

# TLC27L2, TLC27L2A, TLC27L2B, TLC27L7 LinCMOS™ PRECISION DUAL OPERATIONAL AMPLIFIERS

SLOS052C – OCTOBER 1987 – REVISED MARCH 2001

- **Trimmed Offset Voltage:**  
TLC27L7 . . . 500  $\mu\text{V}$  Max at 25°C,  
 $V_{\text{DD}} = 5\text{ V}$
- **Input Offset Voltage Drift . . . Typically**  
0.1  $\mu\text{V}/\text{Month}$ , 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 95  $\mu\text{W}$  at 25°C,  $V_{\text{DD}} = 5\text{ V}$**
- **Output Voltage Range Includes Negative Rail**
- **High Input Impedance . . .  $10^{12}\ \Omega$  Typ**
- **ESD-Protection Circuitry**
- **Small-Outline Package Option Also Available in Tape and Reel**
- **Designed-In Latch-Up immunity**

## description

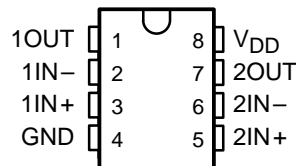
The TLC27L2 and TLC27L7 dual operational amplifiers combine a wide range of input offset voltage grades with low offset voltage drift, high input impedance, extremely low power, and high gain.

### AVAILABLE OPTIONS

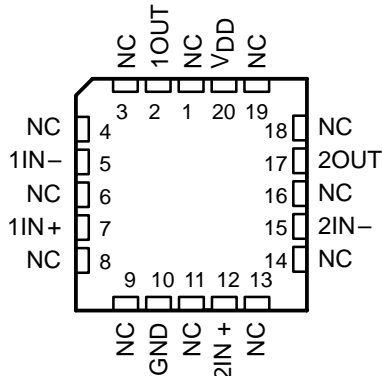
| T <sub>A</sub>       | V <sub>IOmax</sub><br>AT 25°C              | PACKAGE  |                          |                          |  |
|----------------------|--|--|--------------------------|--------------------------|--|
|                      |  | SMALL<br>OUTLINE<br>(D)                            | CHIP<br>CARRIER<br>(FK)  | CERAMIC<br>DIP<br>(JG)   | PLASTIC<br>DIP<br>(P)                              |
| 0°C<br>to<br>70°C    | 500 $\mu\text{V}$<br>2 mV<br>5 mV<br>10 mV | TLC27L7CD<br>TLC27L2BCD<br>TLC27L2ACD<br>TLC27L2CD | —                        | —                        | TLC27L7CP<br>TLC27L2BCP<br>TLC27L2ACP<br>TLC27L2CP |
| –40°C<br>to<br>85°C  | 500 $\mu\text{V}$<br>2 mV<br>5 mV<br>10 mV | TLC27L7ID<br>TLC27L2BID<br>TLC27L2AID<br>TLC27L2ID | —                        | —                        | TLC27L7IP<br>TLC27L2BIP<br>TLC27L2AIP<br>TLC27L2IP |
| –55°C<br>to<br>125°C | 500 $\mu\text{V}$<br>10 mV                 | TLC27L7MD<br>TLC27L2MD                             | TLC27L7MFK<br>TLC27L2MFK | TLC27L7MJG<br>TLC27L2MJG | TLC27L7MP<br>TLC27L2MP                             |

The D package is available taped and reeled. Add R suffix to the device type (e.g., TLC27L7CDR).

D, JG, OR P PACKAGE  
(TOP VIEW)

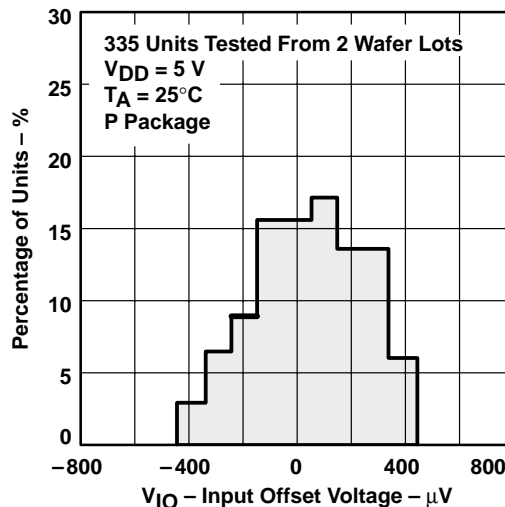


FK PACKAGE  
(TOP VIEW)



NC – No internal connection

DISTRIBUTION OF TLC27L7  
INPUT OFFSET VOLTAGE



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## description (continued)

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 TLC27L2 (10 mV) to the high-precision TLC27L7 (500  $\mu$ V). 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.

In general, many features associated with bipolar technology are available in 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 TLC27L2 and TLC27L7. 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.

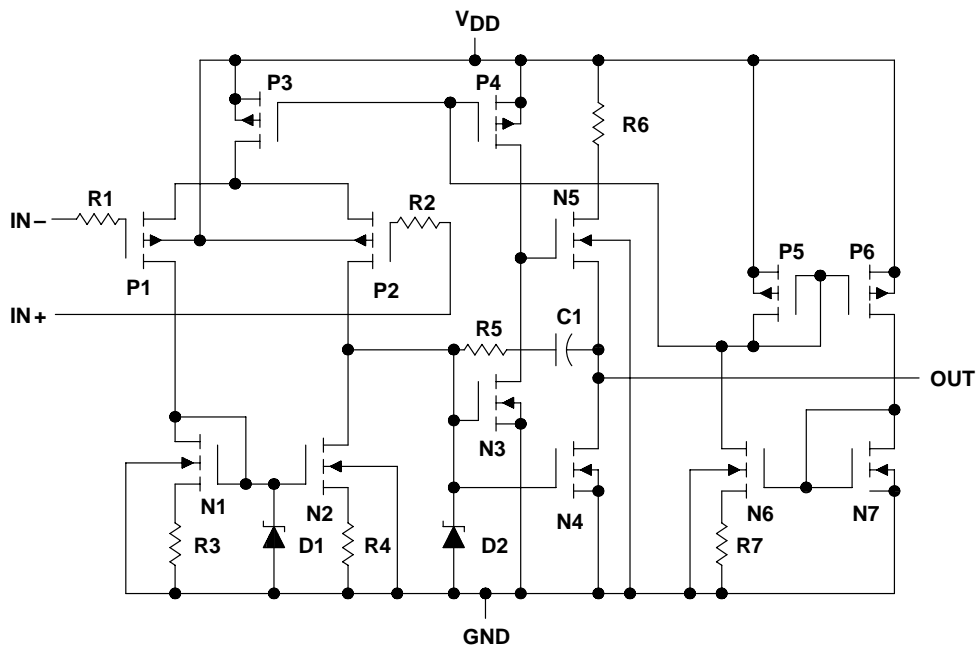
A wide range of packaging options is available, including small-outline and chip-carrier versions for high-density system applications.

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

The TLC27L2 and TLC27L7 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  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ . The I-suffix devices are characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ . The M-suffix devices are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .

## equivalent schematic (each amplifier)



# TLC27L2, TLC27L2A, TLC27L2B, TLC27L7

## LinCMOS™ PRECISION DUAL OPERATIONAL AMPLIFIERS

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

|  |                              |
|--|------------------------------|
| Supply voltage, $V_{DD}$ (see Note 1)  | 18 V                         |
| Differential input voltage (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 or P package | 260°C                        |
| Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: JG 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 | $T_A \leq 25^\circ\text{C}$ | DERATING FACTOR<br>ABOVE $T_A = 25^\circ\text{C}$ | $T_A = 70^\circ\text{C}$ | $T_A = 85^\circ\text{C}$ | $T_A = 125^\circ\text{C}$ |
|---------|-----------------------------|---|--------------------------|--------------------------|---------------------------|
|         | POWER RATING                |   | POWER RATING             | POWER RATING             | POWER RATING              |
| D       | 725 mW                      | 5.8 mW/°C   | 464 mW                   | 377 mW                   | —                         |
| FK      | 1375 mW                     | 11.0 mW/°C  | 880 mW                   | 715 mW                   | 275 mW                    |
| JG      | 1050 mW                     | 8.4 mW/°C   | 672 mW                   | 546 mW                   | 210 mW                    |
| P       | 1000 mW                     | 8.0 mW/°C   | 640 mW                   | 520 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   |



# TLC27L2, TLC27L2A, TLC27L2B, TLC27L7 LinCMOS™ PRECISION DUAL OPERATIONAL AMPLIFIERS

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

| PARAMETER      |  | TEST CONDITIONS                                |  | $T_A$ †                                    | TLC27L2C<br>TLC27L2AC<br>TLC27L2BC<br>TLC27L7C |                   |                              | UNIT |
|----------------|--|--|--|--|--|-------------------|------------------------------|------|
|                |  |  |  |  | MIN  | TYP               | MAX                          |      |
| $V_{IO}$       | Input offset voltage   | TLC27L2C                                       | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$ | 25°C   | 1.1               | 10                           | mV   |
|                |  |  |  |  | Full range                                     |                   | 12                           |      |
|                |  | TLC27L2AC                                      | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$ | 25°C   | 0.9               | 5                            |      |
|                |  |  |  |  | Full range                                     |                   | 6.5                          |      |
|                | TLC27L2BC  | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$     | 25°C                                       | 204  | 2000              | $\mu\text{V}$                |      |
|                |  |  |  | Full range                                 |  | 3000              |                              |      |
|                | TLC27L7C   | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$     | 25°C                                       | 170  | 500               |                              |      |
|                |  |  |  | Full range                                 |  | 1500              |                              |      |
| $\alpha_{VIO}$ | Average temperature coefficient of input offset voltage          |  |  | 25°C to 70°C                               | 1.1  |                   | $\mu\text{V}/^\circ\text{C}$ |      |
| $I_{IO}$       | Input offset current (see Note 4)                                | $V_O = 2.5\text{ V}$ ,                         | $V_{IC} = 2.5\text{ V}$                        | 25°C                                       | 0.1  | 60                | pA                           |      |
|                |  |  |  | 70°C                                       | 7  | 300               |                              |      |
| $I_{IB}$       | Input bias current (see Note 4)                                  | $V_O = 2.5\text{ V}$ ,                         | $V_{IC} = 2.5\text{ V}$                        | 25°C                                       | 0.6  | 60                | pA                           |      |
|                |  |  |  | 70°C                                       | 50   | 600               |                              |      |
| $V_{ICR}$      | Common-mode input voltage range (see Note 5)                     |  |  | 25°C                                       | -0.2<br>to<br>4                                | -0.3<br>to<br>4.2 | V                            |      |
|                |  |  |  | Full range                                 | -0.2<br>to<br>3.5                              |                   | V                            |      |
| $V_{OH}$       | High-level output voltage  | $V_{ID} = 100\text{ mV}$ ,                     | $R_L = 1\text{ M}\Omega$                       | 25°C                                       | 3.2  | 4.1               | V                            |      |
|                |  |  |  | 0°C  | 3  | 4.1               |                              |      |
|                |  |  |  | 70°C                                       | 3  | 4.2               |                              |      |
| $V_{OL}$       | Low-level output voltage   | $V_{ID} = -100\text{ mV}$ ,                    | $I_{OL} = 0$                                   | 25°C                                       | 0  | 50                | mV                           |      |
|                |  |  |  | 0°C  | 0  | 50                |                              |      |
|                |  |  |  | 70°C                                       | 0  | 50                |                              |      |
| $A_{VD}$       | Large-signal differential voltage amplification                  | $V_O = 0.25\text{ V to }2\text{ V}$ ,          | $R_L = 1\text{ M}\Omega$                       | 25°C                                       | 50   | 700               | V/mV                         |      |
|                |  |  |  | 0°C  | 50   | 700               |                              |      |
|                |  |  |  | 70°C                                       | 50   | 380               |                              |      |
| CMRR           | Common-mode rejection ratio                                      | $V_{IC} = V_{ICRmin}$                          |  | 25°C                                       | 65   | 94                | dB                           |      |
|                |  |  |  | 0°C  | 60   | 95                |                              |      |
|                |  |  |  | 70°C                                       | 60   | 95                |                              |      |
| $k_{SVR}$      | Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ ) | $V_{DD} = 5\text{ V to }10\text{ V}$ ,         | $V_O = 1.4\text{ V}$                           | 25°C                                       | 70   | 97                | dB                           |      |
|                |  |  |  | 0°C  | 60   | 97                |                              |      |
|                |  |  |  | 70°C                                       | 60   | 98                |                              |      |
| $I_{DD}$       | Supply current (two amplifiers)                                  | $V_O = 2.5\text{ V}$ ,<br>No load              | $V_{IC} = 2.5\text{ V}$ ,                      | 25°C                                       | 20   | 34                | $\mu\text{A}$                |      |
|                |  |  |  | 0°C  | 24   | 42                |                              |      |
|                |  |  |  | 70°C                                       | 16   | 28                |                              |      |

† 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.



# TLC27L2, TLC27L2A, TLC27L2B, TLC27L7 LinCMOS™ PRECISION DUAL OPERATIONAL AMPLIFIERS

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

| PARAMETER      |  | TEST CONDITIONS                        |  | $T_A$ †                                    | TLC27L2C<br>TLC27L2AC<br>TLC27L2BC<br>TLC27L7C |             |                              | UNIT          |
|----------------|--|--|--|--|--|-------------|------------------------------|---------------|
|                |  |  |  |  | MIN  | TYP         | MAX                          |               |
| $V_{IO}$       | Input offset voltage   | TLC27L2C                               | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$ | 25°C   | 1.1         | 10                           | mV            |
|                |  |  |  |  | Full range                                     |             | 12                           |               |
|                |  | TLC27L2AC                              | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$ | 25°C   | 0.9         | 5                            | mV            |
|                |  |  |  |  | Full range                                     |             | 6.5                          |               |
|                |  | TLC27L2BC                              | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$ | 25°C   | 235         | 2000                         | $\mu\text{V}$ |
|                |  |  |  |  | Full range                                     |             | 3000                         |               |
|                |  | TLC27L7C                               | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$ | 25°C   | 190         | 800                          | $\mu\text{V}$ |
|                |  |  |  |  | Full range                                     |             | 1900                         |               |
| $\alpha_{VIO}$ | Average temperature coefficient of input offset voltage          |  |  | 25°C to 70°C                               | 1  |             | $\mu\text{V}/^\circ\text{C}$ |               |
| $I_{IO}$       | Input offset current (see Note 4)                                | $V_O = 5\text{ V}$ ,                   | $V_{IC} = 5\text{ V}$                          | 25°C                                       | 0.1  | 60          | pA                           |               |
|                |  |  |  | 70°C                                       | 8  | 300         |                              |               |
| $I_{IB}$       | Input bias current (see Note 4)                                  | $V_O = 5\text{ V}$ ,                   | $V_{IC} = 5\text{ V}$                          | 25°C                                       | 0.7  | 60          | 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  | $V_{ID} = 100\text{ mV}$ ,             | $R_L = 1\text{ M}\Omega$                       | 25°C                                       | 8  | 8.9         | V                            |               |
|                |  |  |  | 0°C  | 7.8  | 8.9         |                              |               |
|                |  |  |  | 70°C                                       | 7.8  | 8.9         |                              |               |
| $V_{OL}$       | Low-level output voltage   | $V_{ID} = -100\text{ mV}$ ,            | $I_{OL} = 0$                                   | 25°C                                       | 0  | 50          | mV                           |               |
|                |  |  |  | 0°C  | 0  | 50          |                              |               |
|                |  |  |  | 70°C                                       | 0  | 50          |                              |               |
| $A_{VD}$       | Large-signal differential voltage amplification                  | $V_O = 1\text{ V to }6\text{ V}$ ,     | $R_L = 1\text{ M}\Omega$                       | 25°C                                       | 50   | 860         | V/mV                         |               |
|                |  |  |  | 0°C  | 50   | 1025        |                              |               |
|                |  |  |  | 70°C                                       | 50   | 660         |                              |               |
| CMRR           | Common-mode rejection ratio                                      | $V_{IC} = V_{ICRmin}$                  |  | 25°C                                       | 65   | 97          | dB                           |               |
|                |  |  |  | 0°C  | 60   | 97          |                              |               |
|                |  |  |  | 70°C                                       | 60   | 97          |                              |               |
| $k_{SVR}$      | Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ ) | $V_{DD} = 5\text{ V to }10\text{ V}$ , | $V_O = 1.4\text{ V}$                           | 25°C                                       | 70   | 97          | dB                           |               |
|                |  |  |  | 0°C  | 60   | 97          |                              |               |
|                |  |  |  | 70°C                                       | 60   | 98          |                              |               |
| $I_{DD}$       | Supply current (two amplifiers)                                  | $V_O = 5\text{ V}$ ,<br>No load        | $V_{IC} = 5\text{ V}$ ,                        | 25°C                                       | 29   | 46          | $\mu\text{A}$                |               |
|                |  |  |  | 0°C  | 36   | 66          |                              |               |
|                |  |  |  | 70°C                                       | 22   | 40          |                              |               |

† 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.



