

- Power Dissipation as Low as 10 μ W Typ Per Amplifier
- Operates on a Single Silver-Oxide Watch Battery, $V_{DD} = 1.4$ V Min
- $V_{IO} \dots 450 \mu$ V/850 μ V Max in DIP and Small-Outline Package (TLC1078/79)
- Input Offset Voltage Drift $\dots 0.1 \mu$ V/Month Typ, Including the First 30 Days
- High-impedance LinCMOS™ Inputs
 $I_{IB} = 0.6$ pA Typ
- High Open-Loop Gain $\dots 800000$ Typ
- Output Drive Capability > 20 mA
- Slew Rate $\dots 47$ V/ms Typ
- Common-Mode Input Voltage Range Extends Below the Negative Rail
- Output Voltage Range Includes Negative Rail
- On-Chip ESD-Protection Circuitry
- Small-Outline Package Option Also Available in Tape and Reel

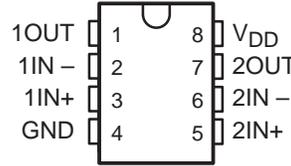
description

The TLC107x operational amplifiers offer ultra-low offset voltage, high gain, 110-kHz bandwidth, 47-V/ms slew rate, and just 150- μ W power dissipation per amplifier.

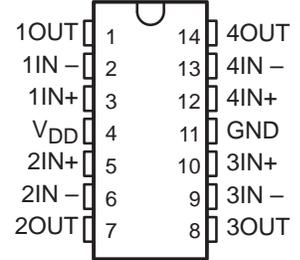
With a supply voltage of 1.4 V, common-mode input to the negative rail, and output swing to the negative rail, the TLC107xQ is an ideal solution for low-voltage battery-operated systems. The 20-mA output drive capability means that the TLC107x can easily drive small resistive and large capacitive loads when needed, while maintaining ultra-low standby power dissipation.

Since this device is functionally compatible as well as pin compatible with the TLC27L2/4 and TLC27L7/9, the TLC107x easily upgrades existing designs that can benefit from its improved performance.

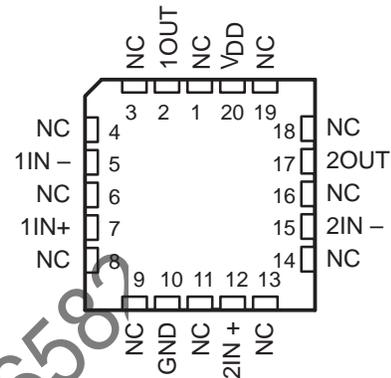
TLC1078
D, JG, OR P PACKAGE
(TOP VIEW)



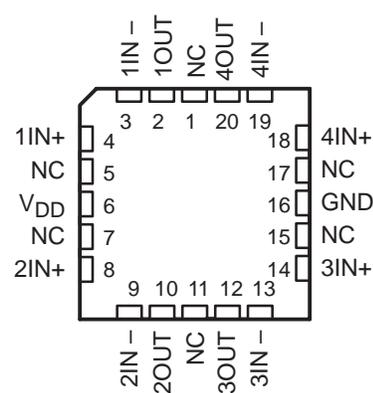
TLC1079
D, J, OR N PACKAGE
(TOP VIEW)



TLC1078
FK PACKAGE
(TOP VIEW)



TLC1079
FK PACKAGE
(TOP VIEW)



NC – No internal connection



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PRODUCTION DATA Information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.



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description (continued)

The TLC107x incorporates internal ESD-protection circuits that will prevent functional failures at voltages up to 2000 V as tested under MIL-PRF-38535, Method 3015.2; however, care should be exercised when handling these devices as exposure to ESD may result in degradation of the device parametric performance. The TLC107x design also inhibits latch-up of the device inputs and outputs even with surge currents as large 100 mA.

The C-suffix devices are characterized for operation from 0°C to 70°C. The I-suffix devices are characterized for operation from -40°C to 85°C. The M-suffix devices are characterized for operation over the full military temperature range of -55°C to 125°C. The wide range of packaging options includes small-outline and chip-carrier versions for high-density system applications.

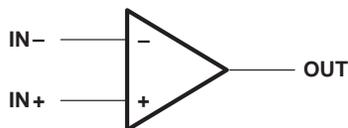
AVAILABLE OPTIONS

| T _A | PACKAGED DEVICES | | | | | | CHIP FORM‡ (Y) |
|----------------|------------------------|--------------------------|-----------------|------------------|-----------------|-----------------|----------------------|
| | SMALL OUTLINE† (D) | CHIP CARRIER (FK) | CERAMIC DIP (J) | CERAMIC DIP (JG) | PLASTIC DIP (N) | PLASTIC DIP (P) | |
| 0°C to 70°C | TLC1078CD TLC1079CD | — | — | — | TLC1079CN | TLC1078CP | TLC1078Y TLC1079Y |
| -40°C to 85°C | TLC1078ID TLC1079ID | — | — | — | TLC1079IN | TLC1078IP | — |
| -55°C to 125°C | TLC1078MD TLC1079MD | TLC1078MFK TLC1079MFK | TLC1079MJ | TLC1078MJG | TLC1079MN | TLC1078MP | — |

† The D package is available taped and reeled. Add the suffix R to the device type (e.g., TLC1078CDR).

‡ Chip forms are tested 25°C only.

symbol (each amplifier)



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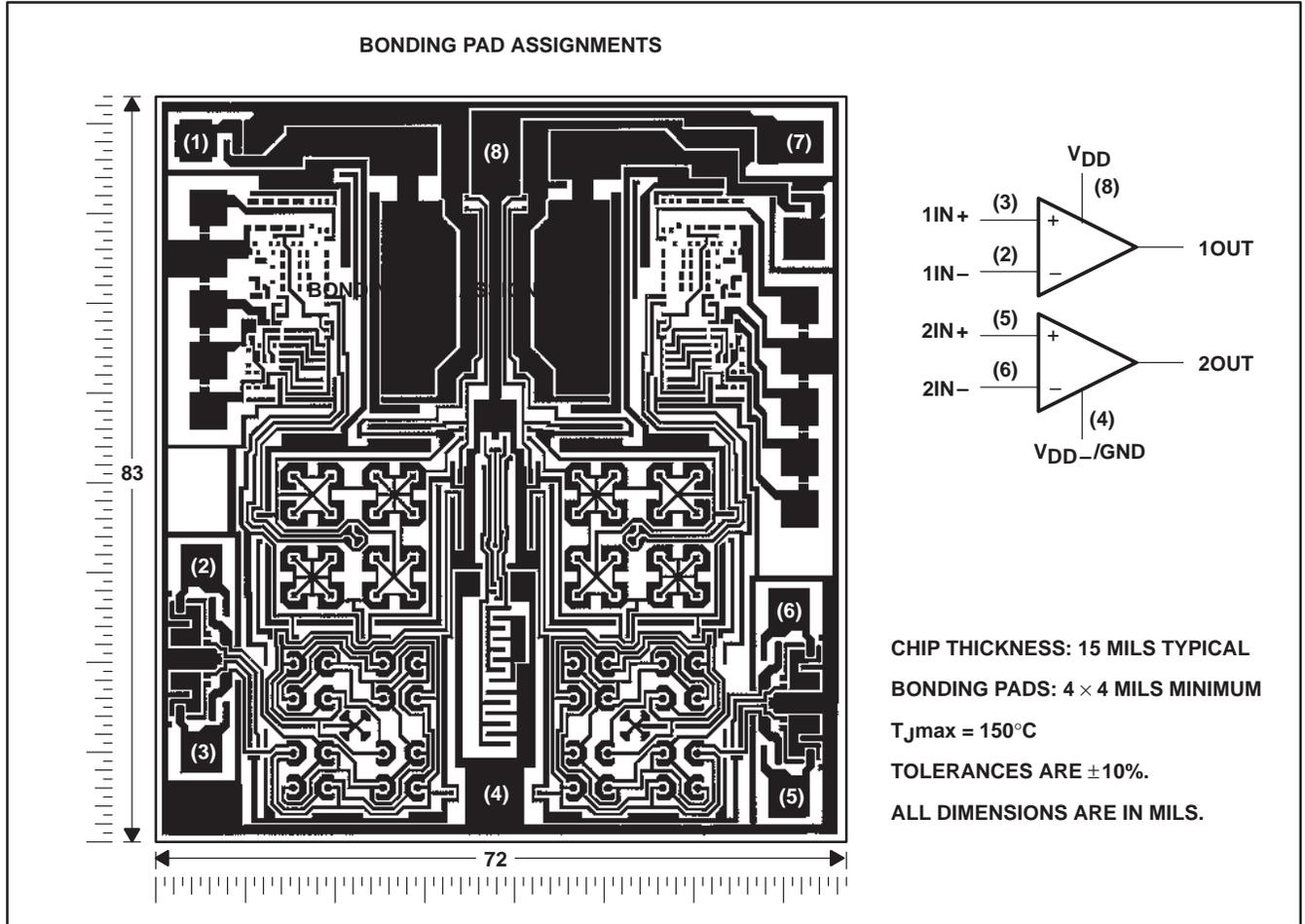
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TLC1087Y chip information

This chip, when properly assembled, displays characteristics similar to the TLC1078C. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. Chips can be mounted with conductive epoxy or a gold-silicon preform.



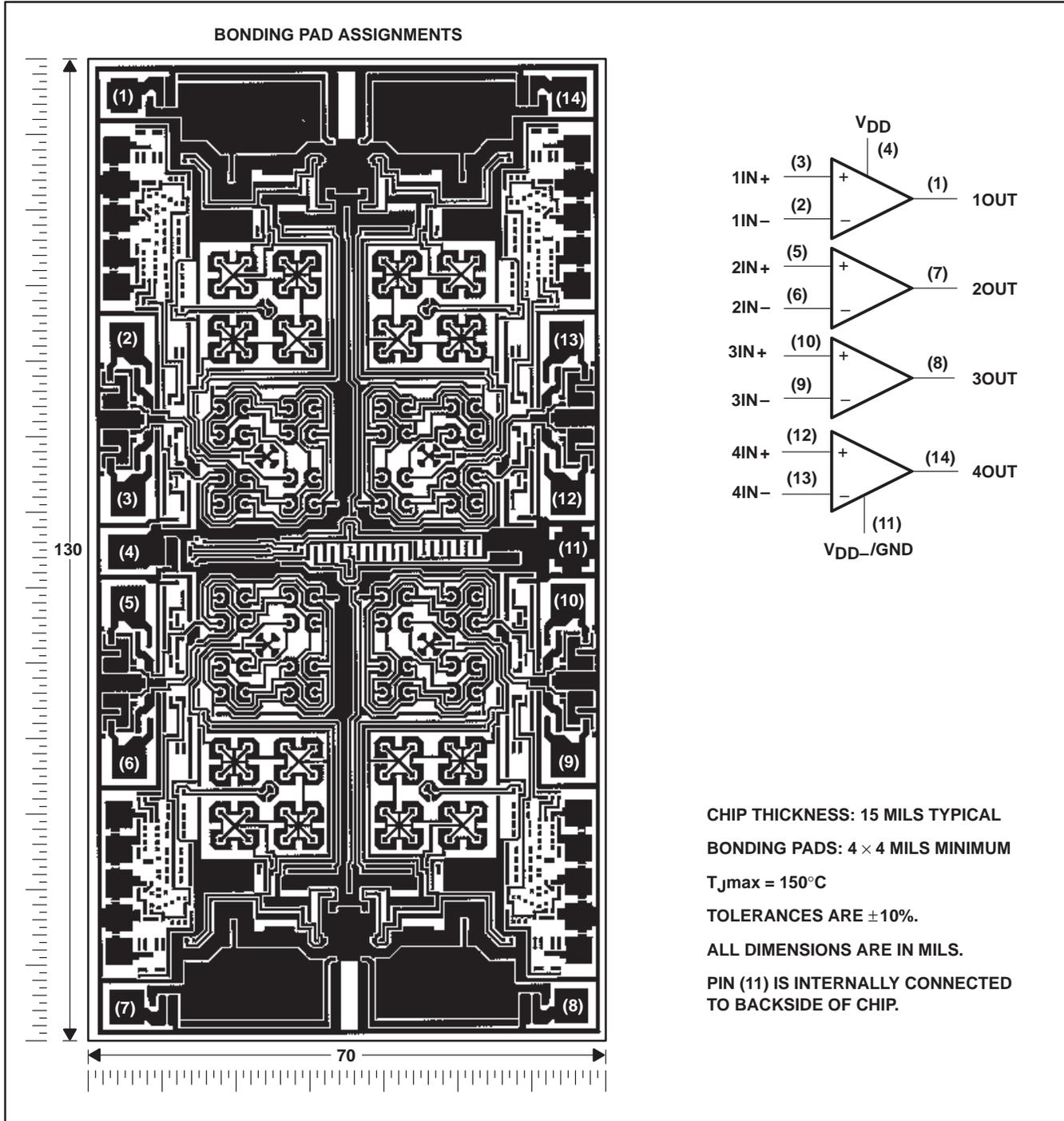
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TLC1079Y chip information

This chip, when properly assembled, display characteristics similar to the TLC1079C. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. Chips can be mounted with conductive epoxy or a gold-silicon preform.

