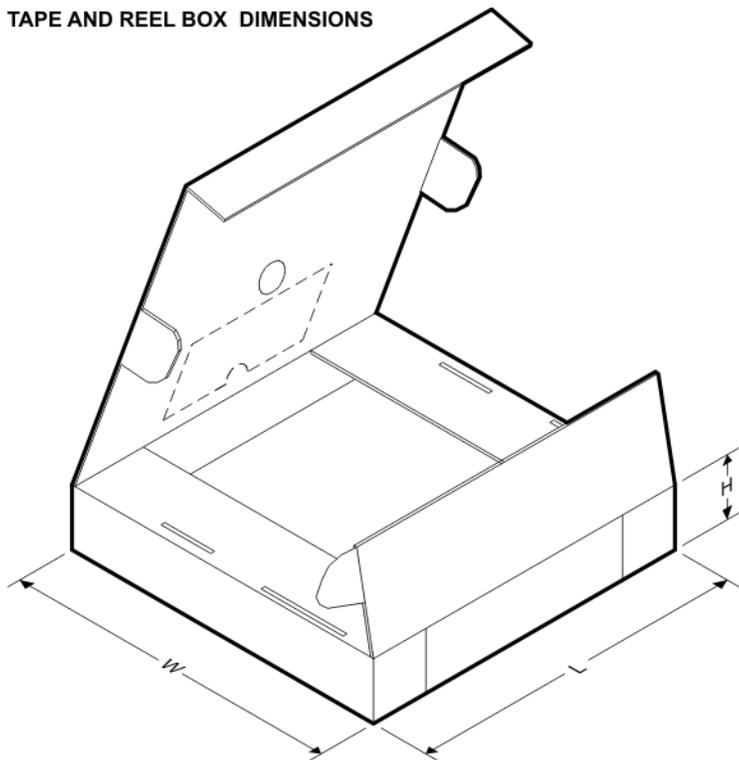


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| TLC27L4ACDR | SOIC | D | 14 | 2500 | 853.0 | 449.0 | 35.0 |
| TLC27L4ACDR | SOIC | D | 14 | 2500 | 340.5 | 336.1 | 32.0 |
| TLC27L4ACDR | SOIC | D | 14 | 2500 | 350.0 | 350.0 | 43.0 |
| TLC27L4AIDR | SOIC | D | 14 | 2500 | 853.0 | 449.0 | 35.0 |
| TLC27L4BCDR | SOIC | D | 14 | 2500 | 367.0 | 367.0 | 38.0 |
| TLC27L4BIDR | SOIC | D | 14 | 2500 | 853.0 | 449.0 | 35.0 |
| TLC27L4CDR | SOIC | D | 14 | 2500 | 350.0 | 350.0 | 43.0 |
| TLC27L4CDR | SOIC | D | 14 | 2500 | 340.5 | 336.1 | 32.0 |
| TLC27L4CDR | SOIC | D | 14 | 2500 | 367.0 | 367.0 | 38.0 |
| TLC27L4CNSR | SO | NS | 14 | 2000 | 853.0 | 449.0 | 35.0 |
| TLC27L4CPWR | TSSOP | PW | 14 | 2000 | 853.0 | 449.0 | 35.0 |
| TLC27L4IDR | SOIC | D | 14 | 2500 | 367.0 | 367.0 | 38.0 |
| TLC27L4IPWR | TSSOP | PW | 14 | 2000 | 853.0 | 449.0 | 35.0 |
| TLC27L9CDR | SOIC | D | 14 | 2500 | 350.0 | 350.0 | 43.0 |
| TLC27L9CNSR | SO | NS | 14 | 2000 | 853.0 | 449.0 | 35.0 |
| TLC27L9IDR | SOIC | D | 14 | 2500 | 350.0 | 350.0 | 43.0 |

