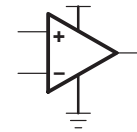


TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

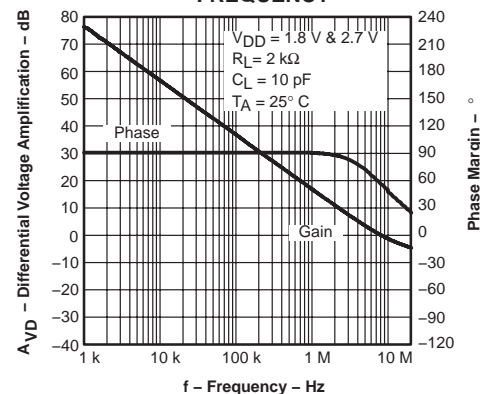
SLOS245E – MARCH 2000 – REVISED JANUARY 2005

- Supply Voltage Range . . . 1.8 V to 3.6 V
- Rail-to-Rail Input/Output
- High Bandwidth . . . 8 MHz
- High Slew Rate . . . 4.8 V/ μ s
- V_{ICR} Exceeds Rails . . . -0.2 V to $V_{DD} + 0.2$
- Supply Current . . . 650 μ A/Channel
- Input Noise Voltage . . . 9 nV/ $\sqrt{\text{Hz}}$ at 10 kHz
- Specified Temperature Range:
0°C to 70°C . . . Commercial Grade
-40°C to 125°C . . . Industrial Grade
- Ultrasmall Packaging
- Universal Operational Amplifier EVM

Operational Amplifier



DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE
VS
FREQUENCY



description

The TLV278x single supply operational amplifiers provide rail-to-rail input and output capability. The TLV278x takes the minimum operating supply voltage down to 1.8 V over the extended industrial temperature range (-40°C to 125°C) while adding the rail-to-rail output swing feature. The TLV278x also provides 8 MHz bandwidth from only 650 μ A of supply current. The maximum recommended supply voltage is 3.6 V, which allows the devices to be operated from (± 1.8 V supplies down to ± 0.9 V) two rechargeable cells.

The combination of wide bandwidth, low noise, and low distortion makes it ideal for high speed and high resolution data converter applications.

All members are available in PDIP, SOIC, and the newer, smaller SOT-23 (singles), MSOP (duals), and TSSOP (quads).

FAMILY PACKAGE TABLE

| DEVICE | V_{DD} [V] | V_{IO} [μ V] | I_{DD}/ch [μ A] | I_{IB} [pA] | GBW [MHz] | SLEW RATE [V/ μ s] | V_n , 1 kHz [nV/ $\sqrt{\text{Hz}}$] | I_O [mA] | SHUTDOWN | RAIL-TO-RAIL |
|------------|-----------------|------------------------|----------------------------------|------------------|--------------|---------------------------|--|---------------|----------|--------------|
| TLV278x(A) | 1.8–3.6 | 250 | 650 | 2.5 | 8 | 5 | 18 | 10 | Y | I/O |
| TLV276x(A) | 1.8–3.6 | 550 | 20 | 3 | 0.5 | 0.23 | 95 | 5 | Y | I/O |
| TLV246x(A) | 2.7–6 | 150 | 550 | 1300 | 6.4 | 1.6 | 11 | 25 | Y | I/O |
| TLV247x(A) | 2.7–6 | 250 | 600 | 2.5 | 2.8 | 1.5 | 15 | 20 | Y | I/O |
| TLV244x(A) | 2.7–10 | 300 | 750 | 1 | 1.81 | 1.4 | 16 | 2 | — | O |
| TLV277x(A) | 2.5–5.5 | 360 | 1000 | 2 | 5.1 | 10.5 | 17 | 6 | Y | O |



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

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.

 **TEXAS
INSTRUMENTS**
WWW.TI.COM

Copyright © 2000–2005, Texas Instruments Incorporated

TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

SLOS245E – MARCH 2000 – REVISED JANUARY 2005

TLV2780 and TLV2781 AVAILABLE OPTIONS(1)

| T _A | V _{IOmax} AT 25°C | PACKAGED DEVICES | | | |
|----------------|-------------------------------|--------------------------|----------------------------|--------------|------------------------|
| | | SMALL OUTLINE (D)† | SOT-23 | | PLASTIC DIP (P) |
| | | | (DBV)‡ | SYMBOL | |
| 0°C to 70°C | 3000 μV | TLV2780CD TLV2781CD | TLV2780CDBV TLV2781CDBV | VASC VATC | — — |
| -40°C to 125°C | 3000 μV | TLV2780ID TLV2781ID | TLV2780IDBV TLV2781IDBV | VASI VATI | TLV2780IP TLV2781IP |
| | 2000 μV | TLV2780AID TLV2781AID | — — | — — | — — |

† This package is available taped and reeled. To order this packaging option, add an **R** suffix to the part number (e.g., TLV2780CDR).