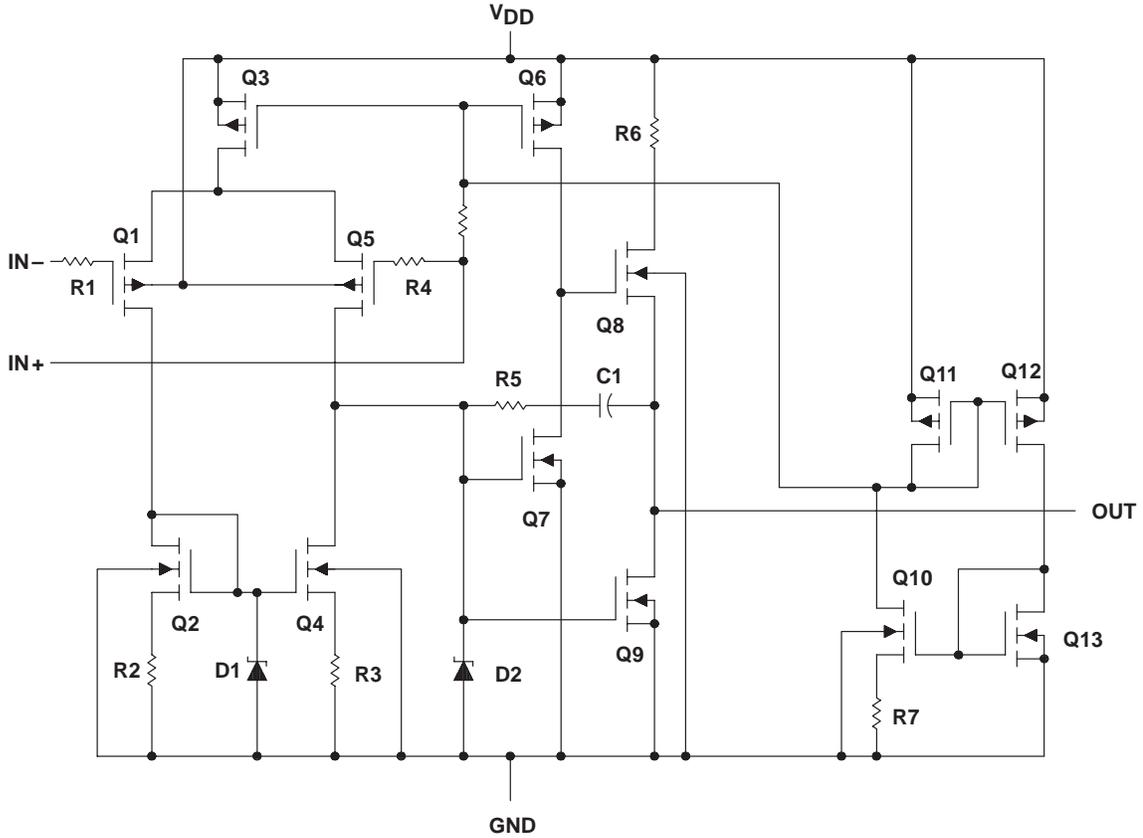


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equivalent schematic (each amplifier)



| ACTUAL DEVICE COMPONENT COUNT | | |
|-------------------------------|---------|---------|
| COMPONENT | TLC1078 | TLC1079 |
| Transistors | 38 | 76 |
| Resistors | 16 | 32 |
| Diodes | 12 | 24 |
| Capacitors | 2 | 4 |

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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, V_{ID} (see Note 2) | $\pm V_{DD}$ |
| Input voltage range, V_I (any input) | -0.3 V to V_{DD} |
| Input current, I_I (each input) | ± 5 mA |
| Output current, I_O (each output) | ± 30 mA |
| Total current into V_{DD} (see Note 3) | 45 mA |
| Duration of short-circuit at (or below) $T_A = 25^\circ\text{C}$ (see Note 3) | unlimited |
| Continuous total power dissipation | see Dissipation Rating Table |
| Operating free-air temperature range, 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 ratings are not exceeded.

DISSIPATION RATING TABLE

| PACKAGE | $T_A \leq 25^\circ\text{C}$ POWER RATING | DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$ | $T_A = 70^\circ\text{C}$ POWER RATING | $T_A = 85^\circ\text{C}$ POWER RATING | $T_A = 125^\circ\text{C}$ POWER RATING |
|---------|---|---|--|--|---|
| D-8 | 725 mW | 5.8 mW/ $^\circ\text{C}$ | 464 mW | 377 mW | 145 mW |
| D-14 | 950 mW | 7.6 mW/ $^\circ\text{C}$ | 608 mW | 494 mW | 190 mW |
| FK | 1375 mW | 11.0 mW/ $^\circ\text{C}$ | 880 mW | 715 mW | 275 mW |
| J | 1375 mW | 11.0 mW/ $^\circ\text{C}$ | 880 mW | 715 mW | 275 mW |
| JG | 1050 mW | 8.4 mW/ $^\circ\text{C}$ | 672 mW | 546 mW | 210 mW |
| N | 1150 mW | 9.2 mW/ $^\circ\text{C}$ | 736 mW | 598 mW | 230 mW |
| P | 1000 mW | 8.0 mW/ $^\circ\text{C}$ | 640 mW | 520 mW | 200 mW |

recommended operating conditions

| | C SUFFIX | | I SUFFIX | | M SUFFIX | | UNIT |
|---------------------------------------|-----------------|-----|----------|-----|----------|-----|------------------|
| | MIN | MAX | MIN | MAX | MIN | MAX | |
| Supply voltage, V_{DD} | 1.4 | 16 | 3 | 16 | 4 | 16 | V |
| Common-mode input voltage, V_{IC} | $V_{DD} = 5$ V | | -0.2 | 4 | -0.2 | 4 | V |
| | $V_{DD} = 10$ V | | -0.2 | 9 | -0.2 | 9 | |
| Operating free-air temperature, T_A | 0 | 70 | -40 | 85 | -55 | 125 | $^\circ\text{C}$ |

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electrical characteristics at specified free-air temperature

| PARAMETER | TEST CONDITIONS | T _A † | TLC1078C | | | | | | UNIT |
|--------------------------|--|--|-----------------------|-------------|-------------|------------------------|-------------|-------------|------------|
| | | | V _{DD} = 5 V | | | V _{DD} = 10 V | | | |
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| V _{IO} | Input offset voltage | V _O = 1.4 V, R _S = 50 Ω , Full range | 25°C | 160 | 450 | | 180 | 600 | μ V |
| α V _{IO} | Temperature coefficient of input offset voltage | V _O = 0, R _I = 1 M Ω | 25°C to 70°C | 1.1 | | | 1 | | μ V/°C |
| I _{IO} | Input offset current (see Note 4) | V _O = V _{DD} /2, V _{IC} = V _{DD} /2 | 25°C | 0.1 | | | 0.1 | | pA |
| I _{IB} | Input bias current (see Note 4) | | 70°C | 7 | 300 | | 7 | 300 | pA |
| V _{ICR} | Common-mode input voltage range (see Note 5) | | 25°C | -0.2 to 4 | -0.3 to 4.2 | | -0.2 to 9 | -0.3 to 9.2 | V |
| | | | Full range | -0.2 to 3.5 | | | -0.2 to 8.5 | | V |
| V _{OH} | High-level output voltage | V _{ID} = 100 mV, R _L = 1 M Ω | 25°C | 3.2 | 4.1 | | 8.2 | 8.9 | V |
| | | | 0°C | 3.2 | 4.1 | | 8.2 | 8.9 | |
| | | | 70°C | 3.2 | 4.2 | | 8.2 | 8.9 | |
| V _{OL} | Low-level output voltage | V _{ID} = -100 mV, I _{OL} = 0 | 25°C | 0 25 | | | 0 25 | | mV |
| | | | 0°C | 0 25 | | | 0 25 | | |
| | | | 70°C | 0 25 | | | 0 25 | | |
| A _{VD} | Large-signal differential voltage amplification | R _L = 1 M Ω , See Note 6 | 25°C | 250 | 525 | | 500 | 850 | V/mV |
| | | | 0°C | 250 | 680 | | 500 | 1010 | |
| | | | 70°C | 200 | 380 | | 350 | 660 | |
| CMRR | Common-mode rejection ratio | V _{IC} = V _{ICRmin} | 25°C | 70 | 95 | | 75 | 97 | dB |
| | | | 0°C | 70 | 95 | | 75 | 97 | |
| | | | 70°C | 70 | 95 | | 75 | 97 | |
| k _{SVR} | Supply-voltage rejection ratio (Δ V _{DD} / Δ V _{IO}) | V _O = 1.4 V | 25°C | 75 | 98 | | 75 | 98 | dB |
| | | | 0°C | 75 | 98 | | 75 | 98 | |
| | | | 70°C | 75 | 98 | | 75 | 98 | |
| I _{DD} | Supply current (two amplifiers) | V _O = V _{DD} /2, V _{IC} = V _{DD} /2, No load | 25°C | 20 | 34 | | 29 | 46 | μ A |
| | | | 0°C | 24 | 42 | | 36 | 66 | |
| | | | 70°C | 16 | 28 | | 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.
 6. At V_{DD} = 5 V, V_O = 0.25 V to 2 V; at V_{DD} = 10 V, V_O = 1 V to 6 V.

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electrical characteristics at specified free-air temperature

| PARAMETER | TEST CONDITIONS | T_A † | TLC1079C | | | | | | UNIT |
|--|---|--------------|-----------------------|-------------|------|------------------------|-------------|---------------|------------------------------|
| | | | $V_{DD} = 5\text{ V}$ | | | $V_{DD} = 10\text{ V}$ | | | |
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| V_{IO} Input offset voltage | $V_O = 1.4\text{ V}, V_{IC} = 0,$ $R_S = 50\ \Omega, R_I = 1\text{ M}\Omega$ | 25°C | 190 | 850 | | 200 | 1150 | μV | |
| Full range | | | 1200 | | 1500 | | | | |
| α_{VIO} Temperature coefficient of input offset voltage | | 25°C to 70°C | 1.1 | | | 1 | | | $\mu\text{V}/^\circ\text{C}$ |
| I_{IO} Input offset current (see Note 4) | $V_O = V_{DD}/2,$ $V_{IC} = V_{DD}/2$ | 25°C | 0.1 | | | 0.1 | | | pA |
| | | 70°C | 7 | 300 | | 7 | 300 | | |
| I_{IB} Input bias current (see Note 4) | | 25°C | 0.6 | | | 0.7 | | | pA |
| | 70°C | 40 | 600 | | 50 | 600 | | | |
| V_{ICR} Common mode input voltage range (see Note 5) | | 25°C | -0.2 to 4 | -0.3 to 4.2 | | -0.2 to 9 | -0.3 to 9.2 | V | |
| | | Full range | -0.2 to 3.5 | | | -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 | 3.2 | 4.1 | | 8.2 | 8.9 | V | |
| | | 0°C | 3.2 | 4.1 | | 8.2 | 8.9 | | |
| | | 70°C | 3.2 | 4.2 | | 8.2 | 8.9 | | |
| V_{OL} Low-level output voltage | $V_{ID} = -100\text{ mV},$ $I_{OL} = 0$ | 25°C | 0 25 | | | 0 25 | | | mV |
| | | 0°C | 0 25 | | | 0 25 | | | |
| | | 70°C | 0 25 | | | 0 25 | | | |
| A_{VD} Large-signal differential voltage amplification | $R_L = 1\text{ M}\Omega,$ See Note 6 | 25°C | 250 | 525 | | 500 | 850 | V/mV | |
| | | 0°C | 250 | 700 | | 500 | 1010 | | |
| | | 70°C | 200 | 380 | | 350 | 660 | | |
| CMRR Common mode rejection ratio | $V_{IC} = V_{ICRmin}$ | 25°C | 70 | 95 | | 75 | 97 | dB | |
| | | 0°C | 70 | 95 | | 75 | 97 | | |
| | | 70°C | 70 | 95 | | 75 | 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 | 75 | 98 | | 75 | 98 | dB | |
| | | 0°C | 75 | 98 | | 75 | 98 | | |
| | | 70°C | 75 | 98 | | 75 | 98 | | |
| I_{DD} Supply current (four amplifiers) | $V_O = V_{DD}/2,$ $V_{IC} = V_{DD}/2,$ No load | 25°C | 40 68 | | | 57 92 | | | μA |
| | | 0°C | 48 84 | | | 72 132 | | | |
| | | 70°C | 31 56 | | | 44 80 | | | |

† Full range is 0°C to 70°C.

NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.

5. This range also applies to each input individually.

6. At $V_{DD} = 5\text{ V}, V_O = 0.25\text{ V to }2\text{ V};$ at $V_{DD} = 10\text{ V}, V_O = 1\text{ V to }6\text{ V}.$

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operating characteristics at specified free-air temperature

| PARAMETER | TEST CONDITIONS | T_A | TLC1078C | | | | | | UNIT |
|--------------------------------------|--|-------|-----------------------|-----|-----|------------------------|-----|------------------------|------|
| | | | $V_{DD} = 5\text{ V}$ | | | $V_{DD} = 10\text{ V}$ | | | |
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SR Slew rate at unity gain | $R_L = 1\text{ M}\Omega$, $C_L = 20\text{ pF}$, $V_{I(PP)} = 1\text{ V}$, See Figure 1 | 25°C | | 32 | | | 47 | V/ms | |
| | | 0°C | | 35 | | | 51 | | |
| | | 70°C | | 27 | | | 38 | | |
| V_n Equivalent input noise voltage | $f = 1\text{ kHz}$, $R_S = 20\ \Omega$ | 25°C | | 68 | | | 68 | nV/ $\sqrt{\text{Hz}}$ | |
| B_1 Unity-gain bandwidth | $C_L = 20\text{ pF}$, See Figure 2 | 25°C | | 85 | | | 110 | kHz | |
| | | 0°C | | 100 | | | 125 | | |
| | | 70°C | | 65 | | | 90 | | |
| ϕ_m Phase margin at unity gain | $C_L = 20\text{ pF}$, See Figure 2 | 25°C | | 34° | | | 38° | | |
| | | 0°C | | 36° | | | 40° | | |
| | | 70°C | | 30° | | | 34° | | |

operating characteristics at specified free-air temperature

| PARAMETER | TEST CONDITIONS | T_A | TLC1079C | | | | | | UNIT |
|--------------------------------------|--|-------|-----------------------|-----|-----|------------------------|-----|------------------------|------|
| | | | $V_{DD} = 5\text{ V}$ | | | $V_{DD} = 10\text{ V}$ | | | |
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SR Slew rate at unity gain | $R_L = 1\text{ M}\Omega$, $C_L = 20\text{ pF}$, $V_{I(PP)} = 1\text{ V}$, See Figure 1 | 25°C | | 32 | | | 47 | V/ms | |
| | | 0°C | | 35 | | | 51 | | |
| | | 70°C | | 27 | | | 38 | | |
| V_n Equivalent input noise voltage | $f = 1\text{ kHz}$, $R_S = 20\ \Omega$ | 25°C | | 68 | | | 68 | nV/ $\sqrt{\text{Hz}}$ | |
| B_1 Unity-gain bandwidth | $C_L = 20\text{ pF}$, See Figure 2 | 25°C | | 85 | | | 110 | kHz | |
| | | 0°C | | 100 | | | 125 | | |
| | | 70°C | | 65 | | | 90 | | |
| ϕ_m Phase margin at unity gain | $C_L = 20\text{ pF}$, See Figure 2 | 25°C | | 34° | | | 38° | | |
| | | 0°C | | 36° | | | 40° | | |
| | | 70°C | | 30° | | | 34° | | |