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

| PARAMETER      |  | TEST CONDITIONS                                |  | $T_A$ †                                    | TLC27L2I<br>TLC27L2AI<br>TLC27L2BI<br>TLC27L7I |             |                              | UNIT |
|----------------|--|--|--|--|--|-------------|------------------------------|------|
|                |  |  |  |  | MIN  | TYP         | MAX                          |      |
| $V_{IO}$       | Input offset voltage   | TLC27L2I                                       | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$ | 25°C   | 1.1 10      |                              | mV   |
|                |  |  |  |  | Full range                                     | 13          |                              |      |
|                |  | TLC27L2AI                                      | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$ | 25°C   | 0.9 5       |                              |      |
|                |  |  |  |  | Full range                                     | 7           |                              |      |
|                | TLC27L2BI  | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$     | 25°C                                       | 240  | 2000        | $\mu\text{V}$                |      |
|                |  |  |  | Full range                                 | 3500   |             |                              |      |
|                | TLC27L7I   | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$     | 25°C                                       | 170  | 500         |                              |      |
|                |  |  |  | Full range                                 | 2000   |             |                              |      |
| $\alpha_{VIO}$ | Average temperature coefficient of input offset voltage          |  |  | 25°C to 85°C                               | 1.1  |             | $\mu\text{V}/^\circ\text{C}$ |      |
| $I_{IO}$       | Input offset current (see Note 4)                                | $V_O = 2.5\text{ V}$ ,                         | $V_{IC} = 2.5\text{ V}$                        | 25°C                                       | 0.1  | 60          | pA                           |      |
|                |  |  |  | 85°C                                       | 24   | 1000        |                              |      |
| $I_{IB}$       | Input bias current (see Note 4)                                  | $V_O = 2.5\text{ V}$ ,                         | $V_{IC} = 2.5\text{ V}$                        | 25°C                                       | 0.6  | 60          | 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  | $V_{ID} = 100\text{ mV}$ ,                     | $R_L = 1\text{ M}\Omega$                       | 25°C                                       | 3.2  | 4.1         | V                            |      |
|                |  |  |  | -40°C                                      | 3  | 4.1         |                              |      |
|                |  |  |  | 85°C                                       | 3  | 4.2         |                              |      |
| $V_{OL}$       | Low-level output voltage   | $V_{ID} = -100\text{ mV}$ ,                    | $I_{OL} = 0$                                   | 25°C                                       | 0  | 50          | mV                           |      |
|                |  |  |  | -40°C                                      | 0  | 50          |                              |      |
|                |  |  |  | 85°C                                       | 0  | 50          |                              |      |
| $A_{VD}$       | Large-signal differential voltage amplification                  | $V_O = 0.25\text{ V to }2\text{ V}$ ,          | $R_L = 1\text{ M}\Omega$                       | 25°C                                       | 50   | 480         | V/mV                         |      |
|                |  |  |  | -40°C                                      | 50   | 900         |                              |      |
|                |  |  |  | 85°C                                       | 50   | 330         |                              |      |
| CMRR           | Common-mode rejection ratio                                      | $V_{IC} = V_{ICRmin}$                          |  | 25°C                                       | 65   | 94          | dB                           |      |
|                |  |  |  | -40°C                                      | 60   | 95          |                              |      |
|                |  |  |  | 85°C                                       | 60   | 95          |                              |      |
| $k_{SVR}$      | Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ ) | $V_{DD} = 5\text{ V to }10\text{ V}$ ,         | $V_O = 1.4\text{ V}$                           | 25°C                                       | 70   | 97          | dB                           |      |
|                |  |  |  | -40°C                                      | 60   | 97          |                              |      |
|                |  |  |  | 85°C                                       | 60   | 98          |                              |      |
| $I_{DD}$       | Supply current (two amplifiers)                                  | $V_O = 2.5\text{ V}$ ,<br>No load              | $V_{IC} = 2.5\text{ V}$ ,                      | 25°C                                       | 20   | 34          | $\mu\text{A}$                |      |
|                |  |  |  | -40°C                                      | 31   | 54          |                              |      |
|                |  |  |  | 85°C                                       | 15   | 26          |                              |      |

† 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.



# TLC27L2, TLC27L2A, TLC27L2B, TLC27L7 LinCMOS™ PRECISION DUAL OPERATIONAL AMPLIFIERS

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

| PARAMETER      |  | TEST CONDITIONS                        |  | $T_A$ †                                    | TLC27L2I<br>TLC27L2AI<br>TLC27L2BI<br>TLC27L7I |             |                              | UNIT          |
|----------------|--|--|--|--|--|-------------|------------------------------|---------------|
|                |  |  |  |  | MIN  | TYP         | MAX                          |               |
| $V_{IO}$       | Input offset voltage   | TLC27L2I                               | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$ | 25°C   | 1.1         | 10                           | mV            |
|                |  |  |  |  | Full range                                     |             | 13                           |               |
|                |  | TLC27L2AI                              | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$ | 25°C   | 0.9         | 5                            | mV            |
|                |  |  |  |  | Full range                                     |             | 7                            |               |
|                |  | TLC27L2BI                              | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$ | 25°C   | 235         | 2000                         | $\mu\text{V}$ |
|                |  |  |  |  | Full range                                     |             | 3500                         |               |
|                |  | TLC27L7I                               | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$ | 25°C   | 190         | 800                          | $\mu\text{V}$ |
|                |  |  |  |  | Full range                                     |             | 2900                         |               |
| $\alpha_{VIO}$ | Average temperature coefficient of input offset voltage          |  |  | 25°C to 85°C                               | 1  |             | $\mu\text{V}/^\circ\text{C}$ |               |
| $I_{IO}$       | Input offset current (see Note 4)                                | $V_O = 5\text{ V}$ ,                   | $V_{IC} = 5\text{ V}$                          | 25°C                                       | 0.1  | 60          | pA                           |               |
|                |  |  |  | 85°C                                       | 26   | 1000        |                              |               |
| $I_{IB}$       | Input bias current (see Note 4)                                  | $V_O = 5\text{ V}$ ,                   | $V_{IC} = 5\text{ V}$                          | 25°C                                       | 0.7  | 60          | 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  | $V_{ID} = 100\text{ mV}$ ,             | $R_L = 1\text{ M}\Omega$                       | 25°C                                       | 8  | 8.9         | V                            |               |
|                |  |  |  | -40°C                                      | 7.8  | 8.9         |                              |               |
|                |  |  |  | 85°C                                       | 7.8  | 8.9         |                              |               |
| $V_{OL}$       | Low-level output voltage   | $V_{ID} = -100\text{ mV}$ ,            | $I_{OL} = 0$                                   | 25°C                                       | 0  | 50          | mV                           |               |
|                |  |  |  | -40°C                                      | 0  | 50          |                              |               |
|                |  |  |  | 85°C                                       | 0  | 50          |                              |               |
| $A_{VD}$       | Large-signal differential voltage amplification                  | $V_O = 1\text{ V to }6\text{ V}$ ,     | $R_L = 1\text{ M}\Omega$                       | 25°C                                       | 50   | 860         | V/mV                         |               |
|                |  |  |  | -40°C                                      | 50   | 1550        |                              |               |
|                |  |  |  | 85°C                                       | 50   | 585         |                              |               |
| CMRR           | Common-mode rejection ratio                                      | $V_{IC} = V_{ICRmin}$                  |  | 25°C                                       | 65   | 97          | dB                           |               |
|                |  |  |  | -40°C                                      | 60   | 97          |                              |               |
|                |  |  |  | 85°C                                       | 60   | 98          |                              |               |
| $k_{SVR}$      | Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ ) | $V_{DD} = 5\text{ V to }10\text{ V}$ , | $V_O = 1.4\text{ V}$                           | 25°C                                       | 70   | 97          | dB                           |               |
|                |  |  |  | -40°C                                      | 60   | 97          |                              |               |
|                |  |  |  | 85°C                                       | 60   | 98          |                              |               |
| $I_{DD}$       | Supply current (two amplifiers)                                  | $V_O = 5\text{ V}$ ,<br>No load        | $V_{IC} = 5\text{ V}$ ,                        | 25°C                                       | 29   | 46          | $\mu\text{A}$                |               |
|                |  |  |  | -40°C                                      | 49   | 86          |                              |               |
|                |  |  |  | 85°C                                       | 20   | 36          |                              |               |

† 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.



# TLC27L2, TLC27L2A, TLC27L2B, TLC27L7 LinCMOS™ PRECISION DUAL OPERATIONAL AMPLIFIERS

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

| PARAMETER      |  | TEST CONDITIONS                                | $T_A$ †  | TLC27L2M<br>TLC27L7M                       |            |                              | UNIT          |               |
|----------------|--|--|--|--|------------|------------------------------|---------------|---------------|
|                |  |  |  | MIN  | TYP        | MAX                          |               |               |
| $V_{IO}$       | Input offset voltage   | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$     | 25°C                                       | 1.1        | 10                           | mV            |               |
|                |  |  |  | Full range                                 |            | 12                           |               |               |
|                |  | TLC27L7M                                       | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$ | 25°C       | 170                          | 500           | $\mu\text{V}$ |
|                |  |  |  |  | Full range |                              | 3750          |               |
| $\alpha_{VIO}$ | Average temperature coefficient of input offset voltage          |  | 25°C to 125°C                                  | 1.4  |            | $\mu\text{V}/^\circ\text{C}$ |               |               |
| $I_{IO}$       | Input offset current (see Note 4)                                | $V_O = 2.5\text{ V}$ ,                         | $V_{IC} = 2.5\text{ V}$                        | 25°C                                       | 0.1        | 60                           | pA            |               |
|                |  |  |  | 125°C                                      | 1.4        | 15                           | nA            |               |
| $I_{IB}$       | Input bias current (see Note 4)                                  | $V_O = 2.5\text{ V}$ ,                         | $V_{IC} = 2.5\text{ V}$                        | 25°C                                       | 0.6        | 60                           | pA            |               |
|                |  |  |  | 125°C                                      | 9          | 35                           | nA            |               |
| $V_{ICR}$      | Common-mode input voltage range (see Note 5)                     |  |  | 25°C                                       | 0 to 4     | -0.3 to 4.2                  | V             |               |
|                |  |  |  | Full range                                 | 0 to 3.5   |                              | V             |               |
| $V_{OH}$       | High-level output voltage  | $V_{ID} = 100\text{ mV}$ ,                     | $R_L = 1\text{ M}\Omega$                       | 25°C                                       | 3.2        | 4.1                          | V             |               |
|                |  |  |  | -55°C                                      | 3          | 4.1                          |               |               |
|                |  |  |  | 125°C                                      | 3          | 4.2                          |               |               |
| $V_{OL}$       | Low-level output voltage   | $V_{ID} = -100\text{ mV}$ ,                    | $I_{OL} = 0$                                   | 25°C                                       | 0          | 50                           | mV            |               |
|                |  |  |  | -55°C                                      | 0          | 50                           |               |               |
|                |  |  |  | 125°C                                      | 0          | 50                           |               |               |
| $A_{VD}$       | Large-signal differential voltage amplification                  | $V_O = 0.25\text{ V to }2\text{ V}$ ,          | $R_L = 1\text{ M}\Omega$                       | 25°C                                       | 50         | 500                          | V/mV          |               |
|                |  |  |  | -55°C                                      | 25         | 1000                         |               |               |
|                |  |  |  | 125°C                                      | 25         | 200                          |               |               |
| $CMRR$         | Common-mode rejection ratio                                      | $V_{IC} = V_{ICRmin}$                          |  | 25°C                                       | 65         | 94                           | dB            |               |
|                |  |  |  | -55°C                                      | 60         | 95                           |               |               |
|                |  |  |  | 125°C                                      | 60         | 85                           |               |               |
| $k_{SVR}$      | Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ ) | $V_{DD} = 5\text{ V to }10\text{ V}$ ,         | $V_O = 1.4\text{ V}$                           | 25°C                                       | 70         | 97                           | dB            |               |
|                |  |  |  | -55°C                                      | 60         | 97                           |               |               |
|                |  |  |  | 125°C                                      | 60         | 98                           |               |               |
| $I_{DD}$       | Supply current (two amplifiers)                                  | $V_O = 2.5\text{ V}$ ,<br>No load              | $V_{IC} = 2.5\text{ V}$ ,                      | 25°C                                       | 20         | 34                           | $\mu\text{A}$ |               |
|                |  |  |  | -55°C                                      | 35         | 60                           |               |               |
|                |  |  |  | 125°C                                      | 14         | 24                           |               |               |

† 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.





# TLC27L2, TLC27L2A, TLC27L2B, TLC27L7 LinCMOS™ PRECISION DUAL OPERATIONAL AMPLIFIERS

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

| PARAMETER      |  | TEST CONDITIONS                        |  | $T_A$ †                                    | TLC27L2M<br>TLC27L7M |             |                              | UNIT          |
|----------------|--|--|--|--|----------------------|-------------|------------------------------|---------------|
|                |  |  |  |  | MIN                  | TYP         | MAX                          |               |
| $V_{IO}$       | Input offset voltage   | TLC27L2M                               | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$ | 25°C                 | 1.1         | 10                           | mV            |
|                |  |  |  |  | Full range           |             | 12                           |               |
|                |  | TLC27L7M                               | $V_O = 1.4\text{ V}$ ,<br>$R_S = 50\ \Omega$ , | $V_{IC} = 0$ ,<br>$R_L = 1\text{ M}\Omega$ | 25°C                 | 190         | 800                          | $\mu\text{V}$ |
|                |  |  |  |  | Full range           |             | 4300                         |               |
| $\alpha_{VIO}$ | Average temperature coefficient of input offset voltage          |  |  | 25°C to 125°C                              | 1.4                  |             | $\mu\text{V}/^\circ\text{C}$ |               |
| $I_{IO}$       | Input offset current (see Note 4)                                | $V_O = 5\text{ V}$ ,                   | $V_{IC} = 5\text{ V}$                          | 25°C                                       | 0.1                  | 60          | pA                           |               |
|                |  |  |  | 125°C                                      | 1.8                  | 15          | nA                           |               |
| $I_{IB}$       | Input bias current (see Note 4)                                  | $V_O = 5\text{ V}$ ,                   | $V_{IC} = 5\text{ V}$                          | 25°C                                       | 0.7                  | 60          | 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  | $V_{ID} = 100\text{ mV}$ ,             | $R_L = 1\text{ M}\Omega$                       | 25°C                                       | 8                    | 8.9         | V                            |               |
|                |  |  |  | -55°C                                      | 7.8                  | 8.8         |                              |               |
|                |  |  |  | 125°C                                      | 7.8                  | 9           |                              |               |
| $V_{OL}$       | Low-level output voltage   | $V_{ID} = -100\text{ mV}$ ,            | $I_{OL} = 0$                                   | 25°C                                       |                      | 0 50        | mV                           |               |
|                |  |  |  | -55°C                                      |                      | 0 50        |                              |               |
|                |  |  |  | 125°C                                      |                      | 0 50        |                              |               |
| $A_{VD}$       | Large-signal differential voltage amplification                  | $V_O = 1\text{ V to }6\text{ V}$ ,     | $R_L = 1\text{ M}\Omega$                       | 25°C                                       | 50                   | 860         | V/mV                         |               |
|                |  |  |  | -55°C                                      | 25                   | 1750        |                              |               |
|                |  |  |  | 125°C                                      | 25                   | 380         |                              |               |
| CMRR           | Common-mode rejection ratio                                      | $V_{IC} = V_{ICRmin}$                  |  | 25°C                                       | 65                   | 97          | dB                           |               |
|                |  |  |  | -55°C                                      | 60                   | 97          |                              |               |
|                |  |  |  | 125°C                                      | 60                   | 91          |                              |               |
| $k_{SVR}$      | Supply-voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ ) | $V_{DD} = 5\text{ V to }10\text{ V}$ , | $V_O = 1.4\text{ V}$                           | 25°C                                       | 70                   | 97          | dB                           |               |
|                |  |  |  | -55°C                                      | 60                   | 97          |                              |               |
|                |  |  |  | 125°C                                      | 60                   | 98          |                              |               |
| $I_{DD}$       | Supply current (two amplifiers)                                  | $V_O = 5\text{ V}$ ,<br>No load        | $V_{IC} = 5\text{ V}$ ,                        | 25°C                                       | 29                   | 46          | $\mu\text{A}$                |               |
|                |  |  |  | -55°C                                      | 56                   | 96          |                              |               |
|                |  |  |  | 125°C                                      | 18                   | 30          |                              |               |

† 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.