‡ This package is only available taped and reeled. For standard quantities (3,000 pieces per reel), add an **R** suffix (i.e., TLV2780CDBVR). For smaller quantities (250 pieces per mini-reel), add a **T** suffix to the part number (e.g., TLV2780CDBVT).

TLV2782 and TLV2783 AVAILABLE OPTIONS(1)

| T _A | V _{IOmax} AT 25°C | PACKAGED DEVICES | | | | | | |
|----------------|-------------------------------|--------------------------|------------------|--------------|------------------|--------------|-----------------------|-----------------------|
| | | SMALL OUTLINE† (D) | MSOP | | | | PLASTIC DIP (N) | PLASTIC DIP (P) |
| | | | (DGK)† | SYMBOL | (DGS)† | SYMBOL | | |
| 0°C to 70°C | 3000 μV | TLV2782CD TLV2783CD | TLV2782CDGK — | xxTIADL — | — TLV2783CDGS | — xxTIADN | — — | — — |
| -40°C to 125°C | 3000 μV | TLV2782ID TLV2783ID | TLV2782IDGK — | xxTIADM — | — TLV2783IDGS | — xxTIADO | — TLV2783IN | TLV2782IP — |
| | 2000 μV | TLV2782AID TLV2783AID | — — | — — | — — | — — | — — | — — |

† This package is available taped and reeled. To order this packaging option, add an **R** suffix to the part number (e.g., TLV2782CDR).

TLV2784 and TLV2785 AVAILABLE OPTIONS(1)

| T _A | V _{IOmax} AT 25°C | PACKAGED DEVICES | | |
|----------------|-------------------------------|--------------------------|------------------------|----------------------------|
| | | SMALL OUTLINE (D) | PLASTIC DIP (N) | TSSOP† (PW) |
| 0°C to 70°C | 3000 μV | TLV2784CD TLV2785CD | — — | TLV2784CPW TLV2785CPW |
| -40°C to 125°C | 3000 μV | TLV2784ID TLV2785ID | TLV2784IN TLV2785IN | TLV2784IPW TLV2785IPW |
| | 2000 μV | TLV2784AID TLV2785AID | — — | TLV2784AIPW TLV2785AIPW |

† This package is available taped and reeled. To order this packaging option, add an **R** suffix to the part number (e.g., TLV2784CDR).

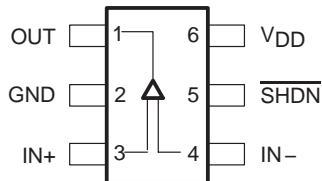
- For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.

TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

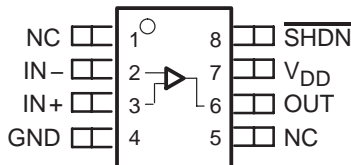
SLOS245E – MARCH 2000 – REVISED JANUARY 2005