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electrical characteristics at specified free-air temperature

| PARAMETER | TEST CONDITIONS | T _A † | TLC1078I | | | | | | UNIT |
|------------------|--|---|-----------------------|-------------|-------------|------------------------|-------------|-------------|-------|
| | | | V _{DD} = 5 V | | | V _{DD} = 10 V | | | |
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| V _{IO} | Input offset voltage | V _O = 1.4 V, R _S = 50 Ω, V _{IC} = 0, R _I = 1 MΩ | 25°C | 160 | 450 | | 180 | 600 | μV |
| α _{VIO} | Temperature coefficient of input offset voltage | | Full range | 950 | | | 1100 | | μV/°C |
| I _{IO} | Input offset current (see Note 4) | V _O = V _{DD} /2, V _{IC} = V _{DD} /2 | 25°C | 0.1 | | | 0.1 | | pA |
| | 85°C | | 24 | 1000 | 26 | 1000 | | | |
| I _{IB} | Input bias current (see Note 4) | | 25°C | 0.6 | | | 0.7 | | pA |
| | 85°C | 200 | 2000 | 220 | 2000 | | | | |
| V _{ICR} | Common-mode input voltage range (see Note 5) | | 25°C | -0.2 to 4 | -0.3 to 4.2 | | -0.2 to 9 | -0.3 to 9.2 | V |
| | | | Full range | -0.2 to 3.5 | | | -0.2 to 8.5 | | V |
| V _{OH} | High-level output voltage | V _{ID} = 100 mV, R _L = 1 MΩ | 25°C | 3.2 | 4.1 | | 8.2 | 8.9 | V |
| | | | -40°C | 3.2 | 4.1 | | 8.2 | 8.9 | |
| | | | 85°C | 3.2 | 4.2 | | 8.2 | 8.9 | |
| V _{OL} | Low-level output voltage | V _{ID} = -100 mV, I _{OL} = 0 | 25°C | 0 25 | | | 0 25 | | mV |
| | | | -40°C | 0 25 | | | 0 25 | | |
| | | | 85°C | 0 25 | | | 0 25 | | |
| AVD | Large-signal differential voltage amplification | R _L = 1 MΩ, See Note 6 | 25°C | 250 | 525 | | 500 | 850 | V/mV |
| | | | -40°C | 250 | 900 | | 500 | 1550 | |
| | | | 85°C | 150 | 300 | | 250 | 585 | |
| CMRR | Common-mode rejection ratio | V _{IC} = V _{ICR} min | 25°C | 70 | 95 | | 75 | 97 | dB |
| | | | -40°C | 70 | 95 | | 75 | 97 | |
| | | | 85°C | 70 | 95 | | 75 | 97 | |
| k _{SVR} | Supply-voltage rejection ratio (ΔV _{DD} /ΔV _{IO}) | V _O = 1.4 V | 25°C | 75 | 98 | | 75 | 98 | dB |
| | | | -40°C | 75 | 98 | | 75 | 98 | |
| | | | 85°C | 75 | 98 | | 75 | 98 | |
| I _{DD} | Supply current (two amplifiers) | V _O = V _{DD} /2, V _{IC} = V _{DD} /2, No load | 25°C | 20 | 34 | | 29 | 46 | μA |
| | | | -40°C | 31 54 | | | 50 86 | | |
| | | | 85°C | 15 26 | | | 20 36 | | |

† Full range is -40°C to 80°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.

6. At V_{DD} = 5 V, V_O = 0.25 V to 2 V; at V_{DD} = 10 V, V_O = 1 V to 6 V.

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electrical characteristics at specified free-air temperature

| PARAMETER | TEST CONDITIONS | TA† | TLC1079I | | | | | | UNIT |
|--------------------------|---|---|--------------|-------------|-------------|-------------|-------------|------------|------|
| | | | VDD = 5 V | | | VDD = 10 V | | | |
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| V _{IO} | Input offset voltage | V _O = 1.4 V, V _{IC} = 0, R _S = 50 Ω , R _I = 1 M Ω | 25°C | 190 850 | | 200 1150 | | μ V | |
| | | Full range | 1350 | | 1650 | | | | |
| α V _{IO} | Temperature coefficient of input offset voltage | | 25°C to 85°C | 1.1 | | 1 | | μ V/°C | |
| I _{IO} | Input offset current (see Note 4) | V _O = V _{DD} / 2, V _{IC} = V _{DD} / 2 | 25°C | 0.1 | | 0.1 | | pA | |
| | | | 85°C | 24 | 1000 | 26 | 1000 | | |
| I _{IB} | Input bias current (see Note 4) | | 25°C | 0.6 | | 0.7 | | pA | |
| | | | 85°C | 200 | 2000 | 220 | 2000 | | |
| V _{ICR} | Common-mode input voltage range (see Note 5) | | 25°C | -0.2 to 4 | -0.3 to 4.2 | -0.2 to 9 | -0.3 to 9.2 | V | |
| | | | Full range | -0.2 to 3.5 | | -0.2 to 8.5 | | V | |
| V _{OH} | High-level output voltage | V _{ID} = 100 mV, R _L = 1 M Ω | 25°C | 3.2 | 4.1 | 8.2 | 8.9 | V | |
| | | | -40°C | 3.2 | 4.1 | 8.2 | 8.9 | | |
| | | | 85°C | 3.2 | 4.2 | 8.2 | 8.9 | | |
| V _{OL} | Low-level output voltage | V _{ID} = -100 mV, I _{OL} = 0 | 25°C | 0 25 | | 0 25 | | mV | |
| | | | -40°C | 0 25 | | 0 25 | | | |
| | | | 85°C | 0 25 | | 0 25 | | | |
| A _{VD} | Large-signal differential voltage amplification | R _L = 1 M Ω , See Note 6 | 25°C | 250 | 525 | 500 | 850 | V/mV | |
| | | | -40°C | 250 | 900 | 500 | 1550 | | |
| | | | 85°C | 150 | 330 | 250 | 585 | | |
| CMRR | Common-mode rejection ratio | V _{IC} = V _{ICRmin} | 25°C | 70 | 95 | 75 | 97 | dB | |
| | | | -40°C | 70 | 95 | 75 | 97 | | |
| | | | 85°C | 70 | 95 | 75 | 97 | | |
| k _{SVR} | Supply-voltage rejection ratio (Δ V _{DD} /ΔV _{IO}) | V _{DD} = 5 V to 10 V, V _O = 1.4 V | 25°C | 75 | 98 | 75 | 98 | dB | |
| | | | -40°C | 75 | 98 | 75 | 98 | | |
| | | | 85°C | 75 | 98 | 75 | 98 | | |
| I _{DD} | Supply current (four amplifiers) | V _O = V _{DD} / 2, V _{IC} = V _{DD} / 2, No load | 25°C | 40 68 | | 57 92 | | μ A | |
| | | | -40°C | 62 108 | | 98 172 | | | |
| | | | 85°C | 29 52 | | 40 72 | | | |

† Full range is -40°C to 85°C.

- NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.
 5. This range also applies to each input individually.
 6. At V_{DD} = 5 V, V_O = 0.25 V to 2 V; at V_{DD} = 10 V, V_O = 1 V to 6 V.

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operating characteristics at specified free-air temperature

| PARAMETER | TEST CONDITIONS | T _A | TLC1078I | | | | | | UNIT |
|---|--|----------------|-----------------------|-----|-----|------------------------|-----|-----|--------|
| | | | V _{DD} = 5 V | | | V _{DD} = 10 V | | | |
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SR Slew rate at unity gain | R _L = 1 MΩ, C _L = 20 pF, V _{I(PP)} = 1 V, See Figure 1 | 25°C | 32 | | | 47 | | | V/ms |
| | | -40°C | 39 | | | 59 | | | |
| | | 85°C | 25 | | | 34 | | | |
| V _n Equivalent input noise voltage | f = 1 kHz, R _S = 20 Ω | 25°C | 68 | | | 68 | | | nV/√Hz |
| B ₁ Unity-gain bandwidth | C _L = 20 pF, See Figure 2 | 25°C | 85 | | | 110 | | | kHz |
| | | -40°C | 130 | | | 155 | | | |
| | | 85°C | 55 | | | 80 | | | |
| φ _m Phase margin at unity gain | C _L = 20 pF, See Figure 2 | 25°C | 34° | | | 38° | | | |
| | | -40°C | 38° | | | 40° | | | |
| | | 85°C | 28° | | | 32° | | | |

operating characteristics at specified free-air temperature

| PARAMETER | TEST CONDITIONS | T _A | TLC1079I | | | | | | UNIT |
|---|--|----------------|-----------------------|-----|-----|------------------------|-----|-----|--------|
| | | | V _{DD} = 5 V | | | V _{DD} = 10 V | | | |
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SR Slew rate at unity gain | R _L = 1 MΩ, C _L = 20 pF, V _{I(PP)} = 1 V, See Figure 1 | 25°C | 32 | | | 47 | | | V/ms |
| | | -40°C | 39 | | | 59 | | | |
| | | 85°C | 25 | | | 34 | | | |
| V _n Equivalent input noise voltage | f = 1 kHz, R _S = 20 Ω | 25°C | 68 | | | 68 | | | nV/√Hz |
| B ₁ Unity-gain bandwidth | C _L = 20 pF, See Figure 2 | 25°C | 85 | | | 110 | | | kHz |
| | | -40°C | 130 | | | 155 | | | |
| | | 85°C | 55 | | | 80 | | | |
| φ _m Phase margin at unity gain | C _L = 20 pF, See Figure 2 | 25°C | 34° | | | 38° | | | |
| | | -40°C | 38° | | | 42° | | | |
| | | 85°C | 28° | | | 32° | | | |

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electrical characteristics at specified operating free-air temperature

| PARAMETER | TEST CONDITIONS | T _A † | TLC1078M | | | | | | UNIT | |
|--------------------------|--|--|-----------------------|-----|------|------------------------|--------|------|------|------------|
| | | | V _{DD} = 5 V | | | V _{DD} = 10 V | | | | |
| | | | MIN | TYP | MAX | MIN | TYP | MAX | | |
| V _{IO} | Input offset voltage | V _O = 1.4 V, V _{IC} = 0, R _S = 50 Ω , R _L = 1 M Ω | 25°C | | 160 | 450 | 180 | | 600 | μ V |
| α V _{IO} | Temperature coefficient of input offset voltage | | 25°C to 125°C | | 1.4 | | 1.4 | | | μ V/°C |
| I _{IO} | Input offset current (see Note 4) | V _O = V _{DD} /2, V _{IC} = V _{DD} /2 | 25°C | | 0.1 | | 0.1 | | | pA |
| I _{IB} | Input bias current (see Note 4) | | 125°C | | 1.4 | 15 | 1.8 | 15 | | nA |
| V _{ICR} | Common-mode input voltage range (see Note 5) | | 25°C | | 0 | -0.3 | 0 | -0.3 | | V |
| | | | Full range | | to 4 | | to 4.2 | | to 9 | |
| V _{OH} | High-level output voltage | V _{ID} = 100 mV, R _L = 1 M Ω | 25°C | | 3.2 | 4.1 | 8.2 | 8.9 | | V |
| | | | -55°C | | 3.2 | 4.1 | 8.2 | 8.8 | | |
| | | | 125°C | | 3.2 | 4.2 | 8.2 | 9 | | |
| V _{OL} | Low-level output voltage | V _{ID} = -100 mV, I _{OL} = 0 | 25°C | | 0 | 25 | 0 | 25 | | mV |
| | | | -55°C | | 0 | 25 | 0 | 25 | | |
| | | | 125°C | | 0 | 25 | 0 | 25 | | |
| A _{VD} | Large-signal differential voltage amplification | R _L = 1 M Ω , See Note 6 | 25°C | | 250 | 525 | 500 | 850 | | V/mV |
| | | | -55°C | | 250 | 950 | 500 | 1750 | | |
| | | | 125°C | | 35 | 200 | 75 | 380 | | |
| CMRR | Common-mode rejection ratio | V _{IC} = V _{ICRmin} | 25°C | | 70 | 95 | 75 | 97 | | dB |
| | | | -55°C | | 70 | 95 | 75 | 97 | | |
| | | | 125°C | | 70 | 85 | 75 | 91 | | |
| k _{SVR} | Supply-voltage rejection ratio (Δ V _{DD} / Δ V _{IO}) | V _O = 1.4 V | 25°C | | 75 | 98 | 75 | 98 | | dB |
| | | | -55°C | | 70 | 98 | 70 | 98 | | |
| | | | 125°C | | 70 | 98 | 70 | 98 | | |
| I _{DD} | Supply current (two amplifiers) | V _O = V _{DD} /2, V _{IC} = V _{DD} /2, No load | 25°C | | 20 | 34 | 29 | 46 | | μ A |
| | | | -55°C | | 35 | 60 | 56 | 96 | | |
| | | | 125°C | | 14 | 24 | 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.
 6. At V_{DD} = 5 V, V_O = 0.25 V to 2 V; at V_{DD} = 10 V, V_O = 1 V to 6 V.

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electrical characteristics at specified free-air temperature

| PARAMETER | TEST CONDITIONS | T_A † | TLC1079M | | | | | | UNIT |
|--|--|---------------|-----------------------|-------------|------|------------------------|-------------|---------------|------------------------------|
| | | | $V_{DD} = 5\text{ V}$ | | | $V_{DD} = 10\text{ V}$ | | | |
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| V_{IO} Input offset voltage | $V_O = 1.4\text{ V}$, $V_{IC} = 0$, $R_S = 50\ \Omega$, $R_I = 1\text{ M}\Omega$ | 25°C | 190 | 850 | | 200 | 1150 | μV | |
| Full range | | | 1600 | | 1900 | | | | |
| α_{VIO} Temperature coefficient of input offset voltage | | 25°C to 125°C | 1.4 | | | 1.4 | | | $\mu\text{V}/^\circ\text{C}$ |
| I_{IO} Input offset current (see Note 4) | $V_O = V_{DD}/2$, $V_{IC} = V_{DD}/2$ | 25°C | 0.1 | | | 0.1 | | | pA |
| | | 125°C | 1.4 | 15 | | 1.8 | 15 | nA | |
| I_{IB} Input bias current (see Note 4) | | 25°C | 0.6 | | | 0.7 | | | pA |
| | | 125°C | 9 | 35 | | 10 | 35 | nA | |
| V_{ICR} Common mode input voltage range (see Note 5) | | 25°C | 0 to 4 | -0.3 to 4.2 | | 0 to 9 | -0.3 to 9.2 | V | |
| | | Full range | 0 to 3.5 | | | 0 to 8.5 | | V | |
| V_{OH} High-level output voltage | $V_{ID} = 100\text{ mV}$, $R_L = 1\text{ M}\Omega$ | 25°C | 3.2 | 4.1 | | 8.2 | 8.9 | V | |
| | | -55°C | 3.2 | 4.1 | | 8.2 | 8.9 | | |
| | | 125°C | 3.2 | 4.2 | | 8.2 | 9 | | |
| V_{OL} Low-level output voltage | $V_{ID} = -100\text{ mV}$, $I_{OL} = 0$ | 25°C | | 0 to 25 | | 0 to 25 | | mV | |
| | | -55°C | | 0 to 25 | | 0 to 25 | | | |
| | | 125°C | | 0 to 25 | | 0 to 25 | | | |
| A_{VD} Large-signal differential voltage amplification | $R_L = 1\text{ M}\Omega$, See Note 6 | 25°C | 250 | 525 | | 500 | 850 | V/mV | |
| | | -55°C | 250 | 950 | | 500 | 1750 | | |
| | | 125°C | 35 | 200 | | 75 | 380 | | |
| CMRR Common-mode rejection ratio | $V_{IC} = V_{ICRmin}$ | 25°C | 70 | 95 | | 75 | 97 | dB | |
| | | -55°C | 70 | 95 | | 75 | 97 | | |
| | | 125°C | 70 | 85 | | 75 | 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 | 75 | 98 | | 75 | 98 | dB | |
| | | -55°C | 70 | 98 | | 70 | 98 | | |
| | | 125°C | 70 | 98 | | 70 | 98 | | |
| I_{DD} Supply current (four amplifiers) | $V_O = V_{DD}/2$, $V_{IC} = V_{DD}/2$, No load | 25°C | | 40 to 68 | | 57 to 92 | | μA | |
| | | -55°C | | 69 to 120 | | 111 to 192 | | | |
| | | 125°C | | 27 to 48 | | 35 to 60 | | | |

† Full range is -55°C to 125°C.