# TLC27L2, TLC27L2A, TLC27L2B, TLC27L7 LinCMOS™ PRECISION DUAL OPERATIONAL AMPLIFIERS

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## operating characteristics, $V_{DD} = 5\text{ V}$

| PARAMETER                               | TEST CONDITIONS  | $T_A$                          | TLC27L2C<br>TLC27L2AC<br>TLC27L2BC<br>TLC27L7C |      |                        | UNIT       |
|---|--|--------------------------------|--|------|------------------------|------------|
|   |  |                                | MIN  | TYP  | MAX                    |            |
| SR Slew rate at unity gain              | $R_L = 1\text{ M}\Omega$ ,<br>$C_L = 20\text{ pF}$ ,<br>See Figure 1                     | $V_{I(PP)} = 1\text{ V}$       | 25°C   | 0.03 |                        | V/ $\mu$ s |
|   |  |                                | 0°C  | 0.04 |                        |            |
|   |  |                                | 70°C   | 0.03 |                        |            |
|   |  | $V_{I(PP)} = 2.5\text{ V}$     | 25°C   | 0.03 |                        |            |
|   |  |                                | 0°C  | 0.03 |                        |            |
|   |  |                                | 70°C   | 0.02 |                        |            |
| $V_n$ Equivalent input noise voltage    | $f = 1\text{ kHz}$ ,<br>See Figure 2   | $R_S = 20\ \Omega$ ,<br>25°C   | 68   |      | nV/ $\sqrt{\text{Hz}}$ |            |
| $B_{OM}$ Maximum output-swing bandwidth | $V_O = V_{OH}$ ,<br>$R_L = 1\text{ M}\Omega$ ,<br>$C_L = 20\text{ pF}$ ,<br>See Figure 1 | 25°C                           | 5  |      | kHz                    |            |
|   |  | 0°C                            | 6  |      |                        |            |
|   |  | 70°C                           | 4.5  |      |                        |            |
| $B_1$ Unity-gain bandwidth              | $V_I = 10\text{ mV}$ ,<br>See Figure 3   | $C_L = 20\text{ pF}$ ,<br>25°C | 85   |      | kHz                    |            |
|   |  |                                | 0°C  | 100  |                        |            |
|   |  |                                | 70°C   | 65   |                        |            |
| $\phi_m$ Phase margin                   | $V_I = 10\text{ mV}$ ,<br>$C_L = 20\text{ pF}$ ,<br>$f = B_1$ ,<br>See Figure 3          | 25°C                           | 34°  |      |                        |            |
|   |  | 0°C                            | 36°  |      |                        |            |
|   |  | 70°C                           | 30°  |      |                        |            |

## operating characteristics, $V_{DD} = 10\text{ V}$

| PARAMETER                               | TEST CONDITIONS  | $T_A$                          | TLC27L2C<br>TLC27L2AC<br>TLC27L2BC<br>TLC27L7C |      |                        | UNIT       |
|---|--|--------------------------------|--|------|------------------------|------------|
|   |  |                                | MIN  | TYP  | MAX                    |            |
| SR Slew rate at unity gain              | $R_L = 1\text{ M}\Omega$ ,<br>$C_L = 20\text{ pF}$ ,<br>See Figure 1                     | $V_{I(PP)} = 1\text{ V}$       | 25°C   | 0.05 |                        | V/ $\mu$ s |
|   |  |                                | 0°C  | 0.05 |                        |            |
|   |  |                                | 70°C   | 0.04 |                        |            |
|   |  | $V_{I(PP)} = 5.5\text{ V}$     | 25°C   | 0.04 |                        |            |
|   |  |                                | 0°C  | 0.05 |                        |            |
|   |  |                                | 70°C   | 0.04 |                        |            |
| $V_n$ Equivalent input noise voltage    | $f = 1\text{ kHz}$ ,<br>See Figure 2   | $R_S = 20\ \Omega$ ,<br>25°C   | 68   |      | nV/ $\sqrt{\text{Hz}}$ |            |
| $B_{OM}$ Maximum output-swing bandwidth | $V_O = V_{OH}$ ,<br>$R_L = 1\text{ M}\Omega$ ,<br>$C_L = 20\text{ pF}$ ,<br>See Figure 1 | 25°C                           | 1  |      | kHz                    |            |
|   |  | 0°C                            | 1.3  |      |                        |            |
|   |  | 70°C                           | 0.9  |      |                        |            |
| $B_1$ Unity-gain bandwidth              | $V_I = 10\text{ mV}$ ,<br>See Figure 3   | $C_L = 20\text{ pF}$ ,<br>25°C | 110  |      | kHz                    |            |
|   |  |                                | 0°C  | 125  |                        |            |
|   |  |                                | 70°C   | 90   |                        |            |
| $\phi_m$ Phase margin                   | $V_I = 10\text{ mV}$ ,<br>$C_L = 20\text{ pF}$ ,<br>$f = B_1$ ,<br>See Figure 3          | 25°C                           | 38°  |      |                        |            |
|   |  | 0°C                            | 40°  |      |                        |            |
|   |  | 70°C                           | 34°  |      |                        |            |



# TLC27L2, TLC27L2A, TLC27L2B, TLC27L7 LinCMOS™ PRECISION DUAL OPERATIONAL AMPLIFIERS

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## operating characteristics, $V_{DD} = 5\text{ V}$

| PARAMETER                               | TEST CONDITIONS  |  | $T_A$ | TLC27L2I<br>TLC27L2AI<br>TLC27L2BI<br>TLC27L7I |     |                        | UNIT |
|---|--|--|-------|--|-----|------------------------|------|
|   |  |  |       | MIN  | TYP | MAX                    |      |
| SR Slew rate at unity gain              | $R_L = 1\text{ M}\Omega$ ,<br>$C_L = 20\text{ pF}$ ,<br>See Figure 1 | $V_{I(PP)} = 1\text{ V}$               | 25°C  | 0.03   |     | V/ $\mu$ s             |      |
|   |  |  | -40°C | 0.04   |     |                        |      |
|   |  |  | 85°C  | 0.03   |     |                        |      |
|   |  | $V_{I(PP)} = 2.5\text{ V}$             | 25°C  | 0.03   |     |                        |      |
|   |  |  | -40°C | 0.04   |     |                        |      |
|   |  |  | 85°C  | 0.02   |     |                        |      |
| $V_n$ Equivalent input noise voltage    | $f = 1\text{ kHz}$ ,<br>See Figure 2                                 | $R_S = 20\ \Omega$ ,                   | 25°C  | 68   |     | nV/ $\sqrt{\text{Hz}}$ |      |
| $B_{OM}$ Maximum output-swing bandwidth | $V_O = V_{OH}$ ,<br>$R_L = 1\text{ M}\Omega$ ,                       | $C_L = 20\text{ pF}$ ,<br>See Figure 1 | 25°C  | 5  |     | kHz                    |      |
|   |  |  | -40°C | 7  |     |                        |      |
|   |  |  | 85°C  | 4  |     |                        |      |
| $B_1$ Unity-gain bandwidth              | $V_I = 10\text{ mV}$ ,<br>See Figure 3                               | $C_L = 20\text{ pF}$ ,                 | 25°C  | 85   |     | kHz                    |      |
|   |  |  | -40°C | 130  |     |                        |      |
|   |  |  | 85°C  | 55   |     |                        |      |
| $\phi_m$ Phase margin                   | $V_I = 10\text{ mV}$ ,<br>$C_L = 20\text{ pF}$ ,                     | $f = B_1$ ,<br>See Figure 3            | 25°C  | 34°  |     |                        |      |
|   |  |  | -40°C | 38°  |     |                        |      |
|   |  |  | 85°C  | 29°  |     |                        |      |

## operating characteristics, $V_{DD} = 10\text{ V}$

| PARAMETER                               | TEST CONDITIONS  |  | $T_A$ | TLC27L2I<br>TLC27L2AI<br>TLC27L2BI<br>TLC27L7I |     |                        | UNIT |
|---|--|--|-------|--|-----|------------------------|------|
|   |  |  |       | MIN  | TYP | MAX                    |      |
| SR Slew rate at unity gain              | $R_L = 1\text{ M}\Omega$ ,<br>$C_L = 20\text{ pF}$ ,<br>See Figure 1 | $V_{I(PP)} = 1\text{ V}$               | 25°C  | 0.05   |     | V/ $\mu$ s             |      |
|   |  |  | -40°C | 0.06   |     |                        |      |
|   |  |  | 85°C  | 0.03   |     |                        |      |
|   |  | $V_{I(PP)} = 5.5\text{ V}$             | 25°C  | 0.04   |     |                        |      |
|   |  |  | -40°C | 0.05   |     |                        |      |
|   |  |  | 85°C  | 0.03   |     |                        |      |
| $V_n$ Equivalent input noise voltage    | $f = 1\text{ kHz}$ ,<br>See Figure 2                                 | $R_S = 20\ \Omega$ ,                   | 25°C  | 68   |     | nV/ $\sqrt{\text{Hz}}$ |      |
| $B_{OM}$ Maximum output-swing bandwidth | $V_O = V_{OH}$ ,<br>$R_L = 1\text{ M}\Omega$ ,                       | $C_L = 20\text{ pF}$ ,<br>See Figure 1 | 25°C  | 1  |     | kHz                    |      |
|   |  |  | -40°C | 1.4  |     |                        |      |
|   |  |  | 85°C  | 0.8  |     |                        |      |
| $B_1$ Unity-gain bandwidth              | $V_I = 10\text{ mV}$ ,<br>See Figure 3                               | $C_L = 20\text{ pF}$ ,                 | 25°C  | 110  |     | kHz                    |      |
|   |  |  | -40°C | 155  |     |                        |      |
|   |  |  | 85°C  | 80   |     |                        |      |
| $\phi_m$ Phase margin                   | $V_I = 10\text{ mV}$ ,<br>$C_L = 20\text{ pF}$ ,                     | $f = B_1$ ,<br>See Figure 3            | 25°C  | 38°  |     |                        |      |
|   |  |  | -40°C | 42°  |     |                        |      |
|   |  |  | 85°C  | 32°  |     |                        |      |



# TLC27L2, TLC27L2A, TLC27L2B, TLC27L7 LinCMOS™ PRECISION DUAL OPERATIONAL AMPLIFIERS

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## operating characteristics, $V_{DD} = 5\text{ V}$

| PARAMETER                               | TEST CONDITIONS  |  | $T_A$ | TLC27L2M<br>TLC27L7M |     |     | UNIT                   |
|---|--|--|-------|----------------------|-----|-----|------------------------|
|   |  |  |       | MIN                  | TYP | MAX |                        |
| SR Slew rate at unity gain              | $R_L = 1\text{ M}\Omega$ ,<br>$C_L = 20\text{ pF}$ ,<br>See Figure 1 | $V_{I(PP)} = 1\text{ V}$               | 25°C  | 0.03                 |     |     | V/ $\mu$ s             |
|   |  |  | -55°C | 0.04                 |     |     |                        |
|   |  |  | 125°C | 0.02                 |     |     |                        |
|   |  | $V_{I(PP)} = 2.5\text{ V}$             | 25°C  | 0.03                 |     |     |                        |
|   |  |  | -55°C | 0.04                 |     |     |                        |
|   |  |  | 125°C | 0.02                 |     |     |                        |
| $V_n$ Equivalent input noise voltage    | $f = 1\text{ kHz}$ ,<br>See Figure 2                                 | $R_S = 20\ \Omega$                     | 25°C  | 68                   |     |     | nV/ $\sqrt{\text{Hz}}$ |
| $B_{OM}$ Maximum output-swing bandwidth | $V_O = V_{OH}$ ,<br>$R_L = 1\text{ M}\Omega$ ,<br>See Figure 1       | $C_L = 20\text{ pF}$ ,<br>See Figure 1 | 25°C  | 5                    |     |     | kHz                    |
|   |  |  | -55°C | 8                    |     |     |                        |
|   |  |  | 125°C | 3                    |     |     |                        |
| $B_1$ Unity-gain bandwidth              | $V_I = 10\text{ mV}$ ,<br>See Figure 3                               | $C_L = 20\text{ pF}$                   | 25°C  | 85                   |     |     | kHz                    |
|   |  |  | -55°C | 140                  |     |     |                        |
|   |  |  | 125°C | 45                   |     |     |                        |
| $\phi_m$ Phase margin                   | $V_I = 10\text{ mV}$ ,<br>$C_L = 20\text{ pF}$ ,                     | $f = B_1$ ,<br>See Figure 3            | 25°C  | 34°                  |     |     |                        |
|   |  |  | -55°C | 39°                  |     |     |                        |
|   |  |  | 125°C | 25°                  |     |     |                        |

## operating characteristics, $V_{DD} = 10\text{ V}$

| PARAMETER                               | TEST CONDITIONS  |  | $T_A$ | TLC27L2M<br>TLC27L7M |     |     | UNIT                   |
|---|--|--|-------|----------------------|-----|-----|------------------------|
|   |  |  |       | MIN                  | TYP | MAX |                        |
| SR Slew rate at unity gain              | $R_L = 1\text{ M}\Omega$ ,<br>$C_L = 20\text{ pF}$ ,<br>See Figure 1 | $V_{I(PP)} = 1\text{ V}$               | 25°C  | 0.05                 |     |     | V/ $\mu$ s             |
|   |  |  | -55°C | 0.06                 |     |     |                        |
|   |  |  | 125°C | 0.03                 |     |     |                        |
|   |  | $V_{I(PP)} = 5.5\text{ V}$             | 25°C  | 0.04                 |     |     |                        |
|   |  |  | -55°C | 0.06                 |     |     |                        |
|   |  |  | 125°C | 0.03                 |     |     |                        |
| $V_n$ Equivalent input noise voltage    | $f = 1\text{ kHz}$ ,<br>See Figure 2                                 | $R_S = 20\ \Omega$                     | 25°C  | 68                   |     |     | nV/ $\sqrt{\text{Hz}}$ |
| $B_{OM}$ Maximum output-swing bandwidth | $V_O = V_{OH}$ ,<br>$R_L = 1\text{ M}\Omega$ ,<br>See Figure 1       | $C_L = 20\text{ pF}$ ,<br>See Figure 1 | 25°C  | 1                    |     |     | kHz                    |
|   |  |  | -55°C | 1.5                  |     |     |                        |
|   |  |  | 125°C | 0.7                  |     |     |                        |
| $B_1$ Unity-gain bandwidth              | $V_I = 10\text{ mV}$ ,<br>See Figure 3                               | $C_L = 20\text{ pF}$                   | 25°C  | 110                  |     |     | kHz                    |
|   |  |  | -55°C | 165                  |     |     |                        |
|   |  |  | 125°C | 70                   |     |     |                        |
| $\phi_m$ Phase margin                   | $V_I = 10\text{ mV}$ ,<br>$C_L = 20\text{ pF}$ ,                     | $f = B_1$ ,<br>See Figure 3            | 25°C  | 38°                  |     |     |                        |
|   |  |  | -55°C | 43°                  |     |     |                        |
|   |  |  | 125°C | 29°                  |     |     |                        |



PARAMETER MEASUREMENT INFORMATION

single-supply versus split-supply test circuits

Because the TLC27L2 and TLC27L7 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.