TLV278x PACKAGE PINOUTS

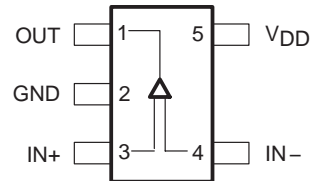
**TLV2780
DBV PACKAGE
(TOP VIEW)**



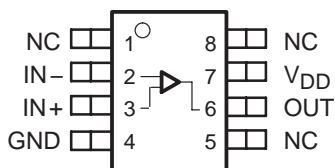
**TLV2780
D OR P PACKAGE
(TOP VIEW)**



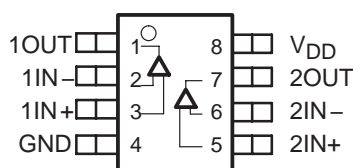
**TLV2781
DBV PACKAGE
(TOP VIEW)**



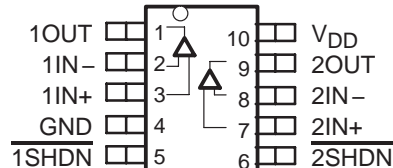
**TLV2781
D OR P PACKAGE
(TOP VIEW)**



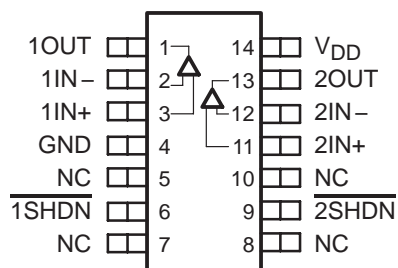
**TLV2782
D, DGK, OR P PACKAGE
(TOP VIEW)**



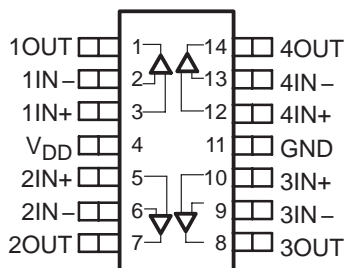
**TLV2783
DGS PACKAGE
(TOP VIEW)**



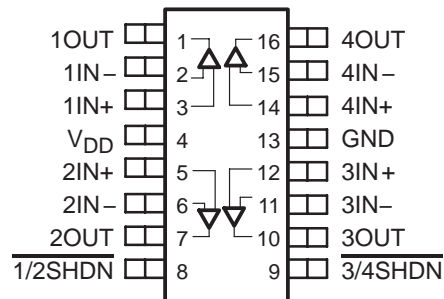
**TLV2783
D OR N PACKAGE
(TOP VIEW)**



**TLV2784
D, N, OR PW PACKAGE
(TOP VIEW)**



**TLV2785
D, N, OR PW PACKAGE
(TOP VIEW)**



NC – No internal connection

TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

SLOS245E – MARCH 2000 – REVISED JANUARY 2005

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

| | |
|--|------------------------------|
| Supply voltage, V_{DD} (see Note 1) | 4 V |
| Differential input voltage, V_{ID} | $\pm V_{DD}$ |
| Input current, I_I (any input) | ± 10 mA |
| Output current, I_O | ± 10 mA |
| 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 125°C |
| Maximum junction temperature, T_J | 150°C |
| Storage temperature range, T_{stg} | -65°C to 150°C |
| Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds | 260°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.

NOTE 1: All voltage values, except differential voltages, are with respect to GND.

DISSIPATION RATING TABLE

| PACKAGE | θ_{JC} (°C/W) | θ_{JA} (°C/W) | $T_A \leq 25^\circ\text{C}$ POWER RATING | $T_A = 125^\circ\text{C}$ POWER RATING |
|------------|-------------------------|-------------------------|---|---|
| D (8) | 38.3 | 176 | 710 mW | 142 mW |
| D (14) | 26.9 | 122.3 | 1022 mW | 204.4 mW |
| D (16) | 25.7 | 114.7 | 1090 mW | 218 mW |
| DBV (5) | 55 | 324.1 | 385 mW | 77.1 mW |
| DBV (6) | 55 | 294.3 | 425 mW | 85 mW |
| DGK (8) | 54.2 | 259.9 | 481 mW | 96.2 mW |
| DGS (10) | 54.1 | 257.7 | 485 mW | 97 mW |
| N (14, 16) | 32 | 78 | 1600 mW | 320.5 mW |
| P (8) | 41 | 104 | 1200 mW | 240.4 mW |
| PW (14) | 29.3 | 173.6 | 720 mW | 144 mW |
| PW (16) | 28.7 | 161.4 | 774 mW | 154.9 mW |

recommended operating conditions

| | | MIN | MAX | UNIT |
|--|---------------|---------------------------|--------------|------|
| Supply voltage, V_{DD} | Single supply | 1.8 | 3.6 | V |
| | Split supply | ± 0.9 | ± 1.8 | |
| Common-mode input voltage range, V_{ICR} | | -0.2 | $V_{DD}+0.2$ | V |
| Operating free-air temperature, T_A | C-suffix | 0 | 70 | °C |
| | I-suffix | -40 | 125 | |
| Shutdown on/off voltage level‡ | V_{IH} | $V_{DD} < 2.7$ V | $0.75V_{DD}$ | V |
| | | $V_{DD} = 2.7$ to 3.6 V | 2 | |
| | V_{IL} | | 0.6 | |

‡ Relative to GND.

TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA
FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT
OPERATIONAL AMPLIFIERS WITH SHUTDOWN

SLOS245E – MARCH 2000 – REVISED JANUARY 2005

electrical characteristics at specified free-air temperature, $V_{DD} = 1.8 \text{ V}$, 2.7 V (unless otherwise noted)

dc performance

| PARAMETER | TEST CONDITIONS | | T_A † | MIN | TYP | MAX | UNIT |
|--|--|--|------------|-----|------|------------------------------|---------------|
| V_{IO} Input offset voltage | $V_O = V_{DD}/2$, $R_L = 2 \text{ k}\Omega$, $R_S = 50 \Omega$ | TLV278x | 25°C | 250 | 3000 | | μV |
| | | | Full range | | 4500 | | |
| | | TLV278xA | 25°C | 250 | 2000 | | |
| | | | Full range | | 3000 | | |
| α_{VIO} Temperature coefficient of input offset voltage | | | | 8 | | $\mu\text{V}/^\circ\text{C}$ | |
| CMRR Common-mode rejection ratio | $V_{IC} = 0 \text{ to } V_{DD}$, $R_S = 50 \Omega$ | $V_{DD} = 1.8 \text{ V}$ | 25°C | 50 | 76 | | dB |
| | | | Full range | | 50 | | |
| | | $V_{DD} = 2.7 \text{ V}/3.6 \text{ V}$ | 25°C | 55 | 80 | | |
| | | | Full range | | 50 | | |
| | $V_{IC} = 1.2 \text{ V to } V_{DD}$, $R_S = 50 \Omega$ | $V_{DD} = 2.7 \text{ V}/3.6 \text{ V}$ | 25°C | 70 | 100 | | |
| | | | Full range | | 70 | | |
| A_{VD} Large-signal differential voltage amplification | $R_L = 2 \text{ k}\Omega$, $V_{O(PP)} = 1 \text{ V}$ | $V_{DD} = 1.8 \text{ V}$ | 25°C | 200 | 600 | | V/mV |
| | | | Full range | | 50 | | |
| | | $V_{DD} = 2.7 \text{ V}/3.6 \text{ V}$ | 25°C | 200 | 1000 | | |
| | | | Full range | | 70 | | |

† Full range is 0°C to 70°C for the C-suffix and –40°C to 125°C for the I-suffix. If not specified, full range is –40°C to 125°C.

input characteristics

| PARAMETER | TEST CONDITIONS | T_A † | MIN | TYP | MAX | UNIT |
|--|--|----------|------------|------|-----|------------------|
| I_{IO} Input offset current | $V_O = V_{DD}/2$, $R_L = 2 \text{ k}\Omega$, $R_S = 50 \Omega$ | 25°C | | 2.5 | 15 | pA |
| | | TLV278xC | Full range | | 100 | |
| | | TLV278xI | Full range | | 300 | |
| I_{IB} Input bias current | $V_O = V_{DD}/2$, $R_L = 2 \text{ k}\Omega$, $R_S = 50 \Omega$ | 25°C | | 2.5 | 15 | pA |
| | | TLV278xC | Full range | | 100 | |
| | | TLV278xI | Full range | | 300 | |
| $r_{i(d)}$ Differential input resistance | | 25°C | | 1000 | | $\text{G}\Omega$ |
| $C_{i(c)}$ Common-mode input capacitance | $f = 1 \text{ kHz}$ | 25°C | | 19 | | pF |

† Full range is 0°C to 70°C for the C-suffix and –40°C to 125°C for the I-suffix. If not specified, full range is –40°C to 125°C.

TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA
FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT
OPERATIONAL AMPLIFIERS WITH SHUTDOWN

SLOS245E – MARCH 2000 – REVISED JANUARY 2005

electrical characteristics at specified free-air temperature, $V_{DD} = 1.8\text{ V}, 2.7\text{ V}$ (unless otherwise noted) (continued)

output characteristics

| PARAMETER | TEST CONDITIONS | | T_A^\dagger | MIN | TYP | MAX | UNIT | |
|---------------------------------------|---|-------------------------|-------------------------|-------------------------|------|-----|------|------|
| V_{OH} High-level output voltage | $I_{OH} = -1\text{ mA}$ | $V_{DD} = 1.8\text{ V}$ | 25°C | 1.7 | 1.77 | | V | |
| | | | Full range | 1.63 | | | | |
| | | $V_{DD} = 2.7\text{ V}$ | 25°C | 2.6 | 2.68 | | | |
| | | | Full range | 2.6 | | | | |
| | | $V_{DD} = 3.6\text{ V}$ | 25°C | | 3.58 | | | |
| | | | $I_{OH} = -5\text{ mA}$ | $V_{DD} = 1.8\text{ V}$ | 25°C | 1.5 | | 1.55 |
| | Full range | | | | 1.46 | | | |
| | $V_{DD} = 2.7\text{ V}$ | 25°C | 2.5 | 2.55 | | | | |
| | | Full range | 2.45 | | | | | |
| $V_{DD} = 3.6\text{ V}$ | | 25°C | | 3.55 | | | | |
| V_{OL} Low-level output voltage | $I_{OL} = 1\text{ mA}$ | | 25°C | | | 70 | mV | |
| | | | Full range | | | 80 | | |
| | $I_{OL} = 5\text{ mA}$ | $V_{DD} = 1.8\text{ V}$ | 25°C | | 180 | 240 | | |
| | | | Full range | | | 290 | | |
| | | $V_{DD} = 2.7\text{ V}$ | 25°C | | 120 | 170 | | |
| | | | Full range | | | 200 | | |
| I_O Output current | $V_{DD} = 1.8\text{ V},$ $V_O = 0.5\text{ V from}$ | Positive rail | 25°C | | | 10 | mA | |
| | | Negative rail | | | | 15 | | |
| | $V_{DD} = 2.7\text{ V},$ $V_O = 0.5\text{ V from}$ | Positive rail | | | | 17 | | |
| | | Negative rail | | | | 23 | | |
| I_{OS} Short-circuit output current | Sourcing | $V_{DD} = 1.8\text{ V}$ | 25°C | | | 13 | mA | |
| | | $V_{DD} = 2.7\text{ V}$ | | | | 35 | | |
| | Sinking | $V_{DD} = 1.8\text{ V}$ | | | | 21 | | |
| | | $V_{DD} = 2.7\text{ V}$ | | | | 45 | | |

† Full range is 0°C to 70°C for the C-suffix and -40°C to 125°C for the I-suffix. If not specified, full range is -40°C to 125°C.

power supply

| PARAMETER | TEST CONDITIONS | | T_A^\dagger | MIN | TYP | MAX | UNIT |
|---|--|-----------------------------------|---------------|-----|-----|-----|---------------|
| I_{DD} Supply current (per channel) | $V_O = V_{DD}/2,$ | $\overline{\text{SHDN}} = V_{DD}$ | 25°C | | 650 | 770 | μA |
| | | | Full range | | | 820 | |
| k_{SVR} Supply voltage rejection ratio ($\Delta V_{DD} / \Delta V_{IO}$) | $V_{DD} = 1.8\text{ V to } 2.7\text{ V},$ $V_{IC} = V_{DD}/2$ | No load, | 25°C | | 60 | 75 | dB |
| | | | Full range | | | 58 | |
| | $V_{DD} = 2.7\text{ V to } 3.6\text{ V},$ $V_{IC} = V_{DD}/2$ | No load, | 25°C | | 75 | 90 | |
| | | | Full range | | | 70 | |
| | $V_{DD} = 1.8\text{ V to } 3.6\text{ V},$ $V_{IC} = V_{DD}/2$ | No load, | 25°C | | 65 | 80 | |
| | | | Full range | | | 60 | |

† Full range is 0°C to 70°C for the C-suffix and -40°C to 125°C for the I-suffix. If not specified, full range is -40°C to 125°C.

TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA
FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT
OPERATIONAL AMPLIFIERS WITH SHUTDOWN

SLOS245E – MARCH 2000 – REVISED JANUARY 2005

electrical characteristics at specified free-air temperature, $V_{DD} = 1.8\text{ V}, 2.7\text{ V}$ (unless otherwise noted) (continued)

dynamic performance

| PARAMETER | | TEST CONDITIONS | | T_A † | MIN | TYP | MAX | UNIT |
|-----------|----------------------------------|---|----------------------|-------------------------|------------|------|-----|------------|
| UGBW | Unity gain bandwidth | $R_L = 2\text{ k}\Omega$, | $C_L = 25\text{ pF}$ | 25°C | | 8 | | MHz |
| SR+ | Positive slew rate at unity gain | $V_{O(PP)} = 1\text{ V}$, $R_L = 2\text{ k}\Omega$, $C_L = 50\text{ pF}$ | | $V_{DD} = 1.8\text{ V}$ | 25°C | 3.3 | 4.3 | V/ μ s |
| | | | | | Full range | 3.1 | | |
| | | | | $V_{DD} = 2.7\text{ V}$ | 25°C | 3.8 | 4.8 | |
| | | | | | Full range | 3.5 | | |
| | | | | $V_{DD} = 3.6\text{ V}$ | 25°C | 4 | 5 | |
| | | | | | Full range | 3.6 | | |
| SR- | Negative slew rate at unity gain | $V_{O(PP)} = 1\text{ V}$, $R_L = 2\text{ k}\Omega$, $C_L = 50\text{ pF}$ | | $V_{DD} = 1.8\text{ V}$ | 25°C | 2.1 | 2.8 | |
| | | | | | Full range | 1.89 | | |
| | | | | $V_{DD} = 2.7\text{ V}$ | 25°C | 2.2 | 2.8 | |
| | | | | | Full range | 1.97 | | |
| | | | | $V_{DD} = 3.6\text{ V}$ | 25°C | 3.5 | 4.2 | |
| | | | | | Full range | 3.4 | | |
| ϕ_m | Phase margin | $R_L = 2\text{ k}\Omega$, | $C_L = 25\text{ pF}$ | 25°C | | 58° | | |
| | Gain margin | | | | | 8 | | dB |
| t_s | Settling time | $V_{DD} = 1.8\text{ V}$, $V_{(STEP)PP} = 1\text{ V}$, $A_V = -1$, $C_L = 10\text{ pF}$, $R_L = 2\text{ k}\Omega$ | | 25°C | 0.1% | 1.7 | | μ s |
| | | | | | 0.01% | 2.8 | | |
| | | | | | 0.1% | 1.7 | | |
| | | | | | 0.01% | 2.4 | | |

† Full range is 0°C to 70°C for the C-suffix and -40°C to 125°C for the I-suffix. If not specified, full range is -40°C to 125°C.

noise/distortion performance

| PARAMETER | | TEST CONDITIONS | | T_A | MIN | TYP | MAX | UNIT |
|-----------|--------------------------------------|---|-------------|-------|--------|-----|------------------------|------|
| THD + N | Total harmonic distortion plus noise | $V_{O(PP)} = V_{DD}/2$, $R_L = 2\text{ k}\Omega$, $f = 10\text{ kHz}$ | $A_V = 1$ | 25°C | 0.055% | | | |
| | | | $A_V = 10$ | | 0.08% | | | |
| | | | $A_V = 100$ | | 0.45% | | | |
| V_n | Equivalent input noise voltage | $f = 1\text{ kHz}$ $f = 10\text{ kHz}$ | | 25°C | 18 | | nV/ $\sqrt{\text{Hz}}$ | |
| | | | | | 9 | | | |
| I_n | Equivalent input noise current | $f = 1\text{ kHz}$ | | 25°C | 0.9 | | fA/ $\sqrt{\text{Hz}}$ | |

shutdown characteristics

| PARAMETER | | TEST CONDITIONS | T_A † | MIN | TYP | MAX | UNIT |
|----------------|--|---------------------------------------|------------|-----|------|------|------|
| $I_{DD(SHDN)}$ | Supply current, per channel in shutdown mode (TLV2780, TLV2783, TLV2785) | $\overline{\text{SHDN}} = 0\text{ V}$ | 25°C | 900 | 1400 | | nA |
| | | | Full range | | | 1700 | |
| $t_{(on)}$ | Amplifier turnon time‡ | $R_L = 2\text{ k}\Omega$ | 25°C | 800 | | | ns |
| $t_{(off)}$ | Amplifier turnoff time‡ | $R_L = 2\text{ k}\Omega$ | | 200 | | | |

† Full range is 0°C to 70°C for the C-suffix and -40°C to 125°C for the I-suffix. If not specified, full range is -40°C to 125°C.