NOTES: 4. The typical values of input bias current and input offset current below 5 pA were determined mathematically.

5. This range also applies to each input individually.

6. At $V_{DD} = 5\text{ V}$, $V_O = 0.25\text{ V to }2\text{ V}$; at $V_{DD} = 10\text{ V}$, $V_O = 1\text{ V to }6\text{ V}$.

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operating characteristics at specified free-air temperature

| PARAMETER | TEST CONDITIONS | T_A | TLC1078M | | | | | | UNIT |
|--------------------------------------|--|-------|-----------------------|-----|-----|------------------------|-----|------------------------|------|
| | | | $V_{DD} = 5\text{ V}$ | | | $V_{DD} = 10\text{ V}$ | | | |
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SR Slew rate at unity gain | $R_L = 1\text{ M}\Omega$, $C_L = 20\text{ pF}$, $V_{I(PP)} = 1\text{ V}$, See Figure 1 | 25°C | | 32 | | | 47 | V/ms | |
| | | -55°C | | 41 | | | 63 | | |
| | | 125°C | | 20 | | | 27 | | |
| V_n Equivalent input noise voltage | $f = 1\text{ kHz}$, $R_S = 20\ \Omega$ | 25°C | | 68 | | | 68 | nV/ $\sqrt{\text{Hz}}$ | |
| B_1 Unity-gain bandwidth | $C_L = 20\text{ pF}$, See Figure 2 | 25°C | | 85 | | | 110 | kHz | |
| | | -55°C | | 140 | | | 165 | | |
| | | 125°C | | 45 | | | 70 | | |
| ϕ_m Phase margin at unity gain | $C_L = 20\text{ pF}$, See Figure 2 | 25°C | | 34° | | | 38° | | |
| | | -55°C | | 39° | | | 43° | | |
| | | 125°C | | 25° | | | 29° | | |

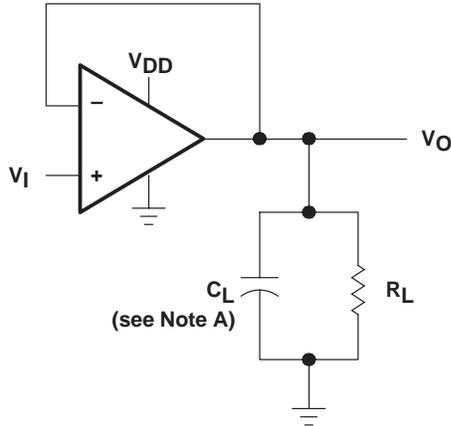
operating characteristics at specified free-air temperature

| PARAMETER | TEST CONDITIONS | T_A | TLC1079M | | | | | | UNIT |
|--------------------------------------|--|-------|-----------------------|-----|-----|------------------------|-----|------------------------|------|
| | | | $V_{DD} = 5\text{ V}$ | | | $V_{DD} = 10\text{ V}$ | | | |
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SR Slew rate at unity gain | $R_L = 1\text{ M}\Omega$, $C_L = 20\text{ pF}$, $V_{I(PP)} = 1\text{ V}$, See Figure 1 | 25°C | | 32 | | | 47 | V/ms | |
| | | -55°C | | 41 | | | 63 | | |
| | | 125°C | | 20 | | | 27 | | |
| V_n Equivalent input noise voltage | $f = 1\text{ kHz}$, $R_S = 20\ \Omega$ | 25°C | | 68 | | | 68 | nV/ $\sqrt{\text{Hz}}$ | |
| B_1 Unity-gain bandwidth | $C_L = 20\text{ pF}$, See Figure 2 | 25°C | | 85 | | | 110 | kHz | |
| | | -55°C | | 140 | | | 165 | | |
| | | 125°C | | 45 | | | 70 | | |
| ϕ_m Phase margin at unity gain | $C_L = 20\text{ pF}$, See Figure 2 | 25°C | | 34° | | | 38° | | |
| | | -55°C | | 39° | | | 43° | | |
| | | 125°C | | 25° | | | 29° | | |

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PARAMETER MEASUREMENT INFORMATION



NOTE A: C_L includes fixture capacitance.

Figure 1. Slew-Rate Test Circuit

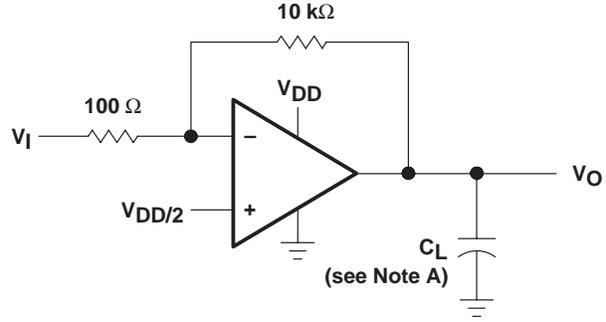


Figure 2. Unity-Gain Bandwidth and Phase-Margin Test Circuit

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TYPICAL CHARACTERISTICS

Table of Graphs

| | | | FIGURE |
|-------------------|---|-------------------------------|-------------------------|
| $\alpha_{V_{IO}}$ | Temperature coefficient of input offset voltage | Distribution | 3 – 6 |
| I_{IB} | Input bias current | vs Free-air temperature | 7 |
| I_{IO} | Input offset current | vs Free-air temperature | 7 |
| V_{IC} | Common-mode input voltage | vs Supply voltage | 8 |
| V_{OH} | High-level output voltage | vs High-level output current | 9, 10 |
| | | vs Supply voltage | 11 |
| | | vs Free-air temperature | 12 |
| V_{OL} | Low-level output voltage | vs Common-mode input voltage | 13, 14 |
| | | vs Differential input voltage | 15 |
| | | vs Free-air temperature | 16 |
| | | vs Low-level output current | 17, 18 |
| A_{VD} | Large-signal differential voltage amplification | vs Supply voltage | 19 |
| | | vs Free-air temperature | 20 |
| | | vs Frequency | 21, 22 |
| V_{OM} | Maximum peak output voltage | vs Frequency | 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 |
| V_n | Equivalent input noise voltage | vs Frequency | 29 |
| B_1 | Unity-gain bandwidth | vs Supply voltage | 30 |
| | | vs Free-air temperature | 31 |
| ϕ_m | Phase margin | vs Supply voltage | 32 |
| | | vs Free-air temperature | 33 |
| | | vs Capacitance load | 34 |
| | Phase shift | vs Frequency | 21, 22 |