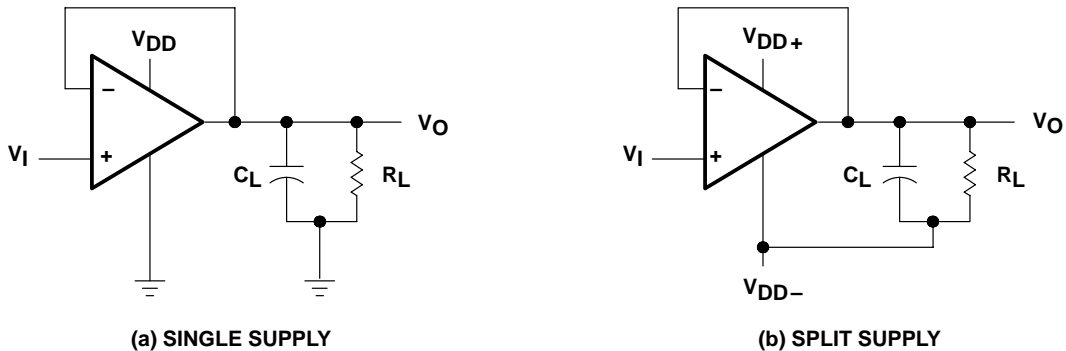


Figure 1. Unity-Gain Amplifier

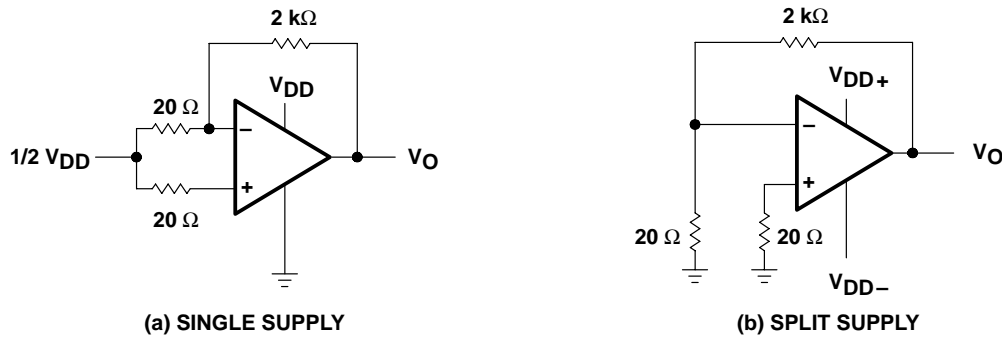


Figure 2. Noise-Test Circuit

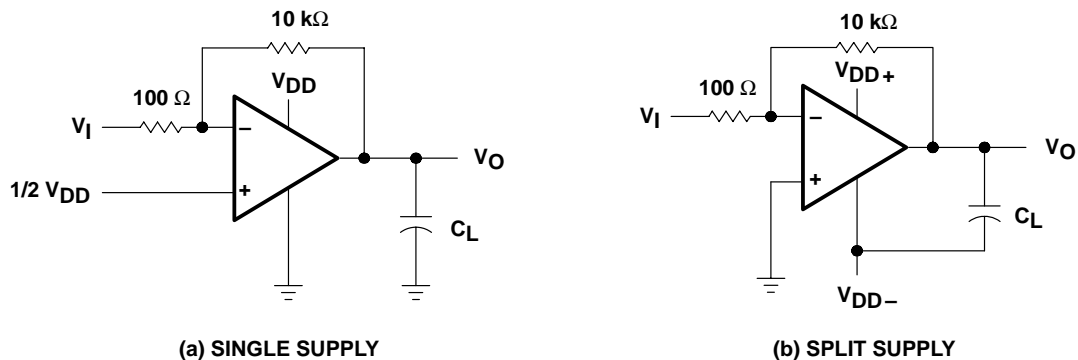


Figure 3. Gain-of-100 Inverting Amplifier

## PARAMETER MEASUREMENT INFORMATION

### input bias current

Because of the high input impedance of the TLC27L2 and TLC27L7 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.

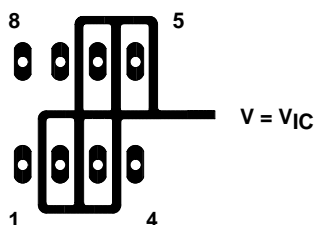


Figure 4. Isolation Metal Around Device Inputs  
(JG and P packages)

### 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.

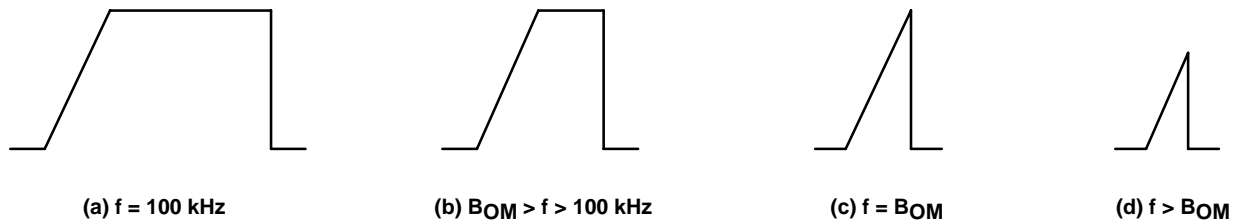


Figure 5. Full-Power-Response Output Signal

test time

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

**TLC27L2, TLC27L2A, TLC27L2B, TLC27L7**  
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**TYPICAL CHARACTERISTICS**

Table of Graphs

|                |   | <b>FIGURE</b>                 |        |
|----------------|---|-------------------------------|--------|
| $V_{IO}$       | Input offset voltage                            | Distribution                  | 6, 7   |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | Distribution                  | 8, 9   |
| $V_{OH}$       | High-level output voltage                       | vs High-level output current  | 10, 11 |
|                |   | vs Supply voltage             | 12     |
|                |   | vs Free-air temperature       | 13     |
| $V_{OL}$       | Low-level output voltage                        | vs Differential input voltage | 14, 16 |
|                |   | vs Free-air temperature       | 15, 17 |
|                |   | vs Low-level output current   | 18, 19 |
| $A_{VD}$       | Large-signal differential voltage amplification | vs Supply voltage             | 20     |
|                |   | vs Free-air temperature       | 21     |
|                |   | vs Frequency                  | 32, 33 |
| $I_{IB}$       | Input bias current                              | vs Free-air temperature       | 22     |
| $I_{IO}$       | 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             | 24     |
|                |   | vs Free-air temperature       | 25     |
| SR             | Slew rate                                       | vs Supply voltage             | 26     |
|                |   | vs Free-air temperature       | 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       | 30     |
|                |   | vs Supply voltage             | 31     |
| $\phi_m$       | Phase margin                                    | vs Supply voltage             | 34     |
|                |   | vs Free-air temperature       | 35     |
|                |   | vs Capacitive Load            | 36     |
| $V_n$          | Equivalent input noise voltage                  | vs Frequency                  | 37     |
|                |   | Phase shift                   | 32, 33 |