## TUBE
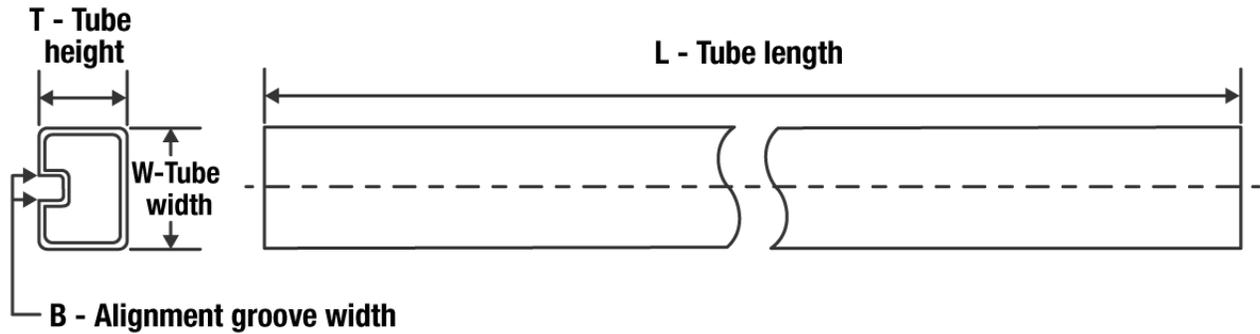


*All dimensions are nominal

| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (µm) | B (mm) |
|---|---|---|---|---|---|---|---|---|
| TLC27L4ACD | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| TLC27L4ACD | D | SOIC | 14 | 50 | 505.46 | 6.76 | 3810 | 4 |
| TLC27L4ACD | D | SOIC | 14 | 50 | 507 | 8 | 3940 | 4.32 |
| TLC27L4ACN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| TLC27L4ACNE4 | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| TLC27L4AID | D | SOIC | 14 | 50 | 505.46 | 6.76 | 3810 | 4 |
| TLC27L4AID | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| TLC27L4AIDG4 | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| TLC27L4AIDG4 | D | SOIC | 14 | 50 | 505.46 | 6.76 | 3810 | 4 |
| TLC27L4AIN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| TLC27L4BCD | D | SOIC | 14 | 50 | 505.46 | 6.76 | 3810 | 4 |
| TLC27L4BCD | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| TLC27L4BCN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| TLC27L4BID | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| TLC27L4BID | D | SOIC | 14 | 50 | 505.46 | 6.76 | 3810 | 4 |
| TLC27L4BIDG4 | D | SOIC | 14 | 50 | 505.46 | 6.76 | 3810 | 4 |
| TLC27L4BIDG4 | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| TLC27L4BIN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| TLC27L4CD | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| TLC27L4CD | D | SOIC | 14 | 50 | 505.46 | 6.76 | 3810 | 4 |
| TLC27L4CD | D | SOIC | 14 | 50 | 507 | 8 | 3940 | 4.32 |
| TLC27L4CN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| TLC27L4CNS | NS | SOP | 14 | 50 | 530 | 10.5 | 4000 | 4.1 |
| TLC27L4CPW | PW | TSSOP | 14 | 90 | 530 | 10.2 | 3600 | 3.5 |
| TLC27L4ID | D | SOIC | 14 | 50 | 505.46 | 6.76 | 3810 | 4 |
| TLC27L4ID | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| TLC27L4IDG4 | D | SOIC | 14 | 50 | 506.6 | 8 | 3940 | 4.32 |
| TLC27L4IDG4 | D | SOIC | 14 | 50 | 505.46 | 6.76 | 3810 | 4 |

| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (µm) | B (mm) |
|--------|--------------|--------------|------|-----|--------|--------|--------|--------|
| TLC27L4IN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| TLC27L4INE4 | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| TLC27L4IPW | PW | TSSOP | 14 | 90 | 530 | 10.2 | 3600 | 3.5 |
| TLC27L9CD | D | SOIC | 14 | 50 | 505.46 | 6.76 | 3810 | 4 |
| TLC27L9CN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| TLC27L9ID | D | SOIC | 14 | 50 | 505.46 | 6.76 | 3810 | 4 |
| TLC27L9IDG4 | D | SOIC | 14 | 50 | 505.46 | 6.76 | 3810 | 4 |
| TLC27L9IN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |

# IMPORTANT NOTICE AND DISCLAIMER