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TYPICAL CHARACTERISTICS

**DISTRIBUTION OF TLC1078
 INPUT OFFSET VOLTAGE
 TEMPERATURE COEFFICIENT**

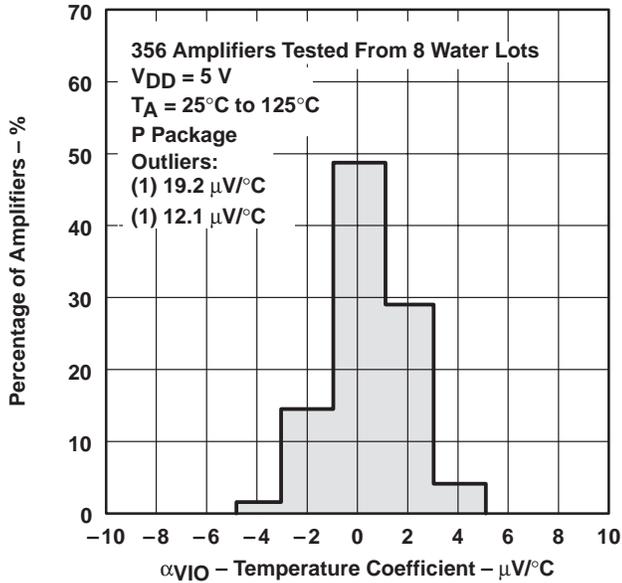


Figure 3

**DISTRIBUTION OF TLC1078
 INPUT OFFSET VOLTAGE
 TEMPERATURE COEFFICIENT**

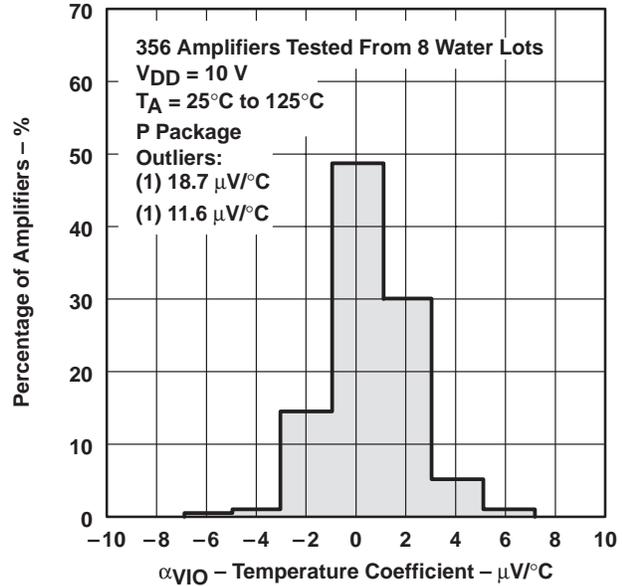


Figure 4

**DISTRIBUTION OF TLC1079
 INPUT OFFSET VOLTAGE
 TEMPERATURE COEFFICIENT**

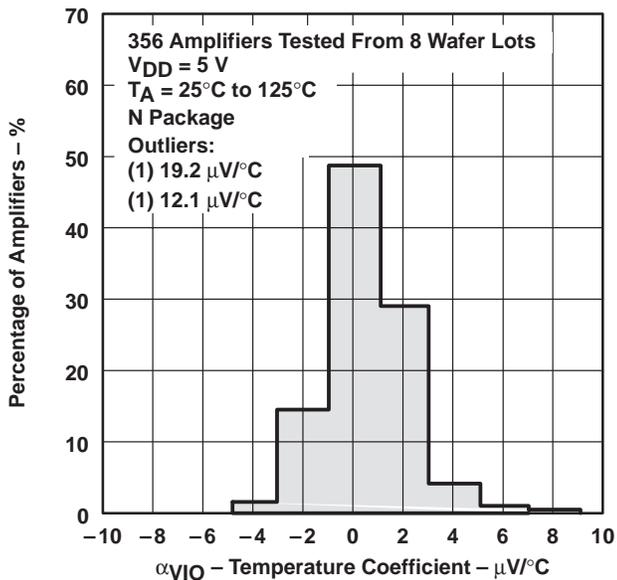


Figure 5

**DISTRIBUTION OF TLC1079
 INPUT OFFSET VOLTAGE
 TEMPERATURE COEFFICIENT**

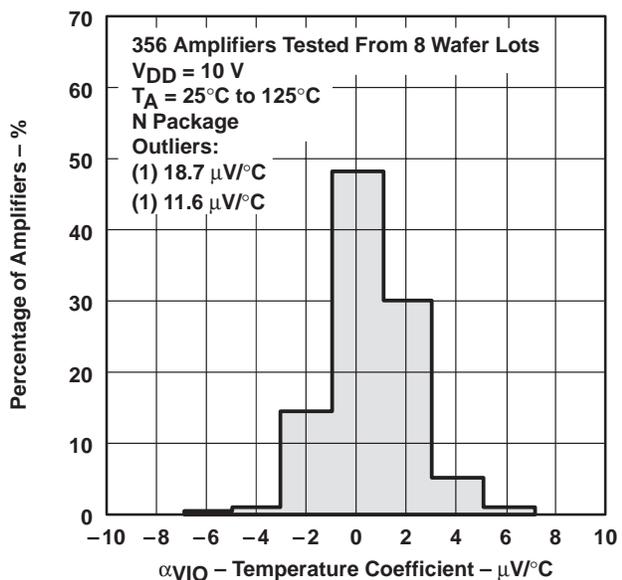


Figure 6

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TYPICAL CHARACTERISTICS

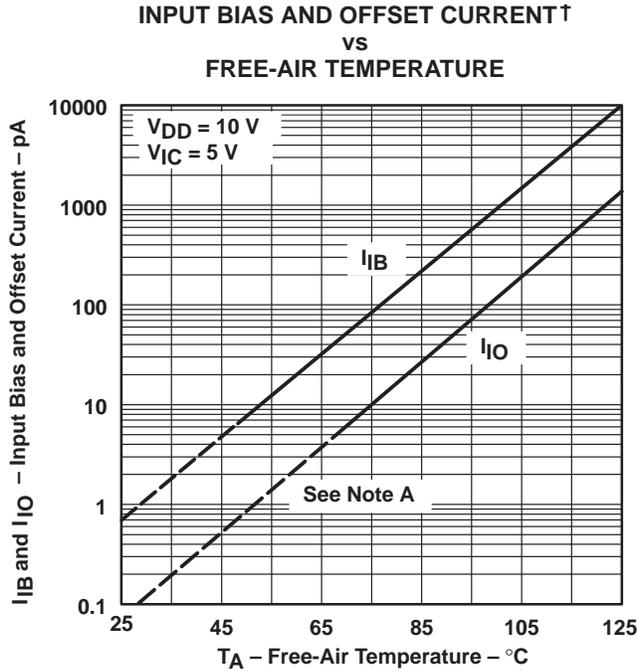


Figure 7

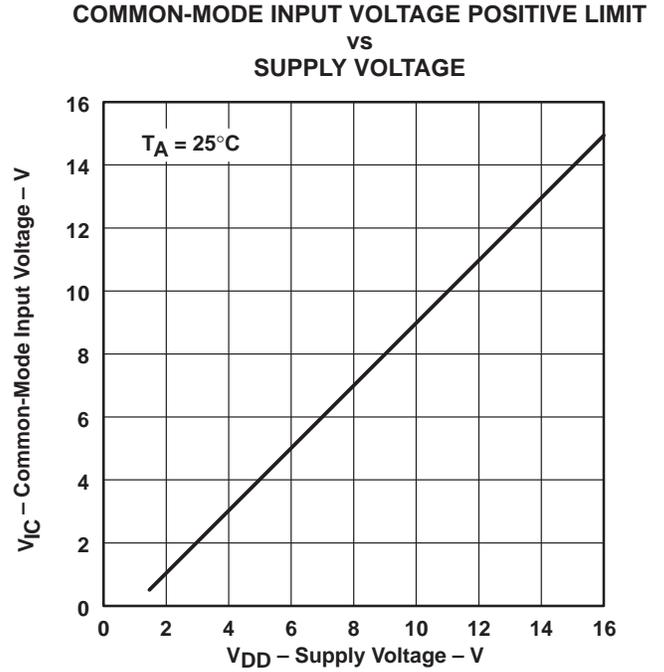


Figure 8

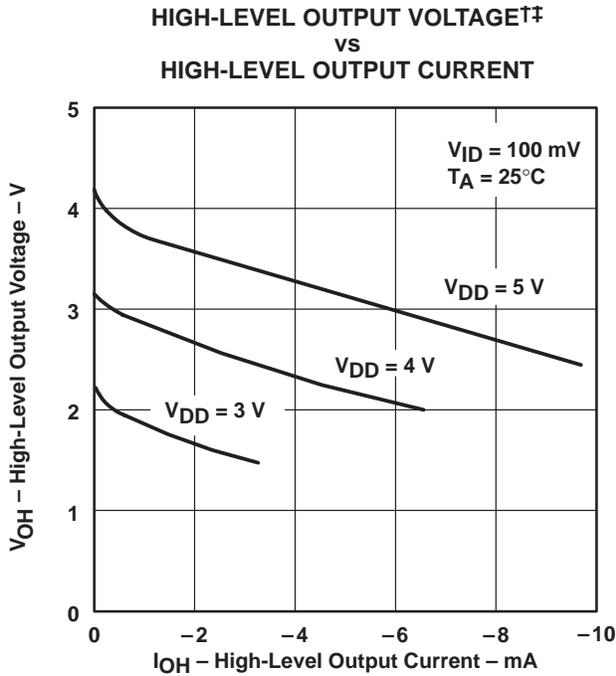


Figure 9

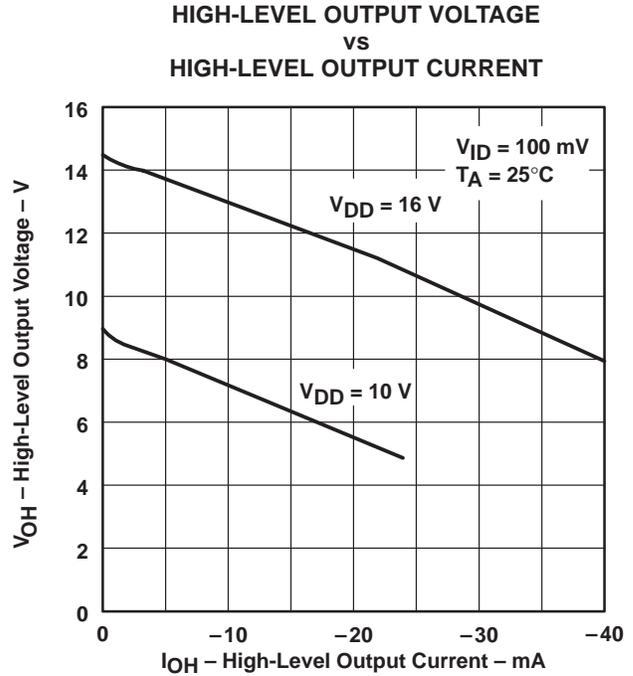


Figure 10

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

‡ The $V_{DD} = 3\text{ V}$ curve does not apply to the TLC1078M.