TYPICAL CHARACTERISTICS

DISTRIBUTION OF TLC27L2  
 INPUT OFFSET VOLTAGE

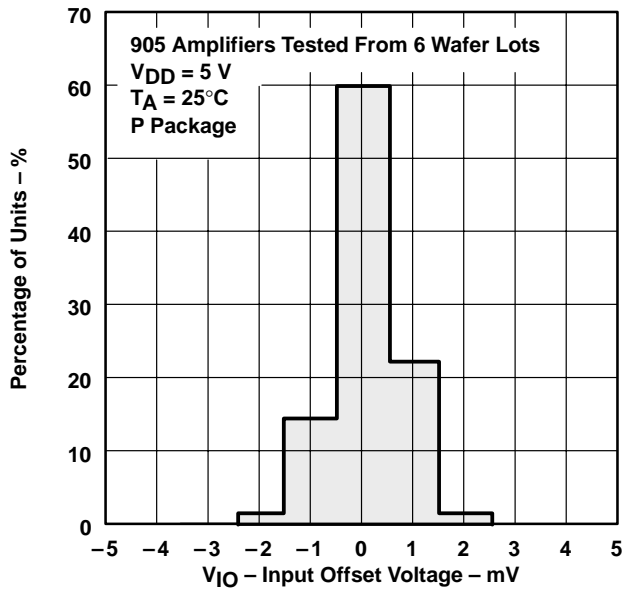


Figure 6

DISTRIBUTION OF TLC27L2  
 INPUT OFFSET VOLTAGE

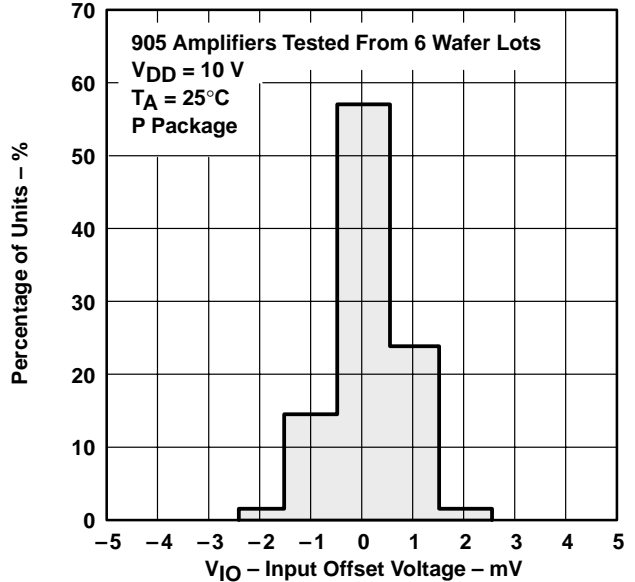


Figure 7

DISTRIBUTION OF TLC27LC AND TLC27L7  
 INPUT OFFSET VOLTAGE  
 TEMPERATURE COEFFICIENT

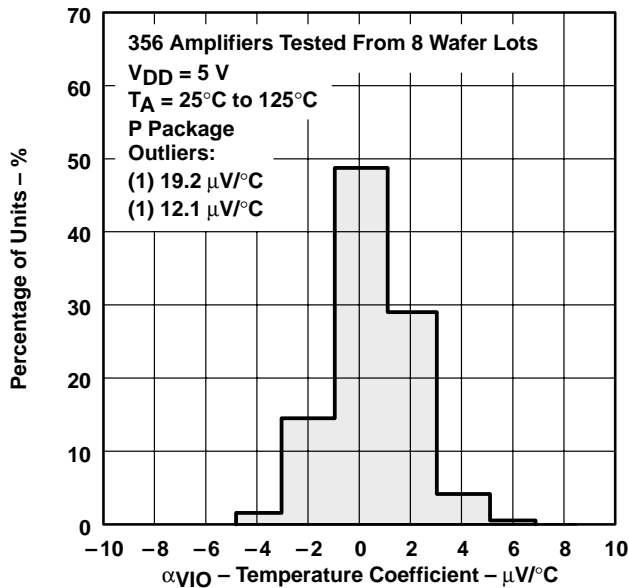


Figure 8

DISTRIBUTION OF TLC27LC AND TLC27L7  
 INPUT OFFSET VOLTAGE  
 TEMPERATURE COEFFICIENT

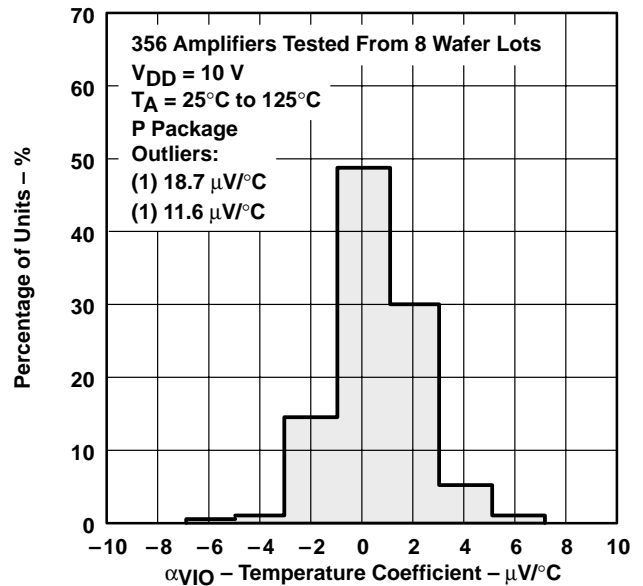


Figure 9

TYPICAL CHARACTERISTICS†

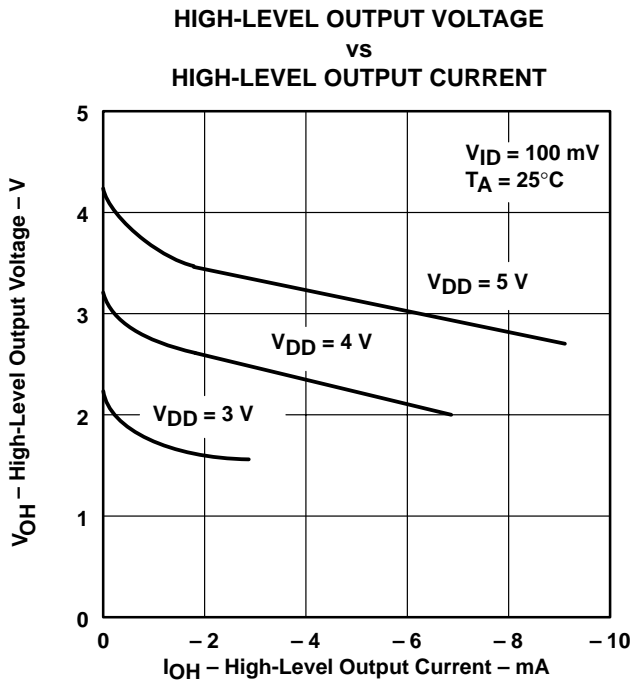


Figure 10

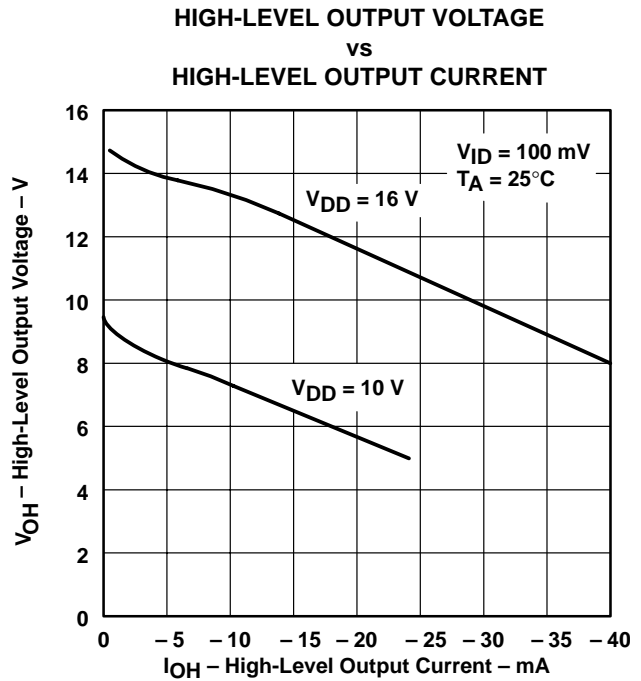


Figure 11

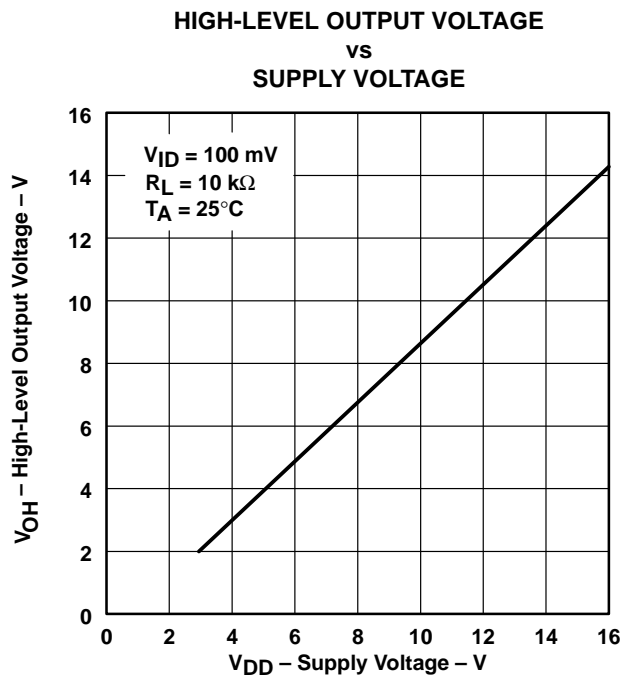


Figure 12

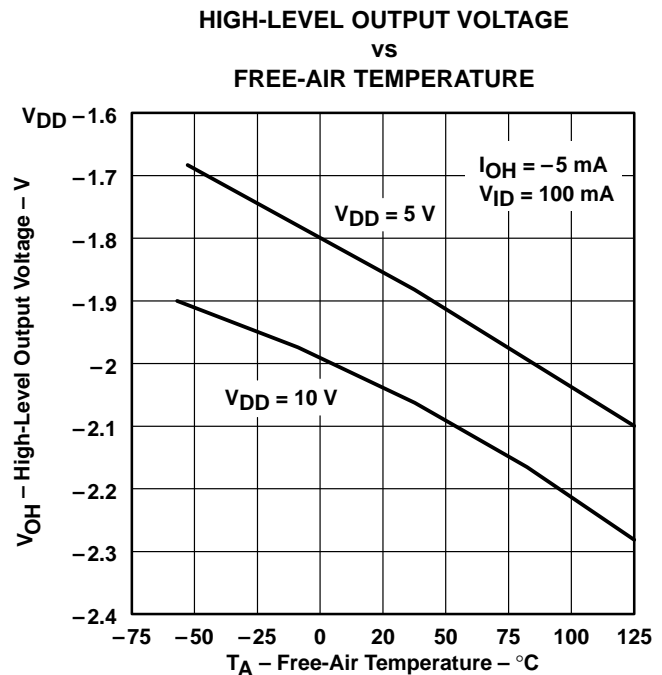


Figure 13

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

TYPICAL CHARACTERISTICS†

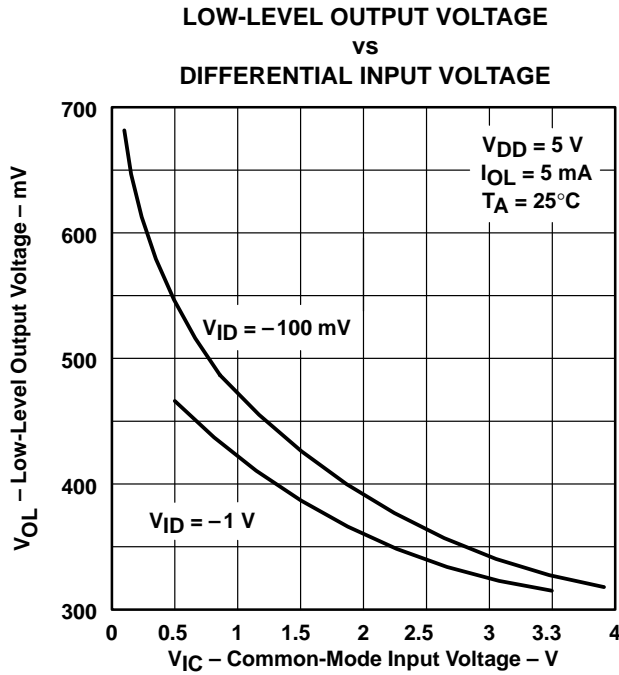


Figure 14

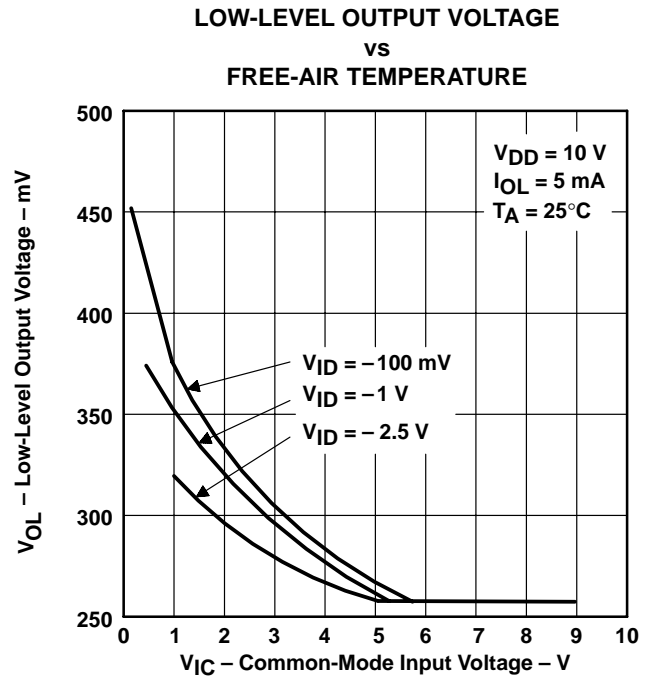


Figure 15

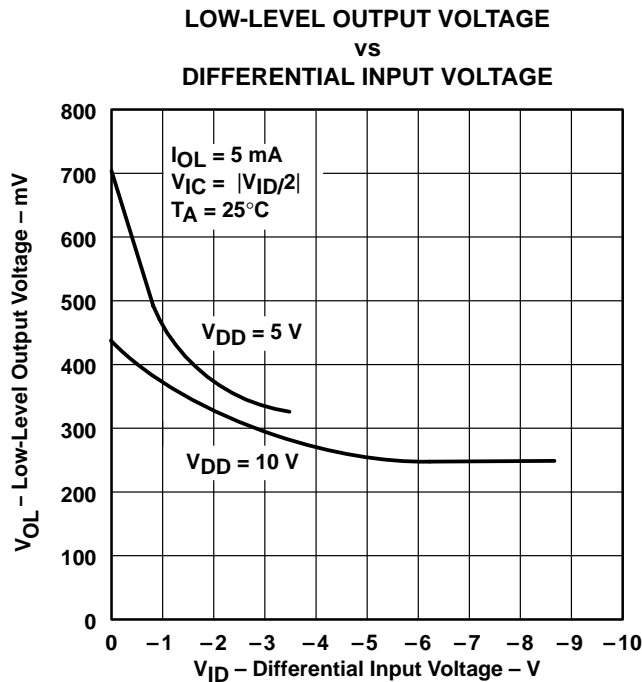


Figure 16

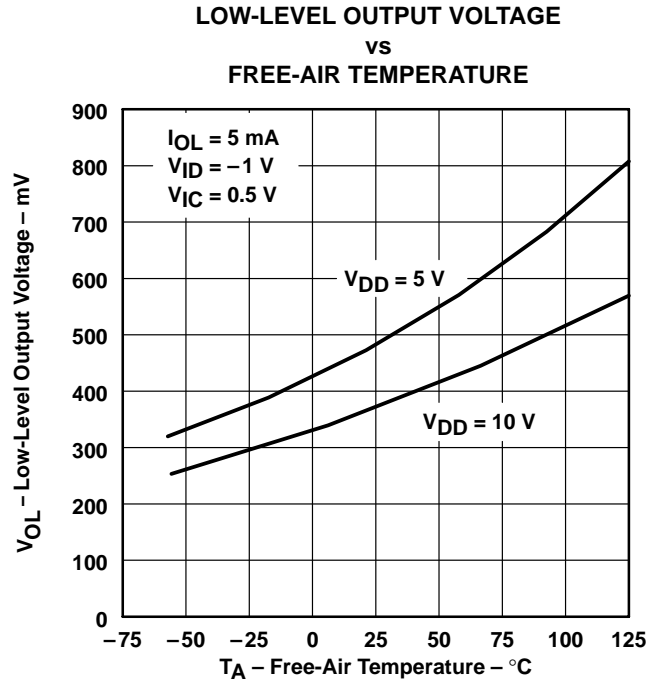


Figure 17

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

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## TYPICAL CHARACTERISTICS†

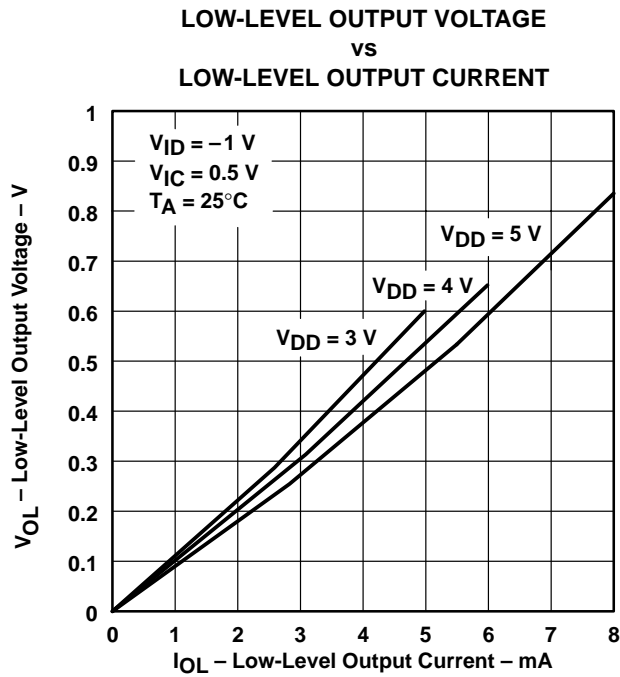


Figure 18

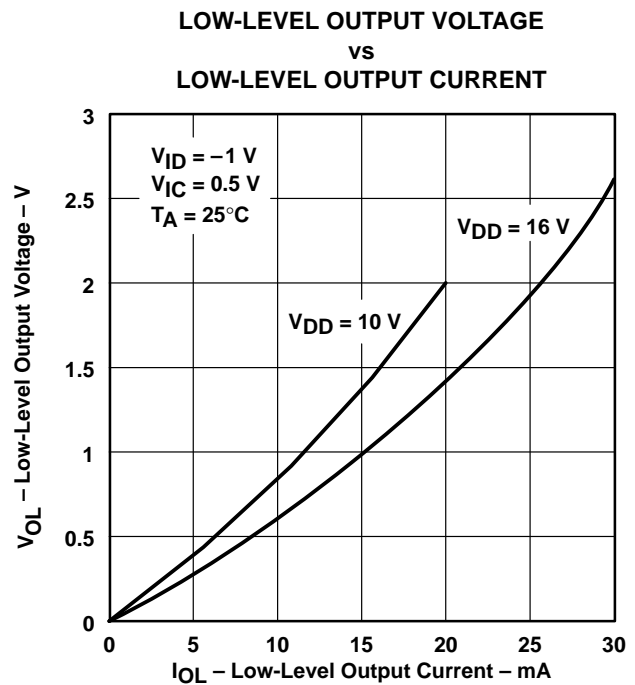


Figure 19

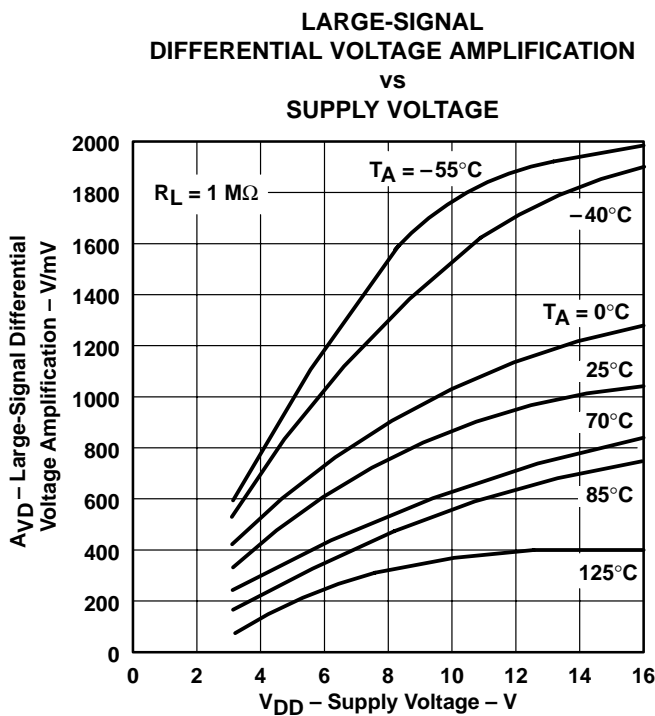


Figure 20

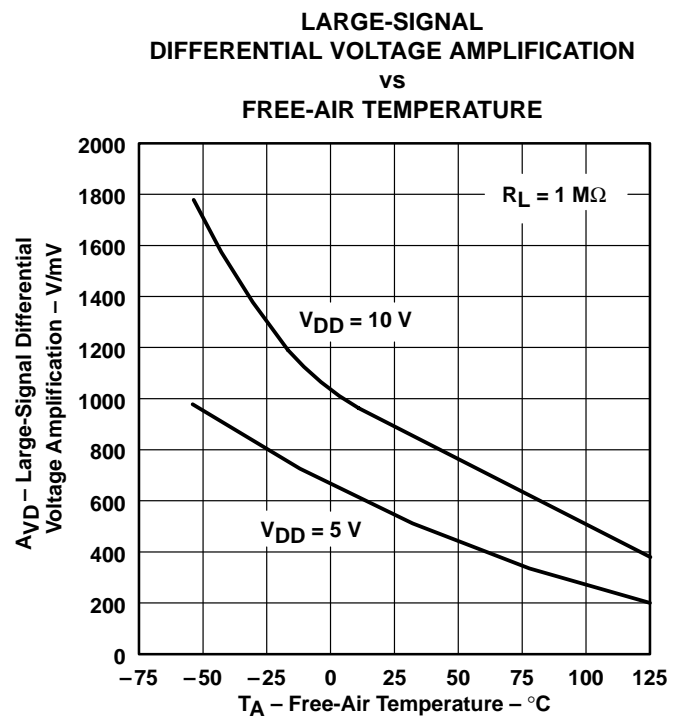
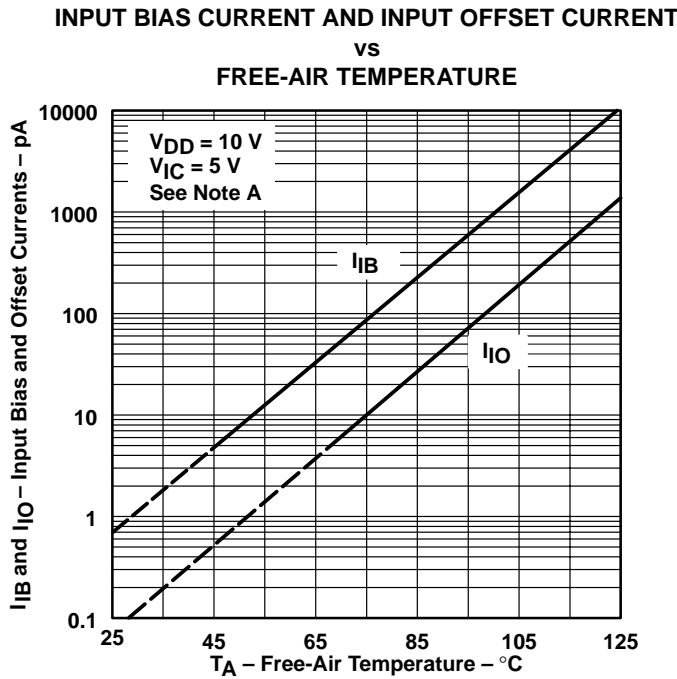


Figure 21

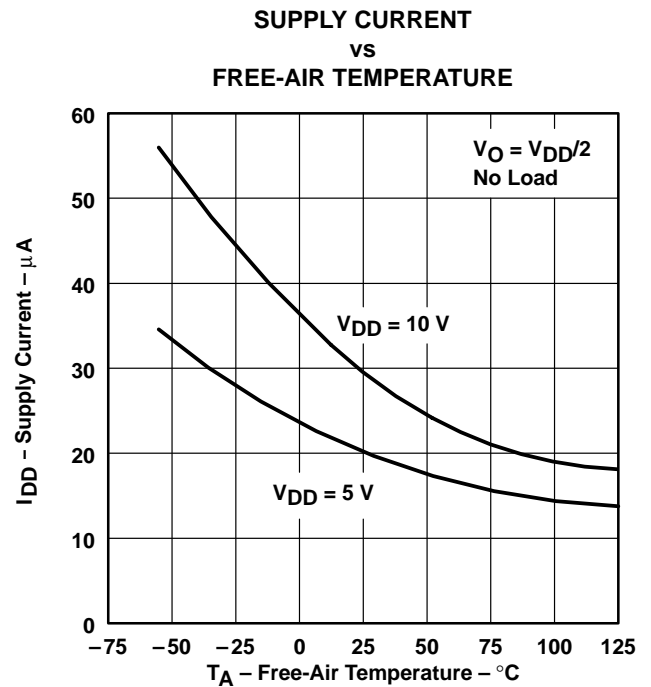
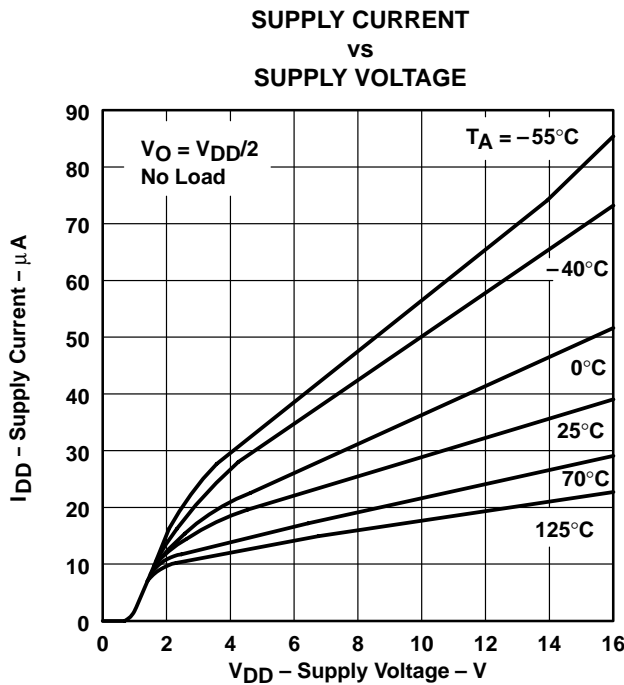
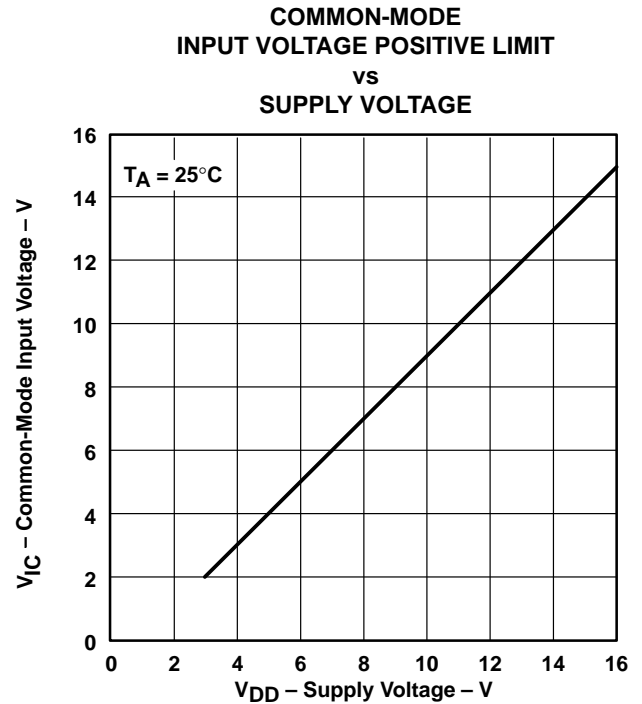
† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.



TYPICAL CHARACTERISTICS†



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



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

# TLC27L2, TLC27L2A, TLC27L2B, TLC27L7 LinCMOS™ PRECISION DUAL OPERATIONAL AMPLIFIERS

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## TYPICAL CHARACTERISTICS†

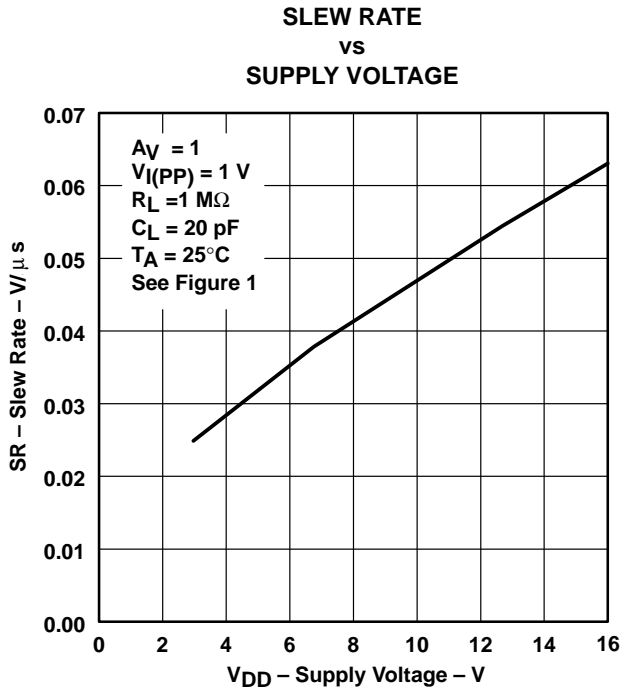


Figure 26

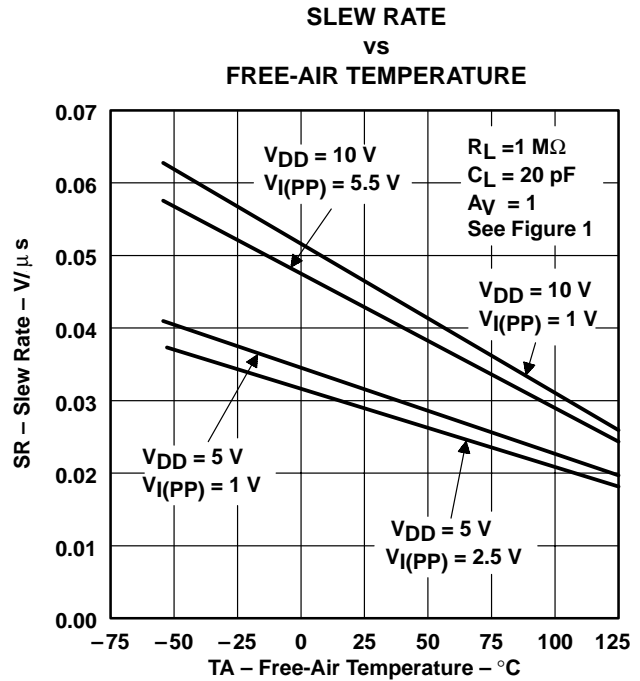


Figure 27

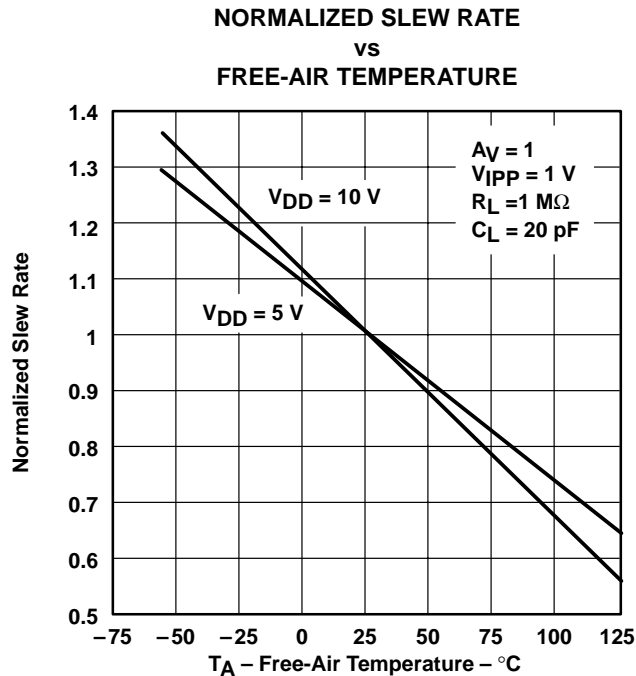


Figure 28

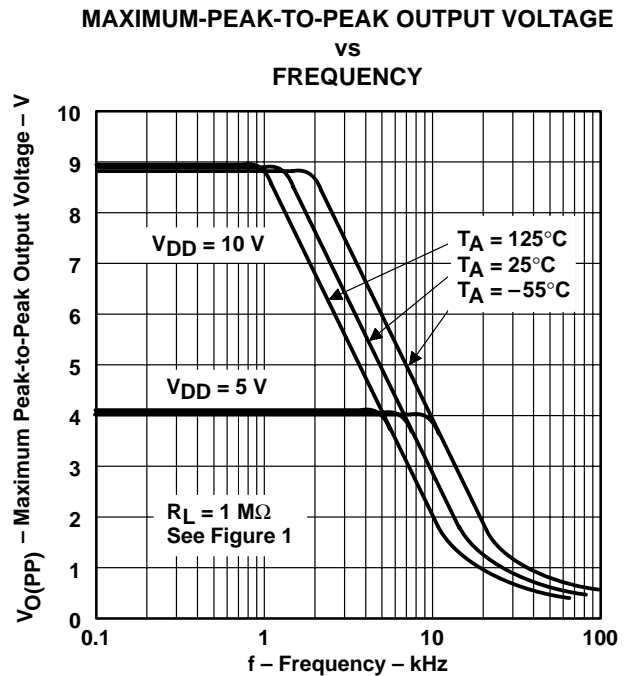


Figure 29

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

TYPICAL CHARACTERISTICS†

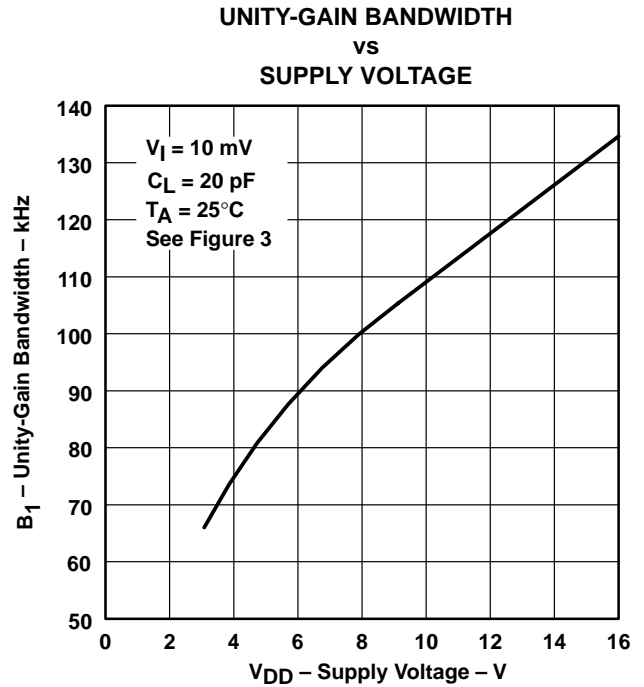
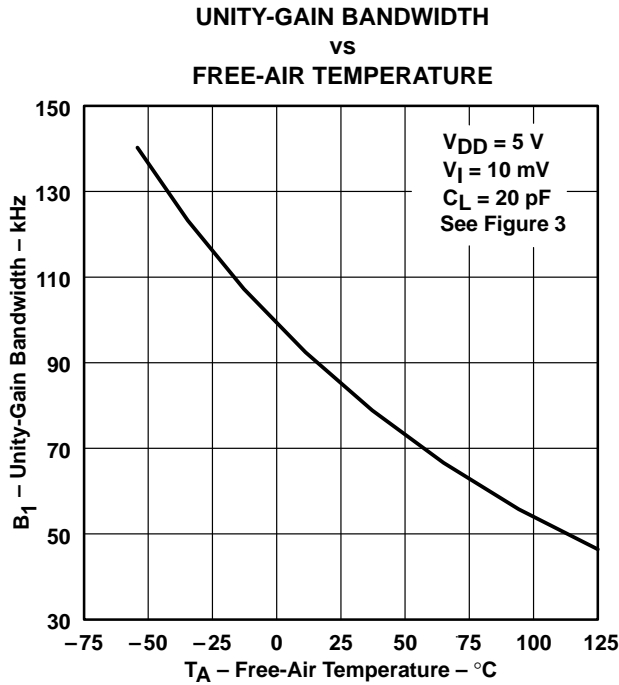