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TYPICAL CHARACTERISTICS

**HIGH-LEVEL OUTPUT VOLTAGE
vs
SUPPLY VOLTAGE**

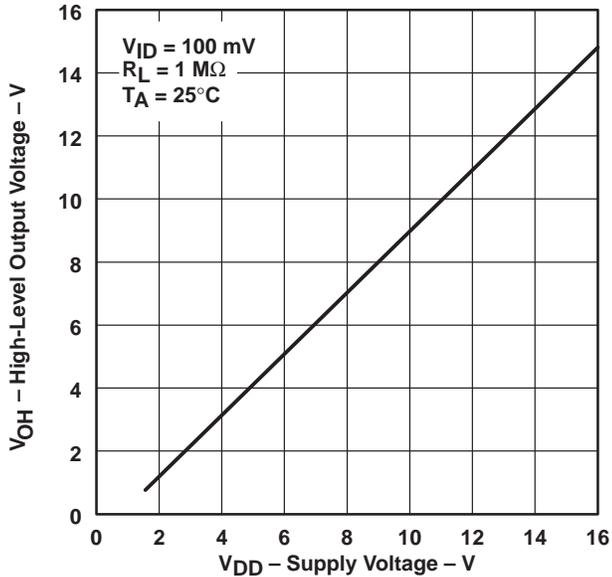


Figure 11

**HIGH-LEVEL OUTPUT VOLTAGE†
vs
FREE-AIR TEMPERATURE**

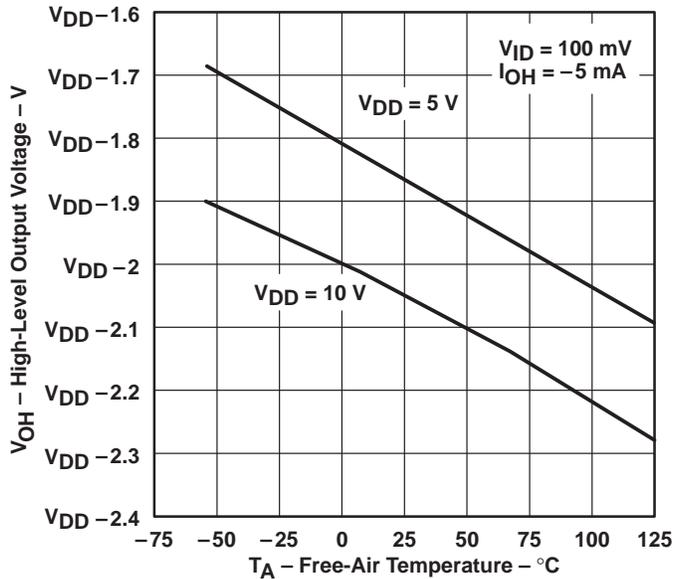


Figure 12

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

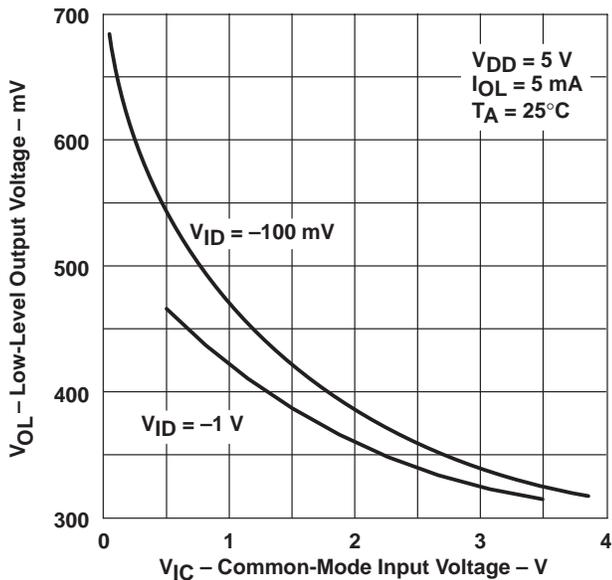


Figure 13

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

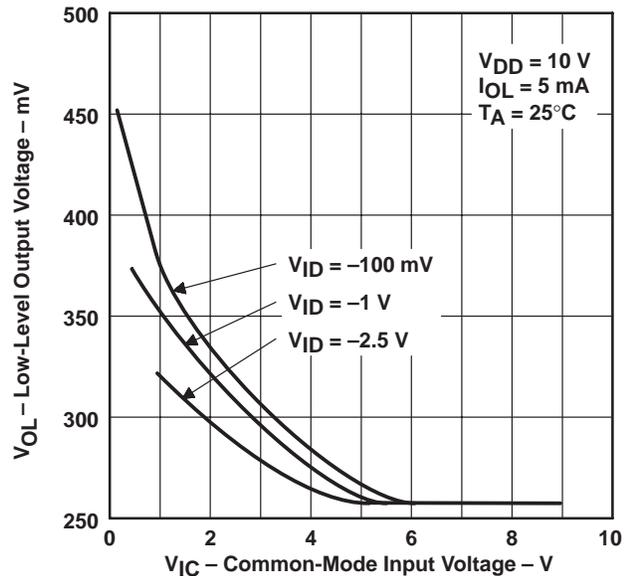


Figure 14

† 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

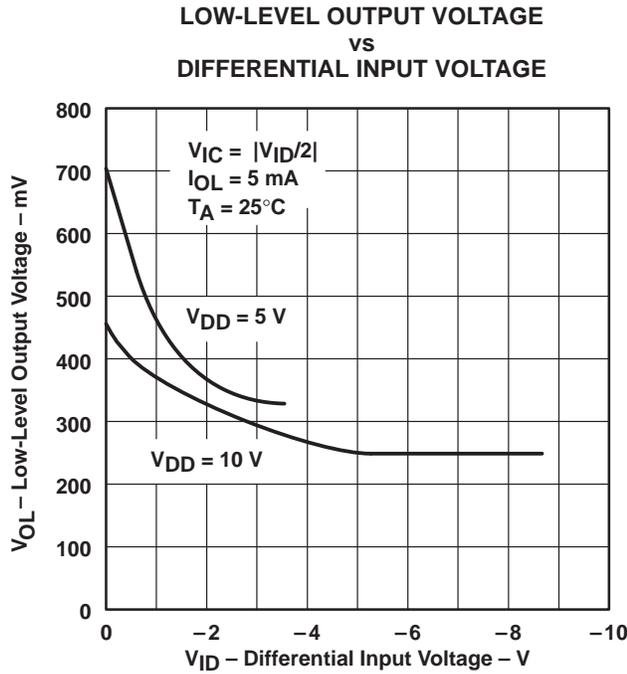


Figure 15

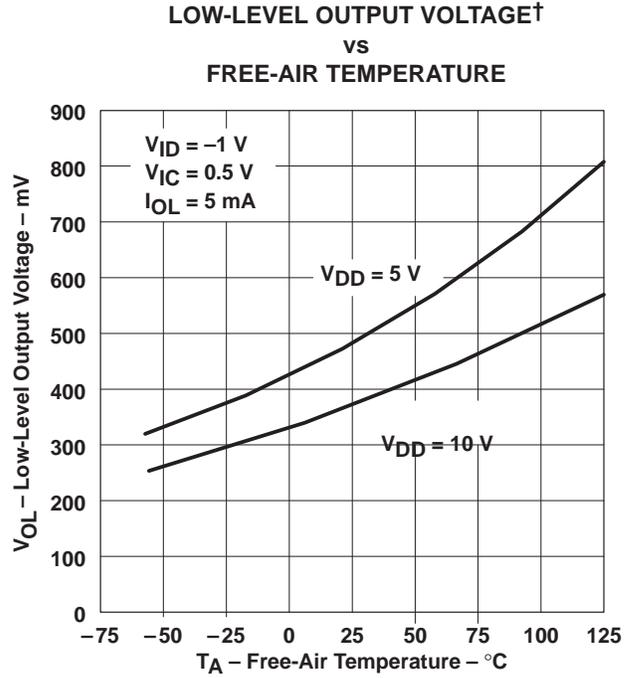


Figure 16

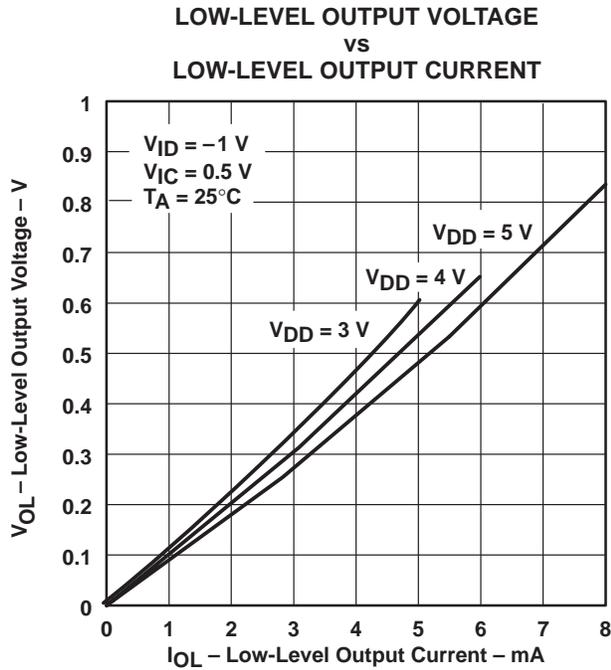


Figure 17

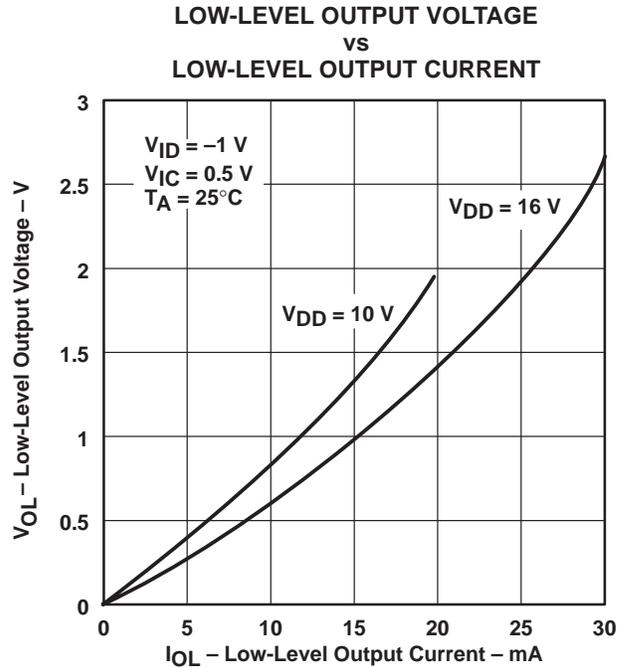


Figure 18

† 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

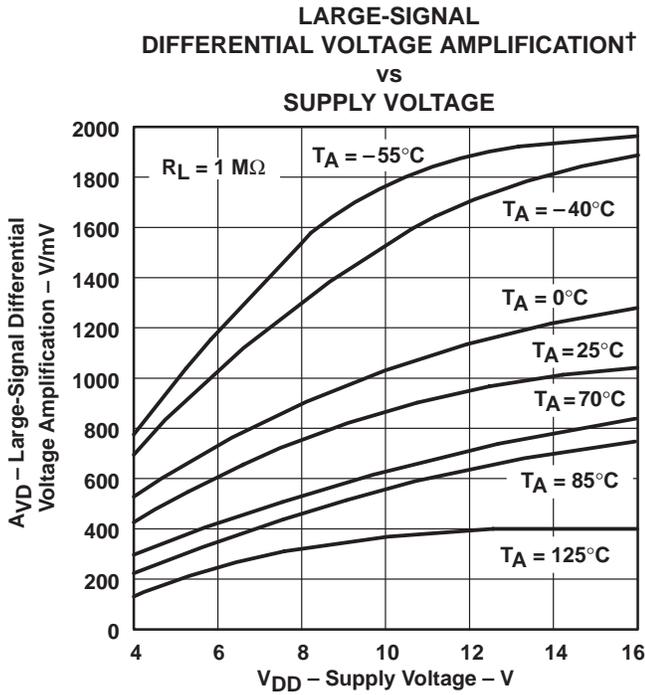


Figure 19

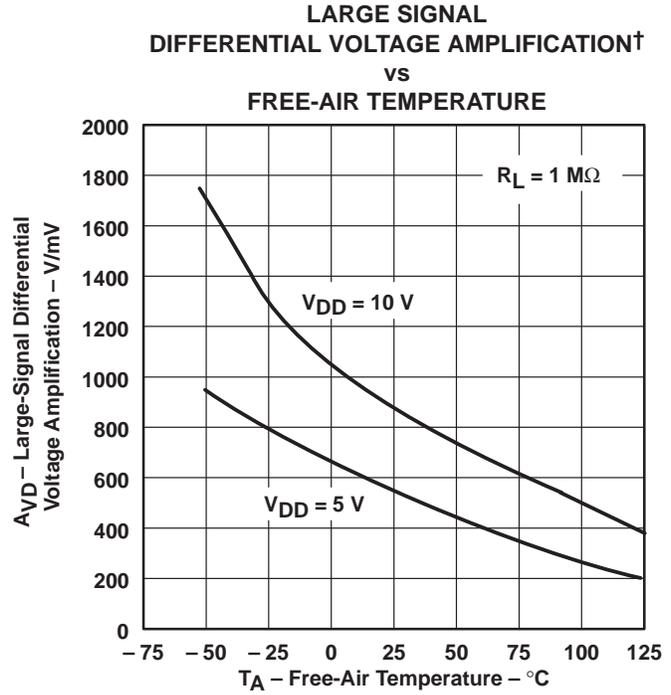


Figure 20

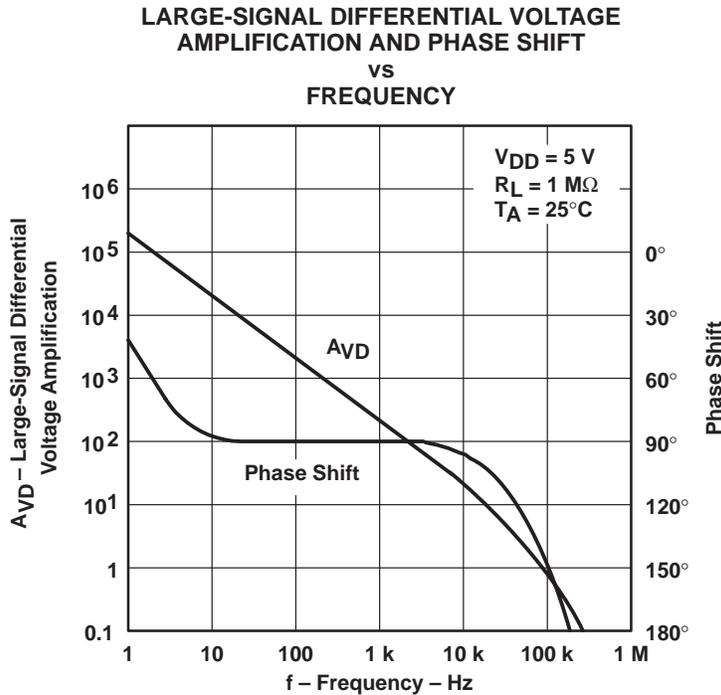


Figure 21

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

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TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT VS FREQUENCY