Figure 30

Figure 31

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

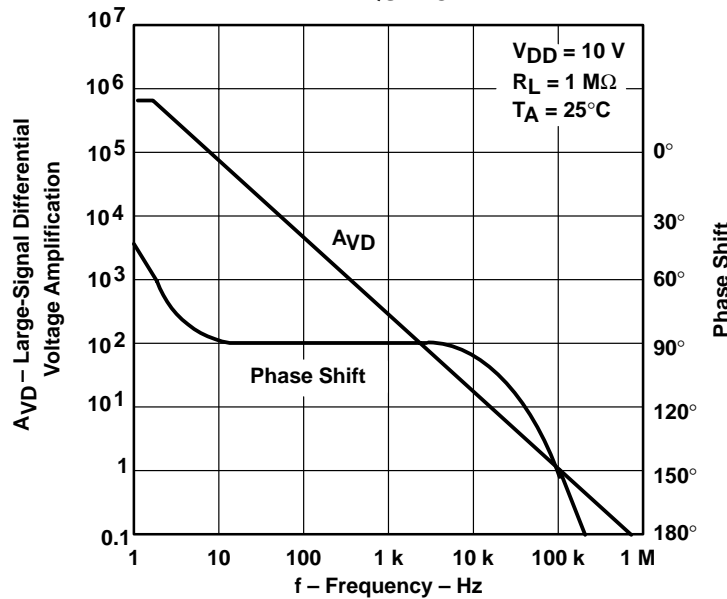


Figure 32

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

TYPICAL CHARACTERISTICS†

LARGE-SIGNAL DIFFERENTIAL VOLTAGE  
 AMPLIFICATION AND PHASE SHIFT  
 vs  
 FREQUENCY

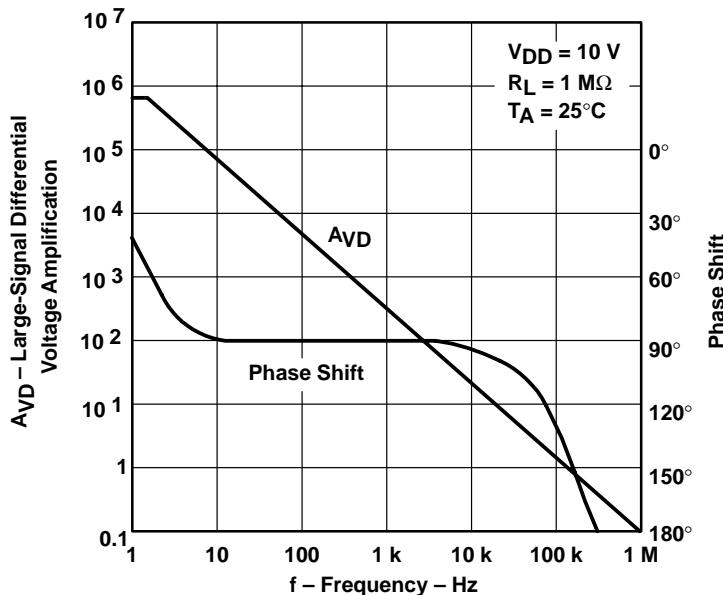


Figure 33

PHASE MARGIN  
 vs  
 SUPPLY VOLTAGE

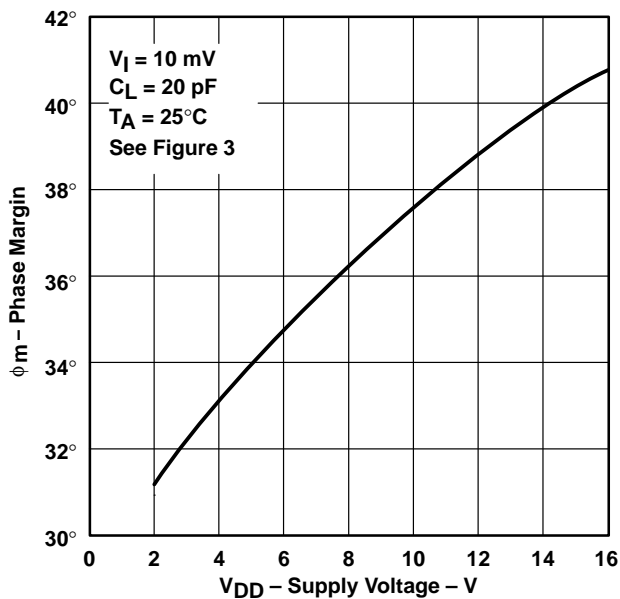


Figure 34

PHASE MARGIN  
 vs  
 FREE-AIR TEMPERATURE

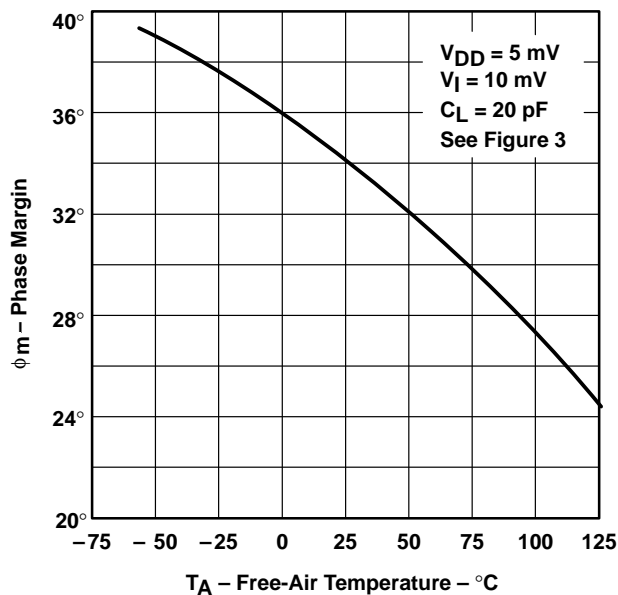


Figure 35

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



TYPICAL CHARACTERISTICS

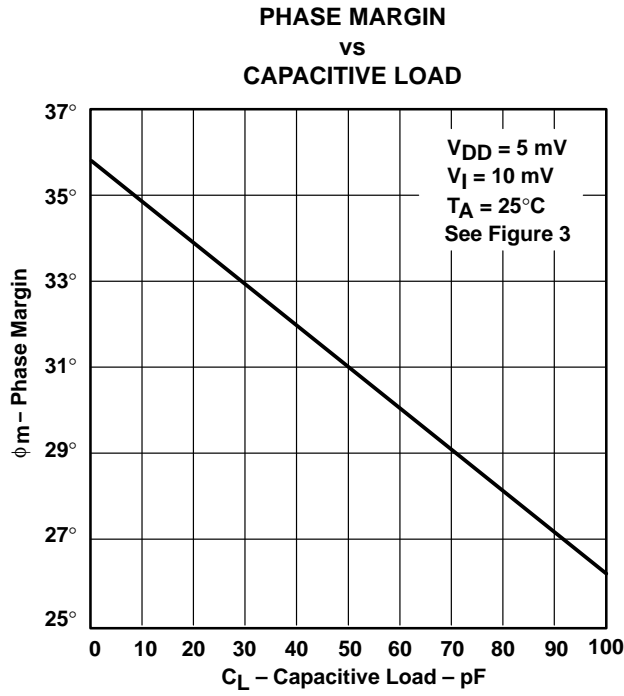


Figure 36

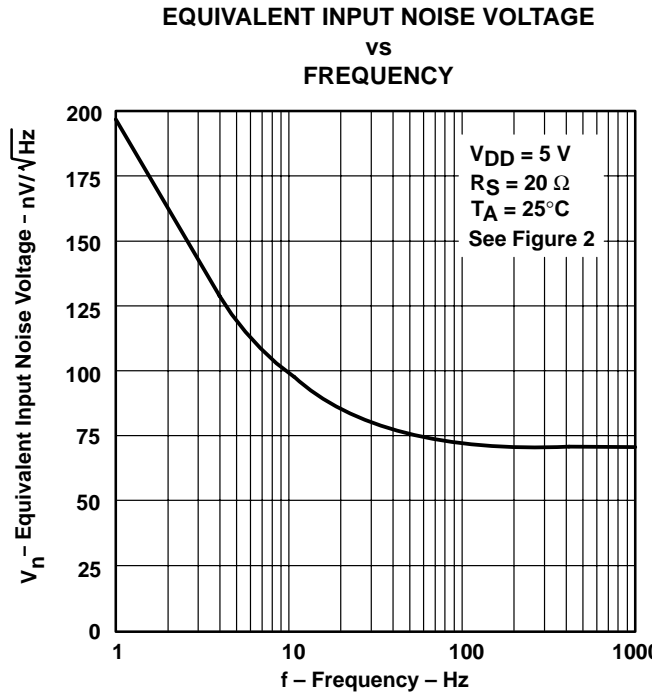


Figure 37

**APPLICATION INFORMATION**

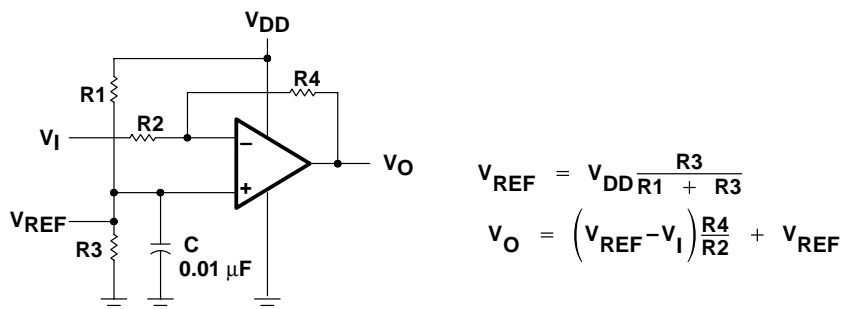
**single-supply operation**

While the TLC27L2 and TLC27L7 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.

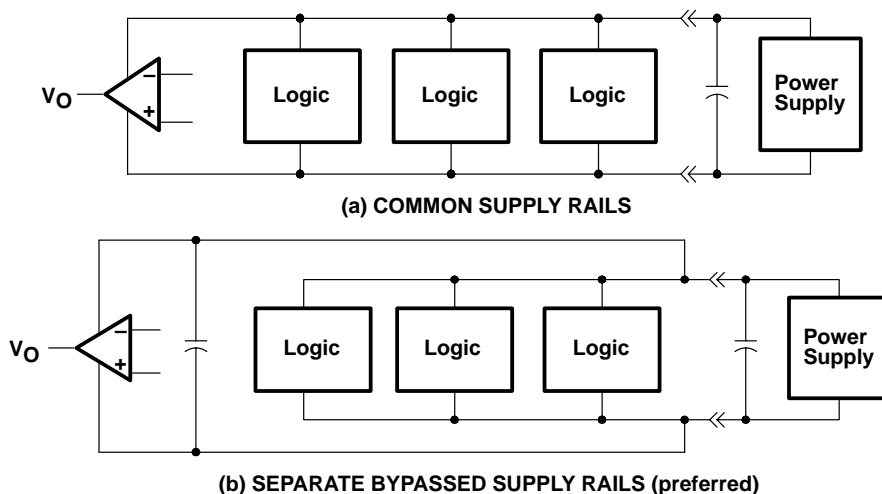
Many single-supply applications require that a voltage be applied to one input to establish a reference level that is above ground. A resistive voltage divider is usually sufficient to establish this reference level (see Figure 38). The low input bias current of the TLC27L2 and TLC27L7 permits the use of very large resistive values to implement the voltage divider, thus minimizing power consumption.

The TLC27L2 and TLC27L7 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.



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



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

## APPLICATION INFORMATION

### input characteristics

The TLC27L2 and TLC27L7 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  $T_A = 25^\circ\text{C}$  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 TLC27L2 and TLC27L7 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  $0.1 \mu\text{V}/\text{month}$ , including the first month of operation.

Because of the extremely high input impedance and resulting low bias current requirements, the TLC27L2 and TLC27L7 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).

Unused amplifiers should be connected as grounded unity-gain followers 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 TLC27L2 and TLC27L7 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  $50 \text{ k}\Omega$ , since bipolar devices exhibit greater noise currents.

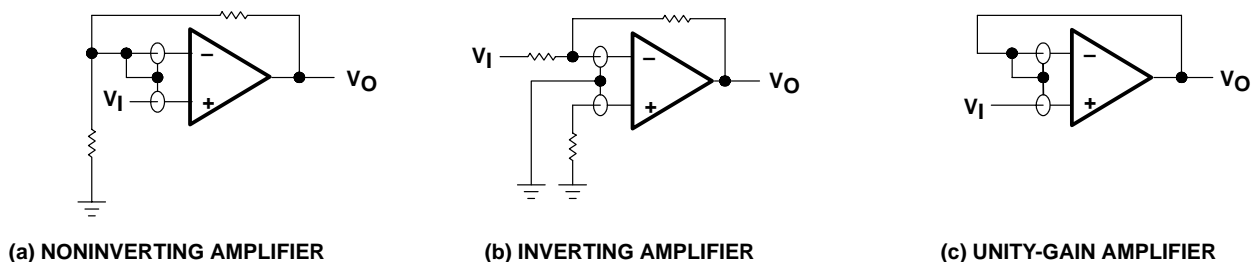


Figure 40. Guard-Ring Schemes

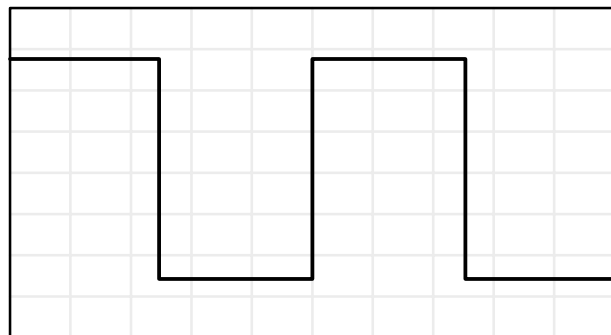
### output characteristics

The output stage of the TLC27L2 and TLC27L7 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 TLC27L2 and TLC27L7 were measured using a  $20\text{-pF}$  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.

APPLICATION INFORMATION

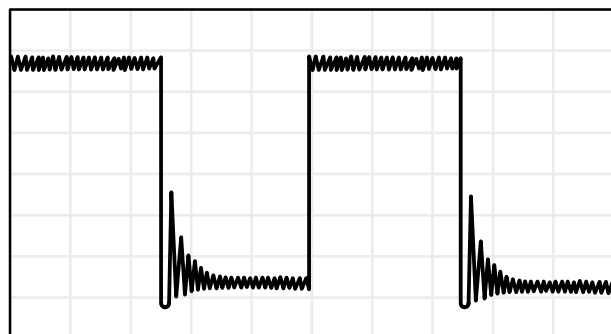
output characteristics (continued)



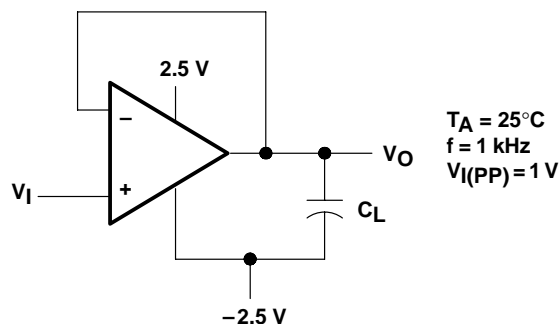
(a)  $C_L = 20 \text{ pF}$ ,  $R_L = \text{NO LOAD}$



(b)  $C_L = 260 \text{ pF}$ ,  $R_L = \text{NO LOAD}$



(c)  $C_L = 310 \text{ pF}$ ,  $R_L = \text{NO LOAD}$



(d) TEST CIRCUIT

$T_A = 25^\circ\text{C}$   
 $f = 1 \text{ kHz}$   
 $V_I(\text{PP}) = 1 \text{ V}$

Figure 41. Effect of Capacitive Loads and Test Circuit

Although the TLC27L2 and TLC27L7 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 ( $R_P$ ) 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.

APPLICATION INFORMATION

output characteristics (continued)

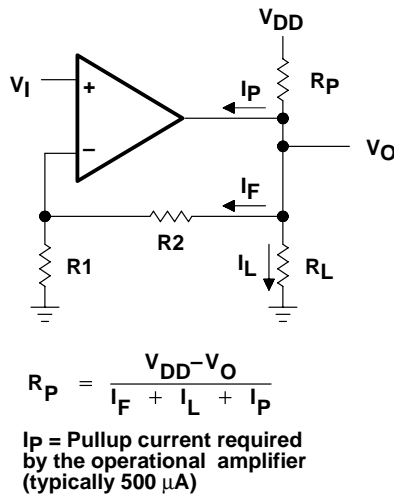


Figure 42. Resistive Pullup to Increase  $V_{OH}$

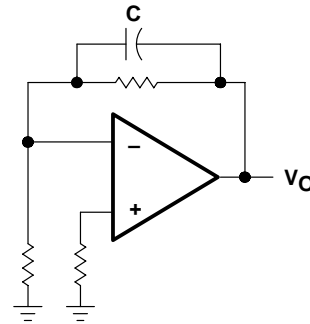


Figure 43. Compensation for Input Capacitance

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 TLC27L2 and TLC27L7 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 TLC27L2 and TLC27L7 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.

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.

APPLICATION INFORMATION

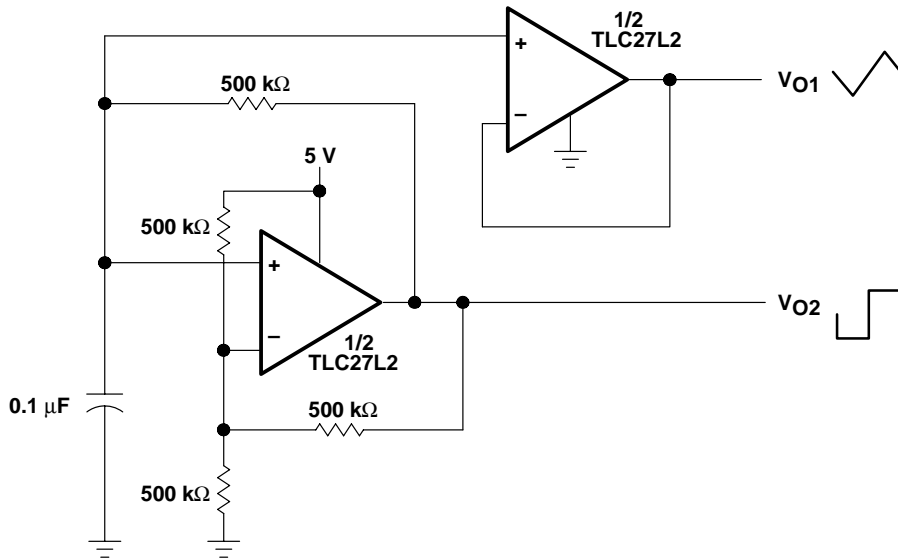
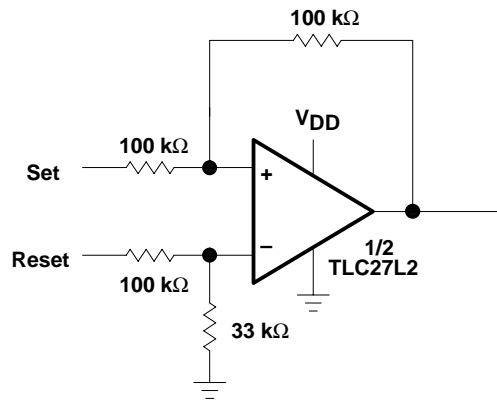


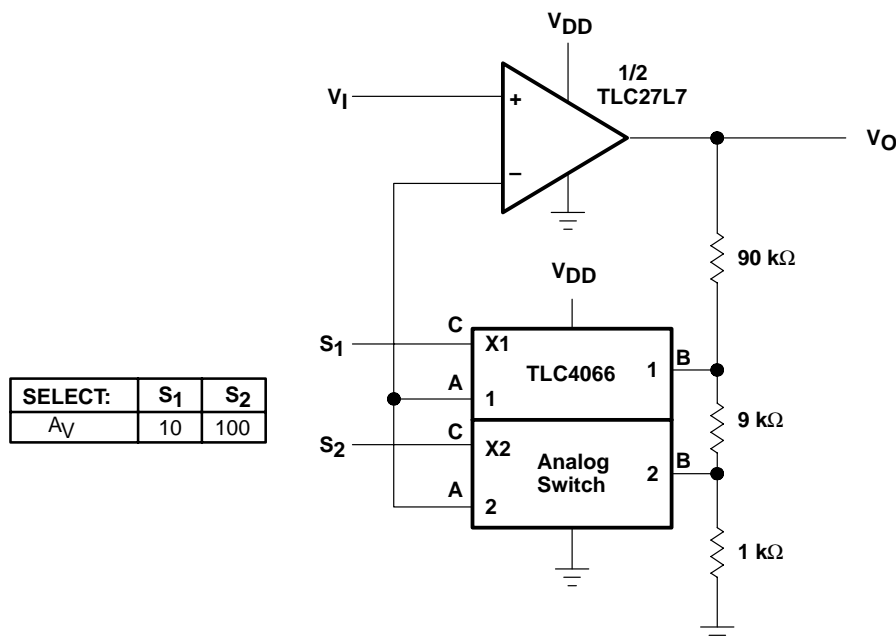
Figure 44. Multivibrator



NOTE: V<sub>DD</sub> = 5 V to 16 V

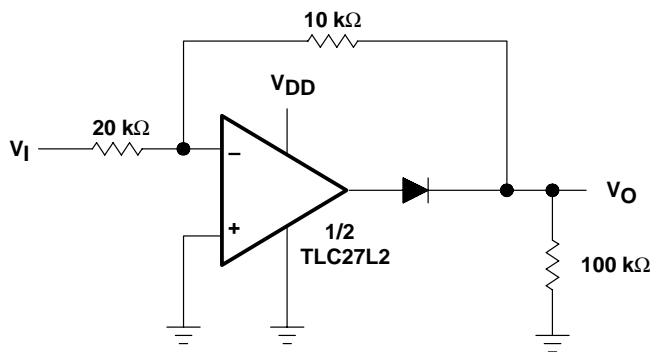
Figure 45. Set/Reset Flip-Flop

APPLICATION INFORMATION



NOTE: V<sub>DD</sub> = 5 V to 12 V

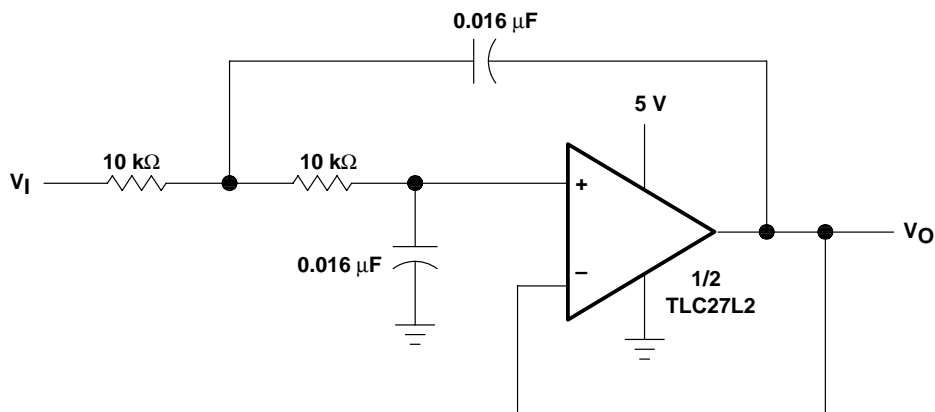
Figure 46. Amplifier With Digital Gain Selection



NOTE: V<sub>DD</sub> = 5 V to 16 V

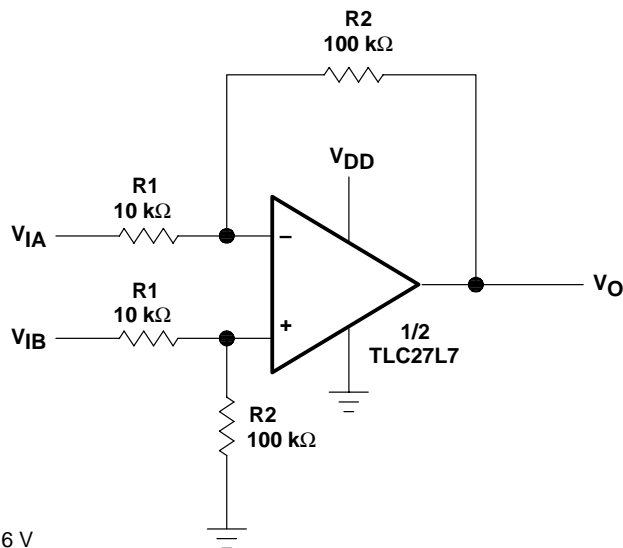
Figure 47. Full-Wave Rectifier

APPLICATION INFORMATION



NOTE: Normalized to  $f_c = 1 \text{ kHz}$  and  $R_L = 10 \text{ k}\Omega$

Figure 48. Two-Pole Low-Pass Butterworth Filter



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

$$V_O = \frac{R_2}{R_1}(V_{IB} - V_{IA})$$

Figure 49. Difference Amplifier



**PACKAGING INFORMATION**

| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup> | Lead/Ball Finish | MSL Peak Temp <sup>(3)</sup>              |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|---|
| 5962-89494032A   | OBSOLETE              | LCCC         | FK              | 20   |             | None                    | Call TI          | Call TI                                   |
| 5962-8949403PA   | OBSOLETE              | CDIP         | JG              | 8    |             | None                    | Call TI          | Call TI                                   |
| 5962-89494042A   | OBSOLETE              | LCCC         | FK              | 20   |             | None                    | Call TI          | Call TI                                   |
| 5962-8949404PA   | OBSOLETE              | CDIP         | JG              | 8    |             | None                    | Call TI          | Call TI                                   |
| TLC27L2ACD       | ACTIVE                | SOIC         | D               | 8    | 75          | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1YEAR/<br>Level-1-220C-UNLIM |
| TLC27L2ACDR      | ACTIVE                | SOIC         | D               | 8    | 2500        | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1YEAR/<br>Level-1-220C-UNLIM |
| TLC27L2ACP       | ACTIVE                | PDIP         | P               | 8    | 50          | Pb-Free (RoHS)          | CU NIPDAU        | Level-NC-NC-NC                            |
| TLC27L2ACPSLE    | OBSOLETE              | SO           | PS              | 8    |             | None                    | Call TI          | Call TI                                   |
| TLC27L2ACPSR     | ACTIVE                | SO           | PS              | 8    | 2000        | None                    | CU NIPDAU        | Level-1-220C-UNLIM                        |
| TLC27L2AID       | ACTIVE                | SOIC         | D               | 8    | 75          | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1YEAR/<br>Level-1-220C-UNLIM |
| TLC27L2AIDR      | ACTIVE                | SOIC         | D               | 8    | 2500        | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1YEAR/<br>Level-1-220C-UNLIM |
| TLC27L2AIP       | ACTIVE                | PDIP         | P               | 8    | 50          | Pb-Free (RoHS)          | CU NIPDAU        | Level-NC-NC-NC                            |
| TLC27L2AMFKB     | OBSOLETE              | LCCC         | FK              | 20   |             | None                    | Call TI          | Call TI                                   |
| TLC27L2AMJG      | OBSOLETE              | CDIP         | JG              | 8    |             | None                    | Call TI          | Call TI                                   |
| TLC27L2AMJGB     | OBSOLETE              | CDIP         | JG              | 8    |             | None                    | Call TI          | Call TI                                   |
| TLC27L2BCD       | ACTIVE                | SOIC         | D               | 8    | 75          | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1YEAR/<br>Level-1-220C-UNLIM |
| TLC27L2BCDR      | ACTIVE                | SOIC         | D               | 8    | 2500        | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1YEAR/<br>Level-1-220C-UNLIM |
| TLC27L2BCP       | ACTIVE                | PDIP         | P               | 8    | 50          | Pb-Free (RoHS)          | CU NIPDAU        | Level-NC-NC-NC                            |
| TLC27L2BID       | ACTIVE                | SOIC         | D               | 8    | 75          | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1YEAR/<br>Level-1-220C-UNLIM |
| TLC27L2BIDR      | ACTIVE                | SOIC         | D               | 8    | 2500        | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1YEAR/<br>Level-1-220C-UNLIM |
| TLC27L2BIP       | ACTIVE                | PDIP         | P               | 8    | 50          | Pb-Free (RoHS)          | CU NIPDAU        | Level-NC-NC-NC                            |
| TLC27L2CD        | ACTIVE                | SOIC         | D               | 8    | 75          | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1YEAR/<br>Level-1-220C-UNLIM |
| TLC27L2CDR       | ACTIVE                | SOIC         | D               | 8    | 2500        | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1YEAR/<br>Level-1-220C-UNLIM |
| TLC27L2CP        | ACTIVE                | PDIP         | P               | 8    | 50          | Pb-Free (RoHS)          | CU NIPDAU        | Level-NC-NC-NC                            |
| TLC27L2CPSR      | ACTIVE                | SO           | PS              | 8    | 2000        | None                    | CU NIPDAU        | Level-1-220C-UNLIM                        |
| TLC27L2CPW       | ACTIVE                | TSSOP        | PW              | 8    | 150         | None                    | CU NIPDAU        | Level-1-220C-UNLIM                        |
| TLC27L2CPWLE     | OBSOLETE              | TSSOP        | PW              | 8    |             | None                    | Call TI          | Call TI                                   |
| TLC27L2CPWR      | ACTIVE                | TSSOP        | PW              | 8    | 2000        | None                    | CU NIPDAU        | Level-1-220C-UNLIM                        |
| TLC27L2ID        | ACTIVE                | SOIC         | D               | 8    | 75          | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1YEAR/<br>Level-1-220C-UNLIM |
| TLC27L2IDR       | ACTIVE                | SOIC         | D               | 8    | 2500        | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1YEAR/<br>Level-1-220C-UNLIM |

| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup> | Lead/Ball Finish | MSL Peak Temp <sup>(3)</sup>              |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|---|
| TLC27L2IP        | ACTIVE                | PDIP         | P               | 8    | 50          | Pb-Free (RoHS)          | CU NIPDAU        | Level-NC-NC-NC                            |
| TLC27L2IPW       | ACTIVE                | TSSOP        | PW              | 8    | 150         | None                    | CU NIPDAU        | Level-1-220C-UNLIM                        |
| TLC27L2IPWLE     | OBSOLETE              | TSSOP        | PW              | 8    |             | None                    | Call TI          | Call TI                                   |
| TLC27L2IPWR      | ACTIVE                | TSSOP        | PW              | 8    | 2000        | None                    | CU NIPDAU        | Level-1-220C-UNLIM                        |
| TLC27L2MD        | ACTIVE                | SOIC         | D               | 8    | 75          | None                    | CU NIPDAU        | Level-1-220C-UNLIM                        |
| TLC27L2MDR       | ACTIVE                | SOIC         | D               | 8    | 2500        | None                    | CU NIPDAU        | Level-1-220C-UNLIM                        |
| TLC27L2MFKB      | OBSOLETE              | LCCC         | FK              | 20   |             | None                    | Call TI          | Call TI                                   |
| TLC27L2MJG       | OBSOLETE              | CDIP         | JG              | 8    |             | None                    | Call TI          | Call TI                                   |
| TLC27L2MJGB      | OBSOLETE              | CDIP         | JG              | 8    |             | None                    | Call TI          | Call TI                                   |
| TLC27L7CD        | ACTIVE                | SOIC         | D               | 8    | 75          | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1YEAR/<br>Level-1-220C-UNLIM |
| TLC27L7CDR       | ACTIVE                | SOIC         | D               | 8    | 2500        | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1YEAR/<br>Level-1-220C-UNLIM |
| TLC27L7CP        | ACTIVE                | PDIP         | P               | 8    | 50          | Pb-Free (RoHS)          | CU NIPDAU        | Level-NC-NC-NC                            |
| TLC27L7CPSR      | ACTIVE                | SO           | PS              | 8    | 2000        | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1YEAR/<br>Level-1-220C-UNLIM |
| TLC27L7ID        | ACTIVE                | SOIC         | D               | 8    | 75          | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1YEAR/<br>Level-1-220C-UNLIM |
| TLC27L7IDR       | ACTIVE                | SOIC         | D               | 8    | 2500        | Pb-Free (RoHS)          | CU NIPDAU        | Level-2-260C-1YEAR/<br>Level-1-220C-UNLIM |
| TLC27L7IP        | ACTIVE                | PDIP         | P               | 8    | 50          | Pb-Free (RoHS)          | CU NIPDAU        | Level-NC-NC-NC                            |
| TLC27L7MFKB      | OBSOLETE              | LCCC         | FK              | 20   |             | None                    | Call TI          | Call TI                                   |
| TLC27L7MJG       | OBSOLETE              | CDIP         | JG              | 8    |             | None                    | Call TI          | Call TI                                   |
| TLC27L7MJGB      | OBSOLETE              | CDIP         | JG              | 8    |             | None                    | Call TI          | Call TI                                   |

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

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

<sup>(2)</sup> Eco Plan - May not be currently available - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**None:** Not yet available Lead (Pb-Free).

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

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

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| Interface        | <a href="http://interface.ti.com">interface.ti.com</a>             | Digital Control     | <a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a> |
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| Power Mgmt       | <a href="http://power.ti.com">power.ti.com</a>                     | Optical Networking  | <a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a> |
| Microcontrollers | <a href="http://microcontroller.ti.com">microcontroller.ti.com</a> | Security            | <a href="http://www.ti.com/security">www.ti.com/security</a>             |
|                  |  | Telephony           | <a href="http://www.ti.com/telephony">www.ti.com/telephony</a>           |
|                  |  | Video & Imaging     | <a href="http://www.ti.com/video">www.ti.com/video</a>                   |
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