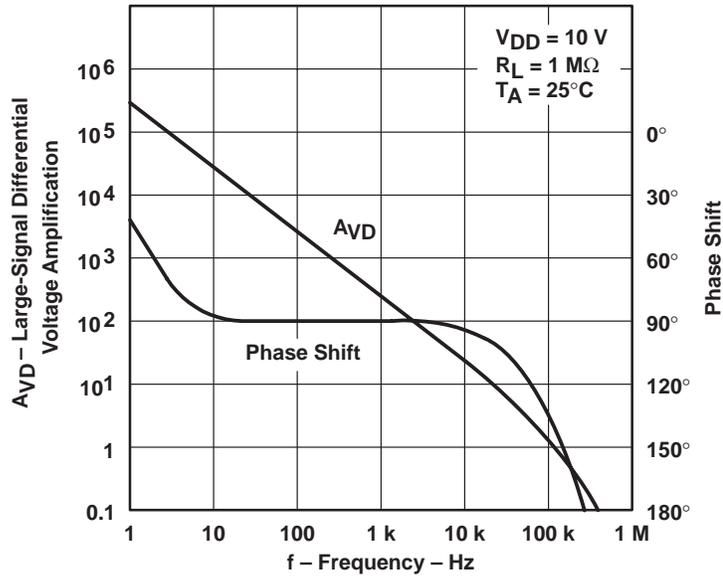


Figure 22

MAXIMUM PEAK OUTPUT VOLTAGE VS FREQUENCY

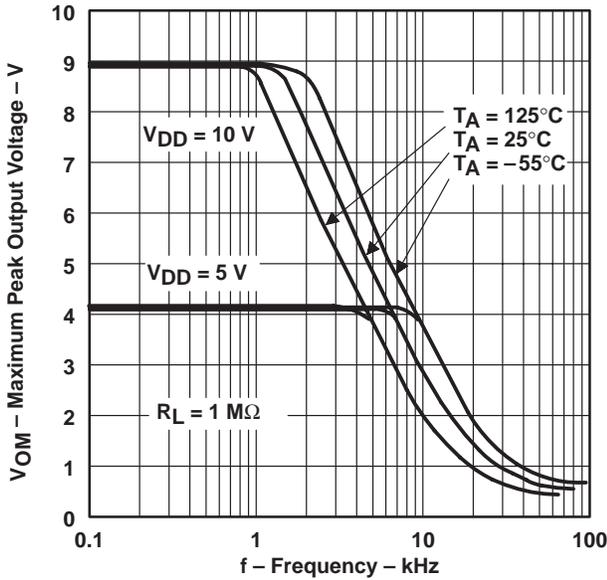


Figure 23

SUPPLY CURRENT VS SUPPLY VOLTAGE

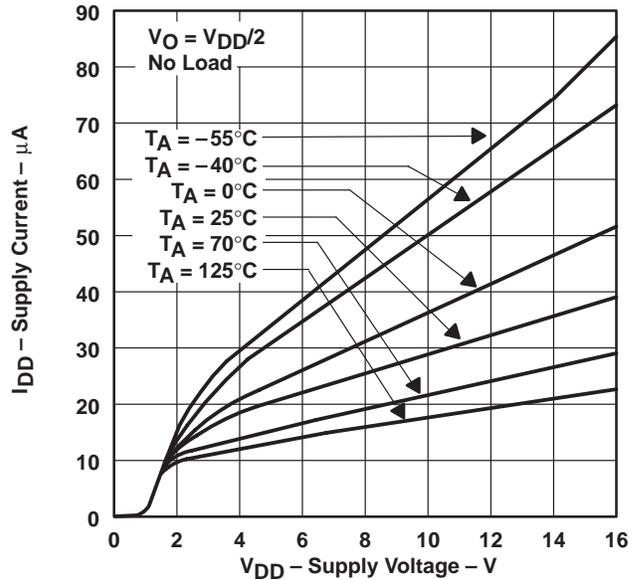


Figure 24

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

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

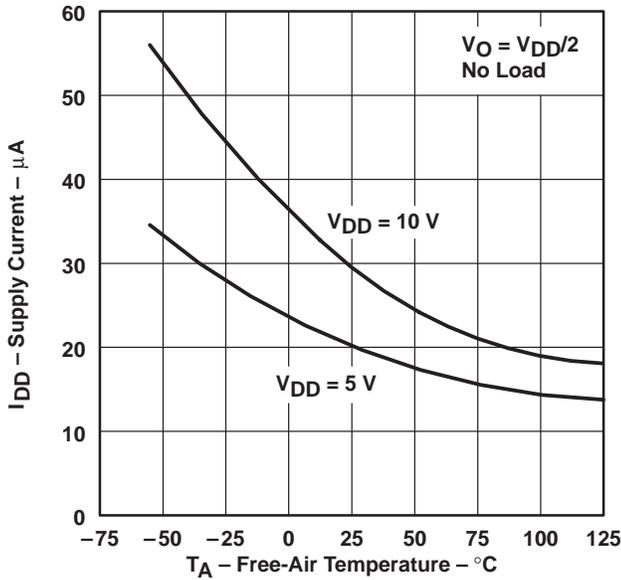


Figure 25

**SLEW RATE
 vs
 SUPPLY VOLTAGE**

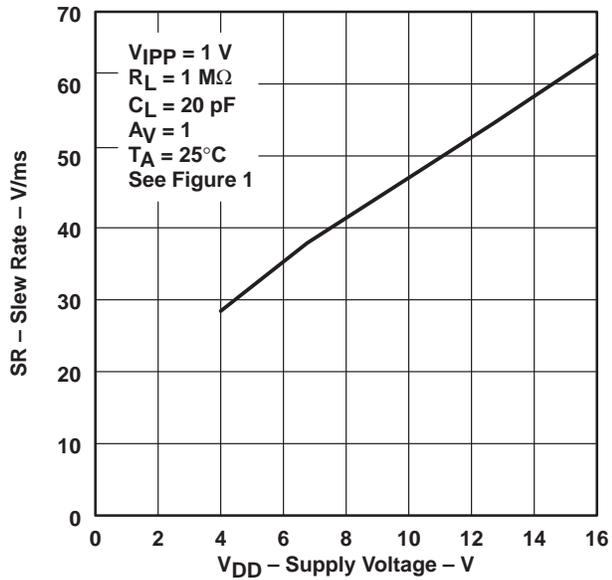


Figure 26

**SLEW RATE†
 vs
 FREE-AIR TEMPERATURE**

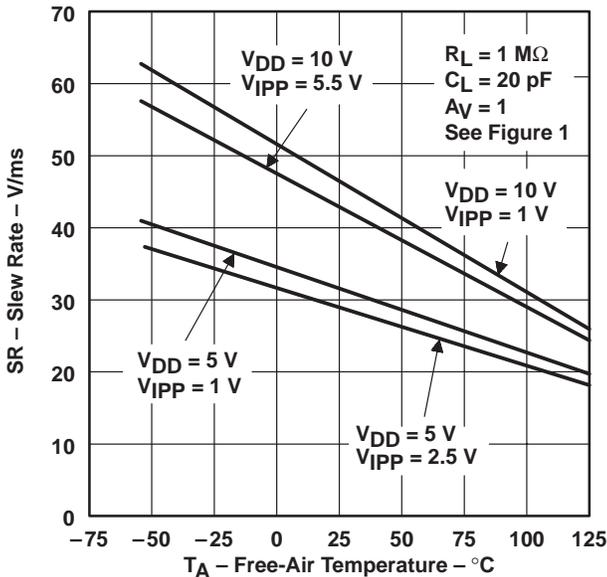


Figure 27

**NORMALIZED SLEW RATE†
 vs
 FREE-AIR TEMPERATURE**

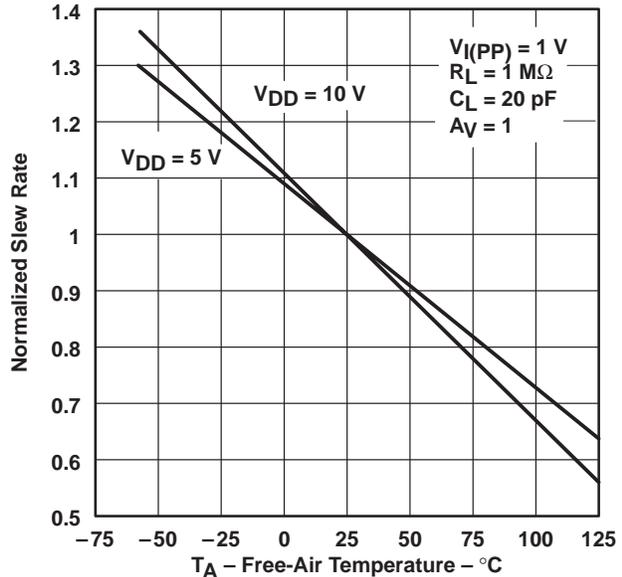


Figure 28

† 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

EQUIVALENT INPUT NOISE VOLTAGE
VS
FREQUENCY

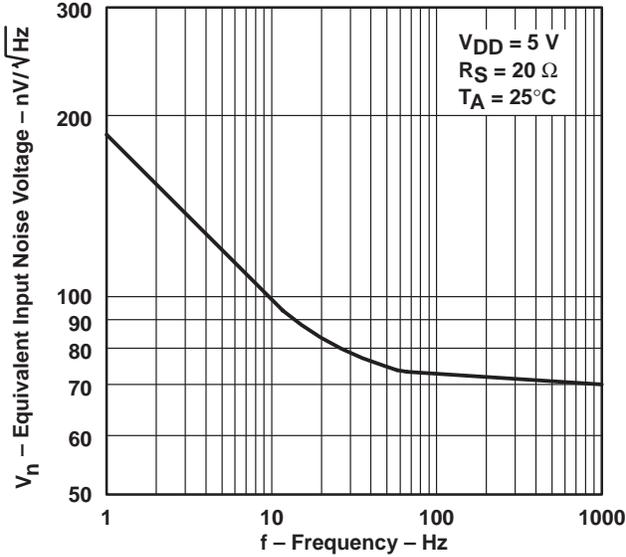


Figure 29

UNITY-GAIN BANDWIDTH
VS
SUPPLY VOLTAGE

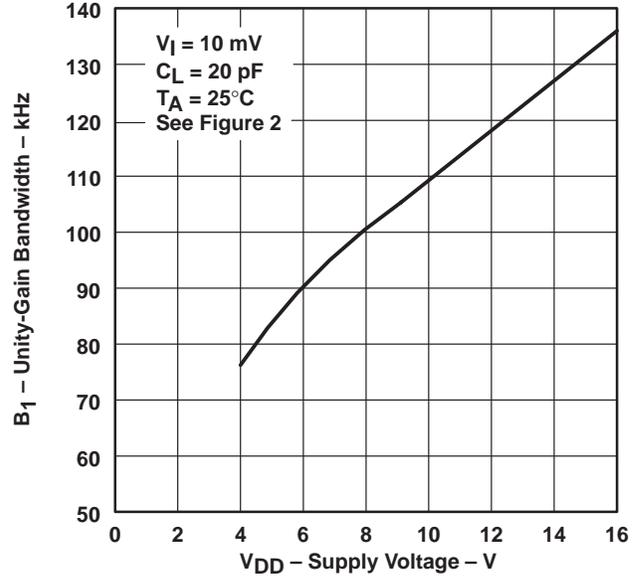


Figure 30

UNITY-GAIN BANDWIDTH
VS
FREE-AIR TEMPERATURE

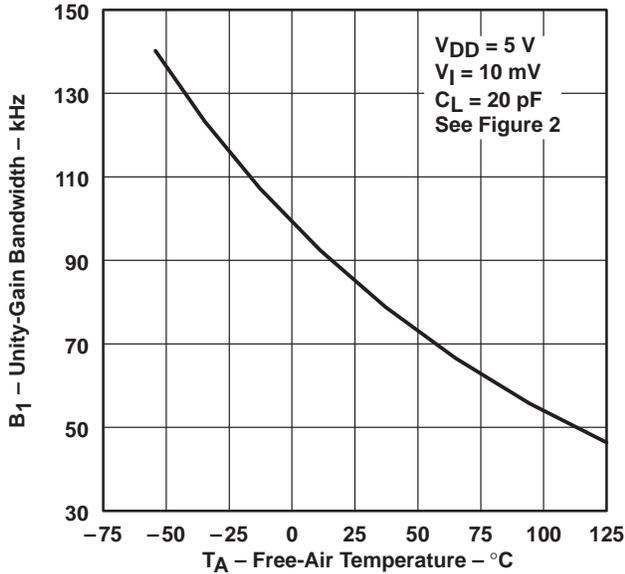


Figure 31

PHASE MARGIN
VS
SUPPLY VOLTAGE

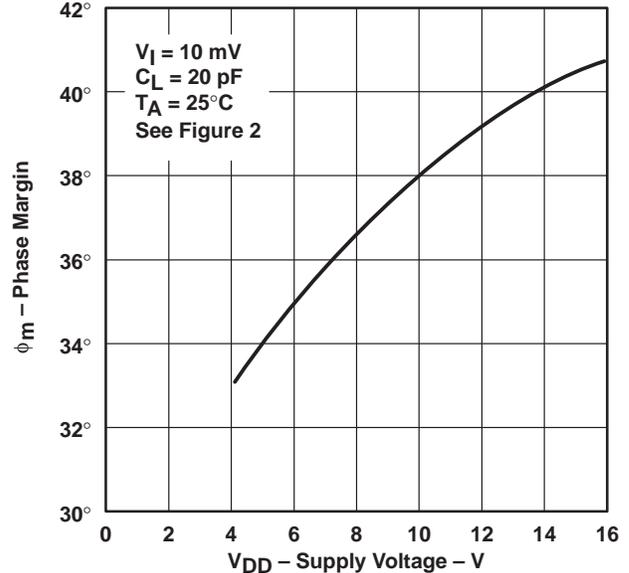


Figure 32

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

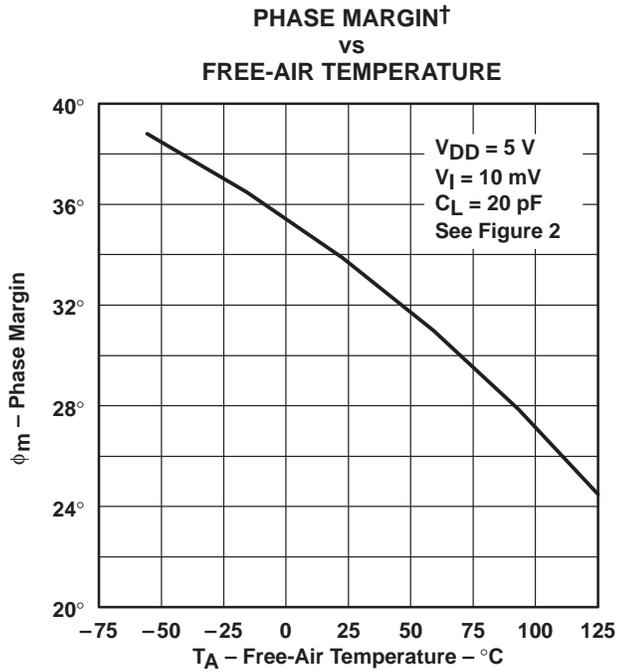


Figure 33

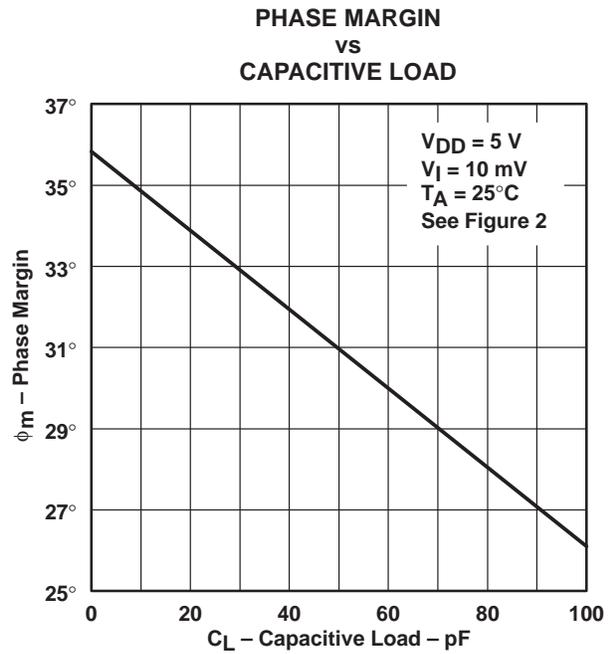


Figure 34

† 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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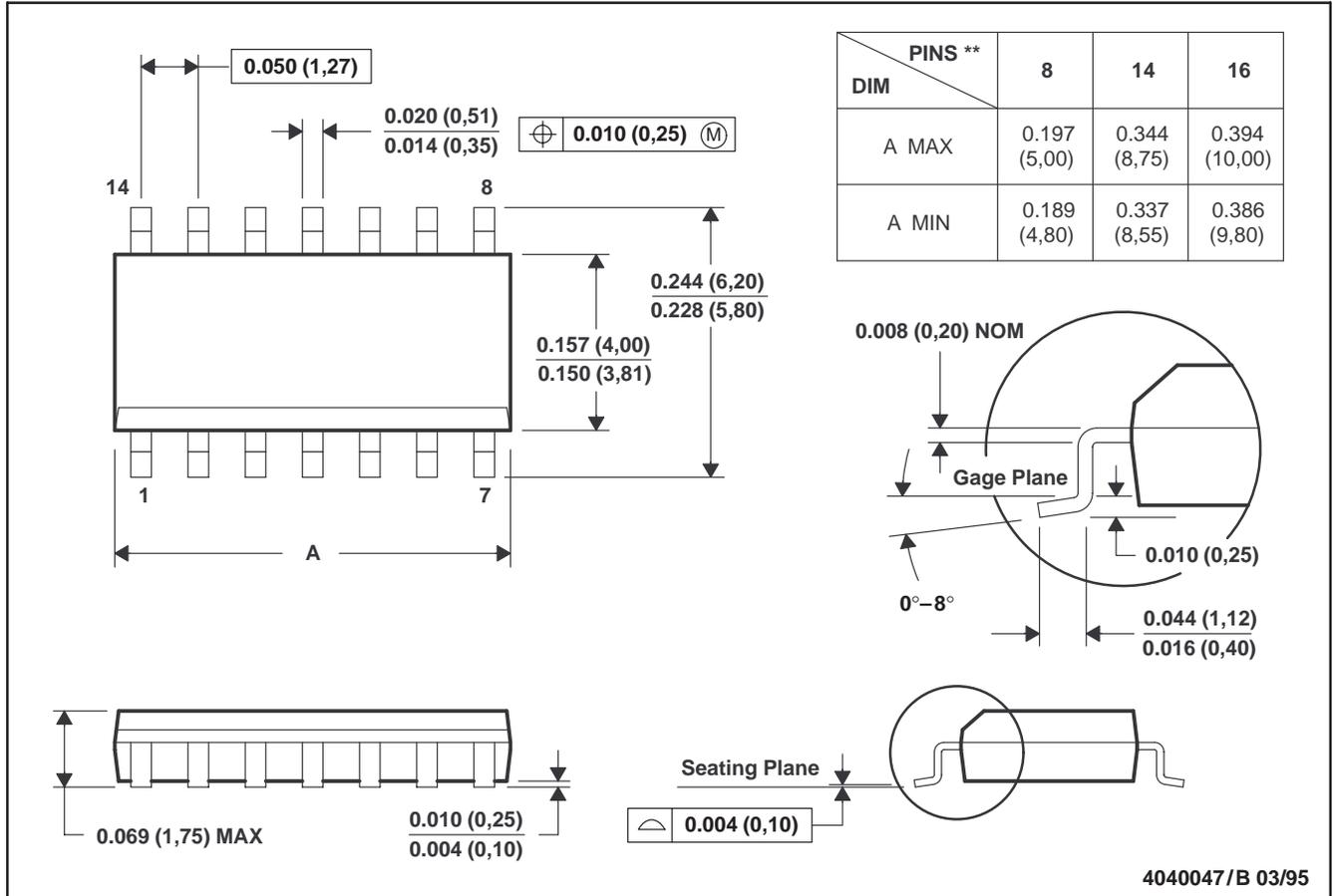


MECHANICAL INFORMATION

D (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PIN SHOWN



- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).
 D. Four center pins are connected to die mount pad.
 E. Falls within JEDEC MS-012

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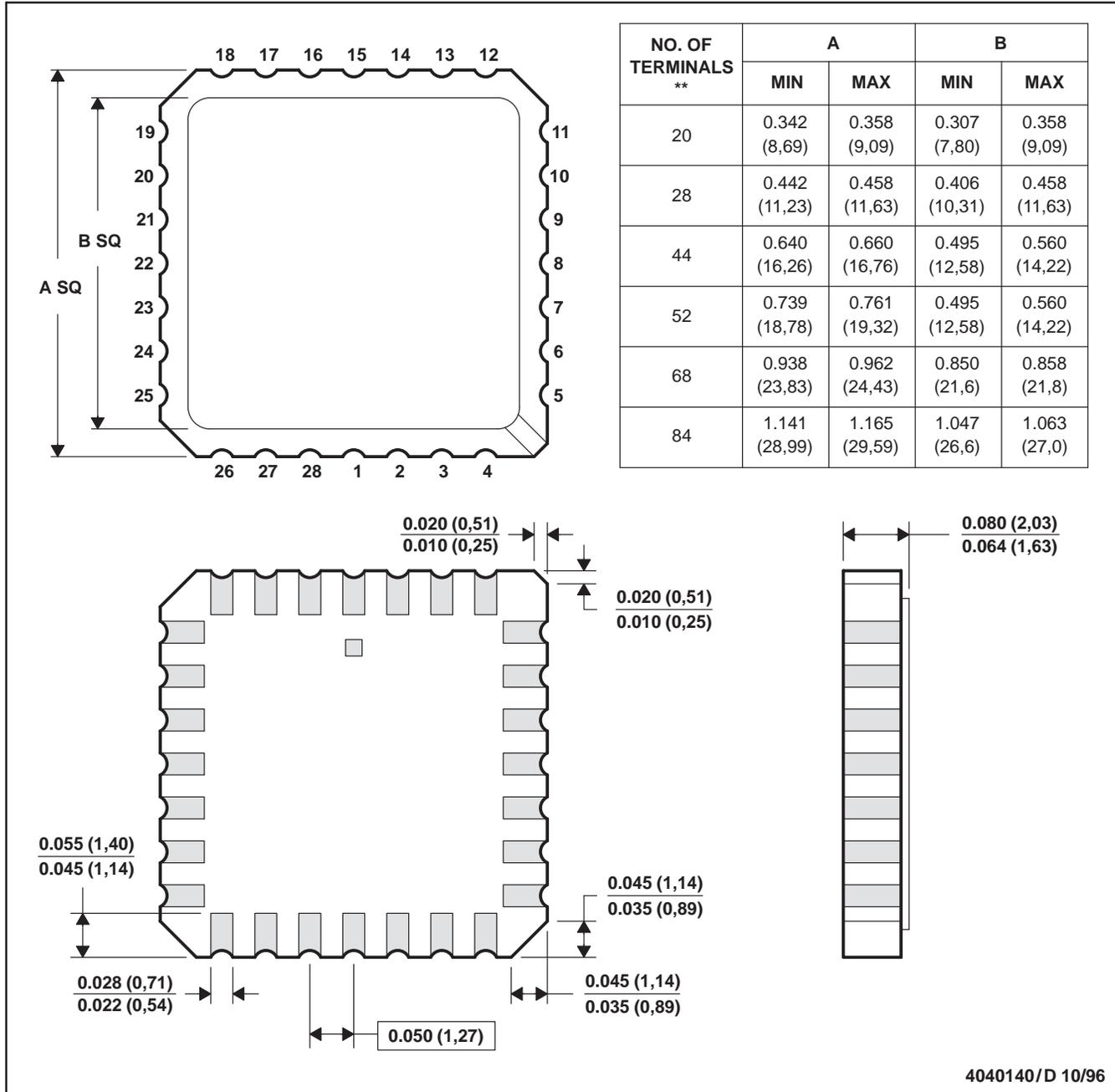
Email: iiehonashun@163.com

MECHANICAL INFORMATION

FK (S-CQCC-N)**

LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. This package can be hermetically sealed with a metal lid.
 D. The terminals are gold plated.
 E. Falls within JEDEC MS-004

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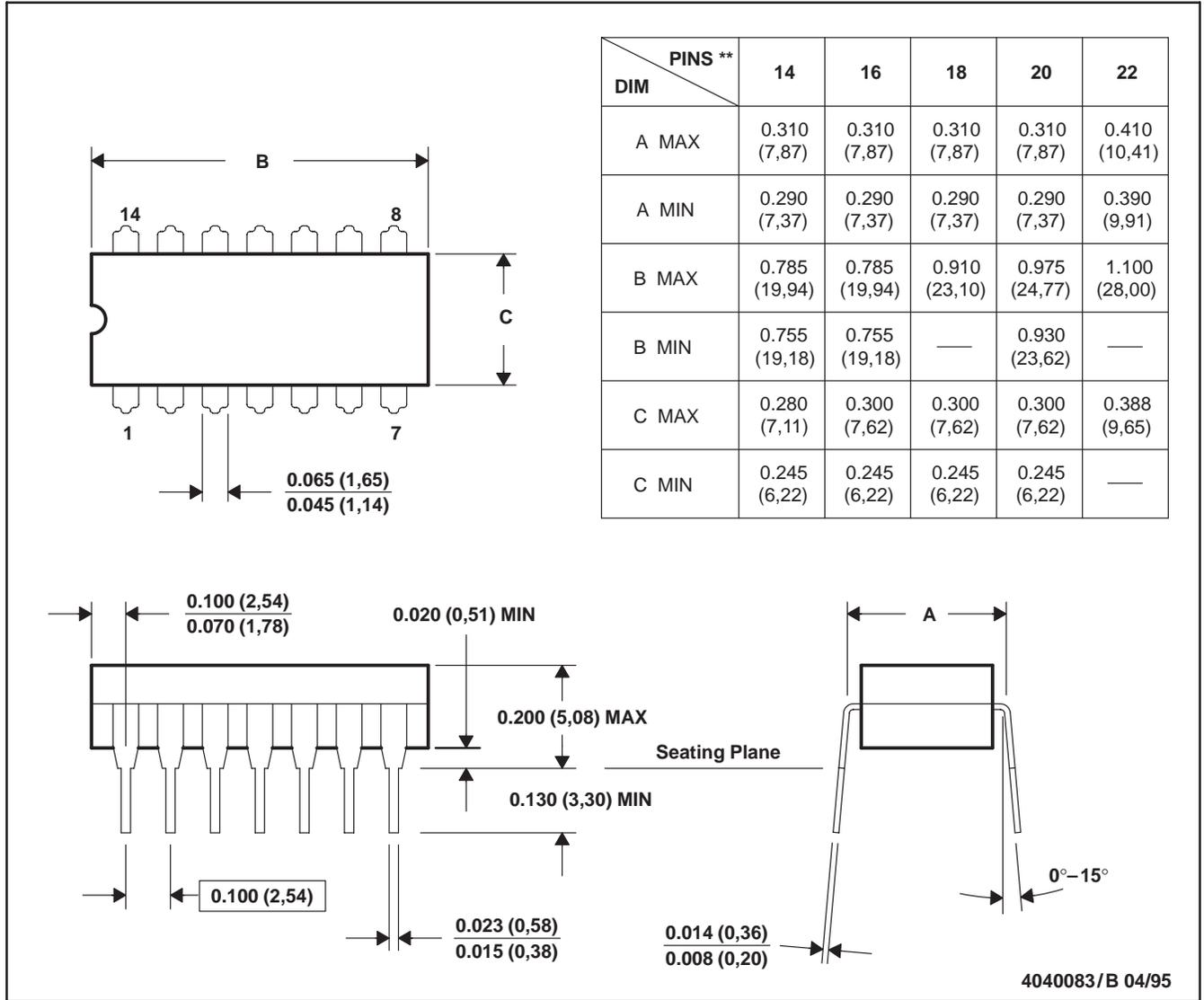


MECHANICAL INFORMATION

J (R-GDIP-T**)

CERAMIC DUAL-IN-LINE PACKAGE

14 PIN SHOWN



- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. This package can be hermetically sealed with a ceramic lid using glass frit.
 D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.
 E. Falls within MIL-STD-1835 GDIP1-T14, GDIP1-T16, GDIP1-T18, GDIP1-T20, and GDIP1-T22

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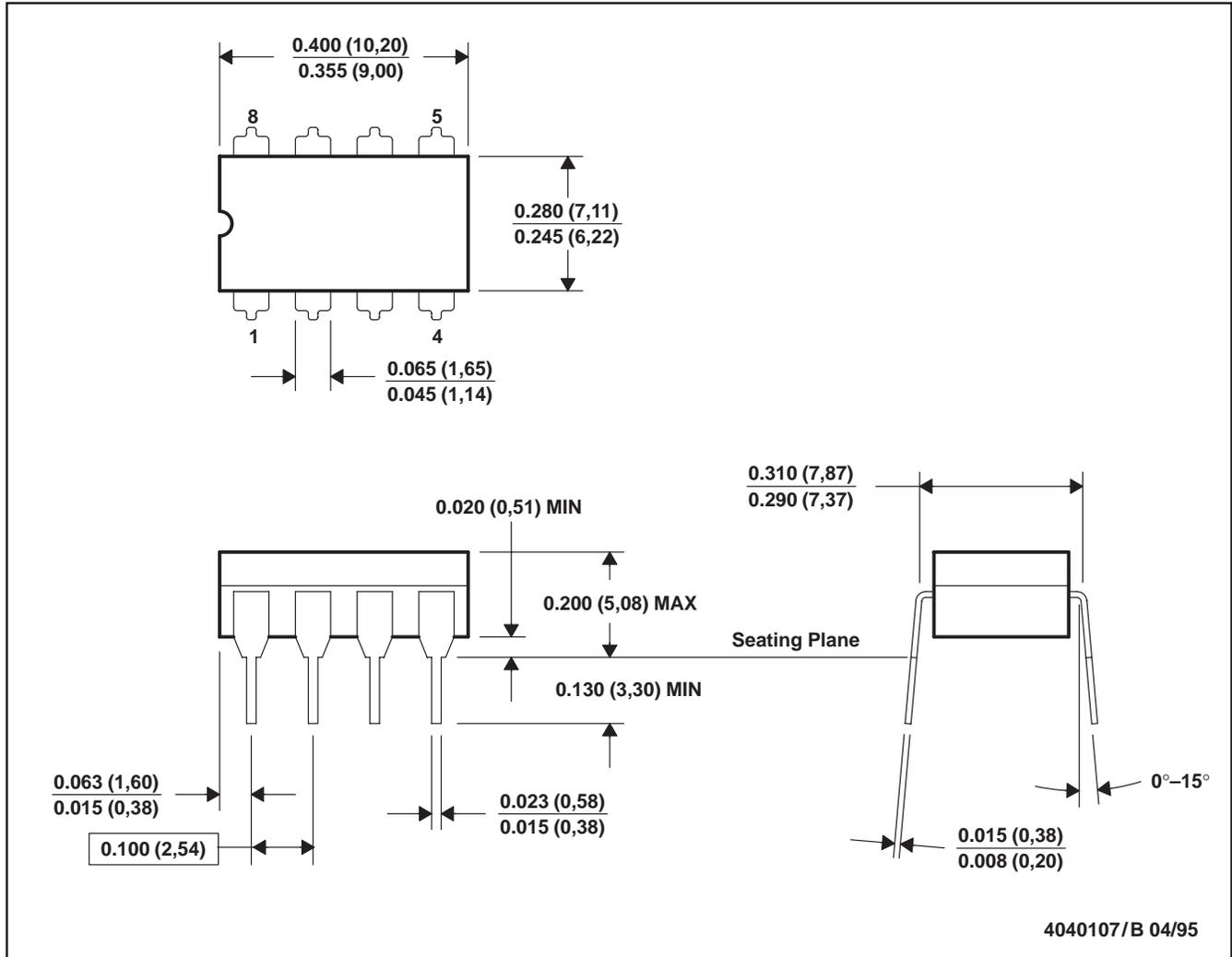
LMC MOS™ μPOWER PRECISION OPERATIONAL AMPLIFIERS

SLOS179 – FEBRUARY 1997

MECHANICAL INFORMATION

JG (R-GDIP-T8)

CERAMIC DUAL-IN-LINE PACKAGE



- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. This package can be hermetically sealed with a ceramic lid using glass frit.
 D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only
 E. Falls within MIL-STD-1835 GDIP1-T8

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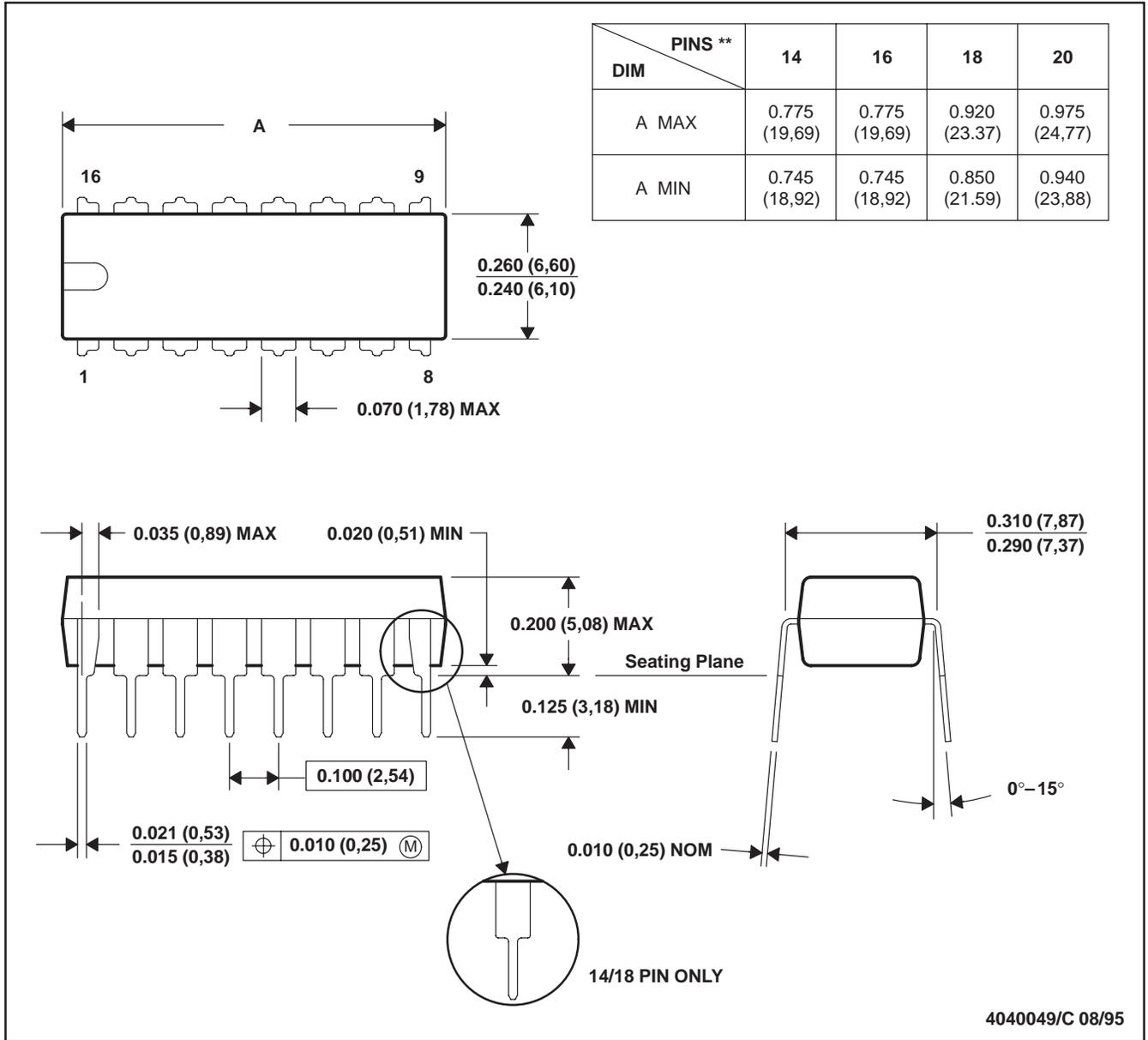
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MECHANICAL INFORMATION

N (R-PDIP-T**)

PLASTIC DUAL-IN-LINE PACKAGE

16 PIN SHOWN



- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Falls within JEDEC MS-001 (20 pin package is shorter than MS-001.)

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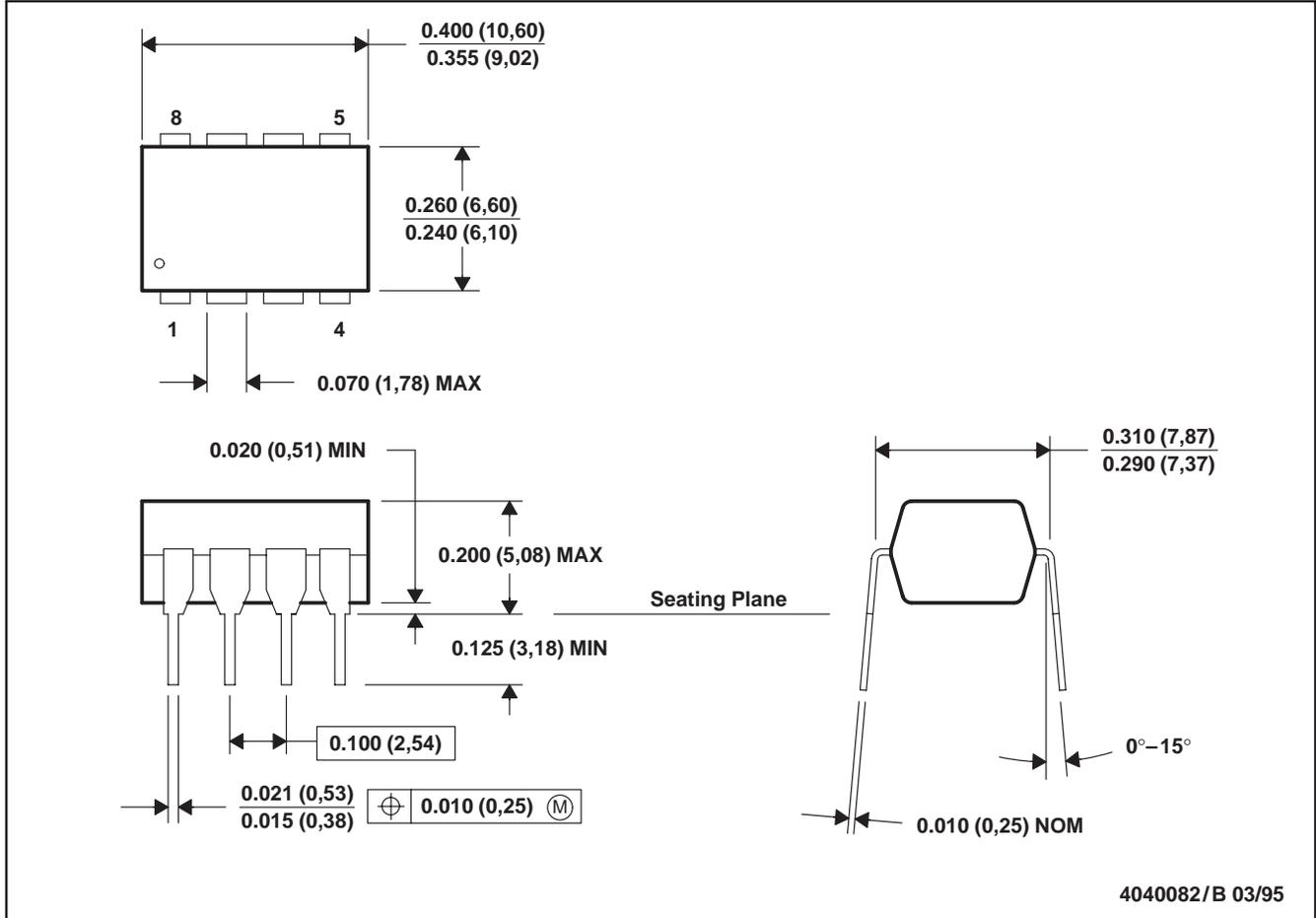
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TLC1078, TLC1078Y, TLC1079, TLC1079Y
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MECHANICAL INFORMATION

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE



- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Falls within JEDEC MS-001

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