‡ Disable time and enable time are defined as the interval between application of the logic signal to $\overline{\text{SHDN}}$ and the point at which the supply current has reached half its final value.

TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA
FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT
OPERATIONAL AMPLIFIERS WITH SHUTDOWN

SLOS245E – MARCH 2000 – REVISED JANUARY 2005

TYPICAL CHARACTERISTICS

Table of Graphs

| | | | FIGURE |
|-----------------------|--|------------------------------|---------------|
| V _{IO} | Input offset voltage | vs Common-mode input voltage | 1, 2 |
| CMRR | Common-mode rejection ratio | vs Frequency | 3 |
| V _{OH} | High-level output voltage | vs High-level output current | 4, 6 |
| V _{OL} | Low-level output voltage | vs Low-level output current | 5, 7 |
| V _{O(PP)} | Maximum peak-to-peak output voltage | vs Frequency | 8 |
| Z _o | Output impedance | vs Frequency | 9 |
| I _{DD} | Supply current | vs Supply voltage | 10 |
| I _{DD} | Supply current | vs Free-air temperature | 11 |
| PSRR | Power supply rejection ratio | vs Frequency | 12 |
| A _{VD} | Differential voltage amplification & phase | vs Frequency | 13 |
| | Gain-bandwidth product | vs Free-air temperature | 14 |
| SR | Slew rate | vs Supply voltage | 15 |
| | | vs Free-air temperature | 16, 17 |
| φ _m | Phase margin | vs Load capacitance | 18 |
| V _n | Equivalent input noise voltage | vs Frequency | 19 |
| | Voltage-follower large-signal pulse response | vs Time | 20 |
| | Voltage-follower small-signal pulse response | vs Time | 21 |
| | Inverting large-signal pulse response | vs Time | 22 |
| | Inverting small-signal pulse response | vs Time | 23 |
| | Crosstalk | vs Frequency | 24 |
| | Shutdown forward & reverse isolation | vs Frequency | 25 |
| I _{DD(SHDN)} | Shutdown supply current | vs Free-air temperature | 26 |
| I _{DD(SHDN)} | Shutdown supply current | vs Supply voltage | 27 |
| I _{DD(SHDN)} | Shutdown supply current/output voltage | vs Time | 28 |

TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

SLOS245E – MARCH 2000 – REVISED JANUARY 2005

TYPICAL CHARACTERISTICS

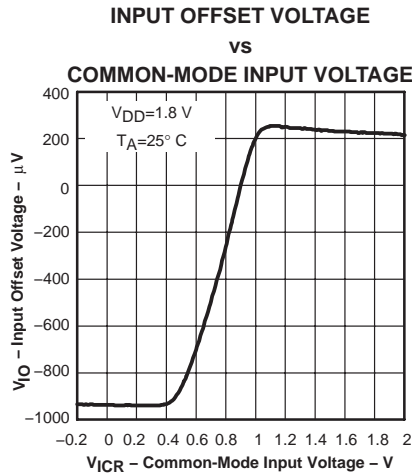


Figure 1

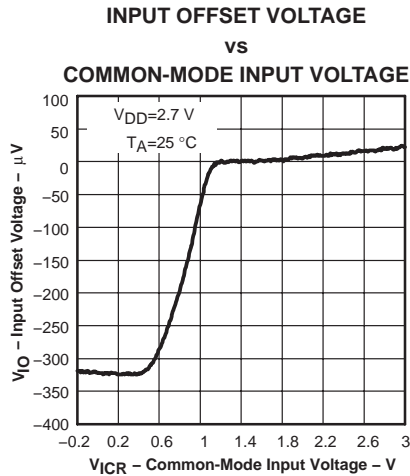


Figure 2

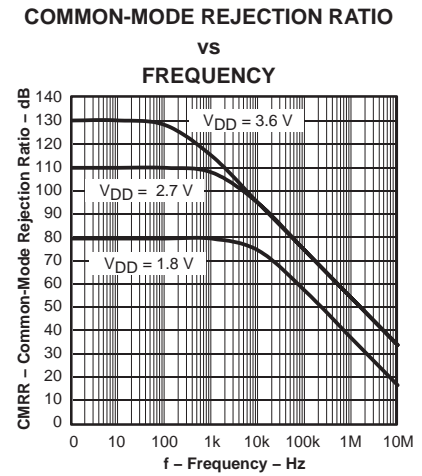


Figure 3

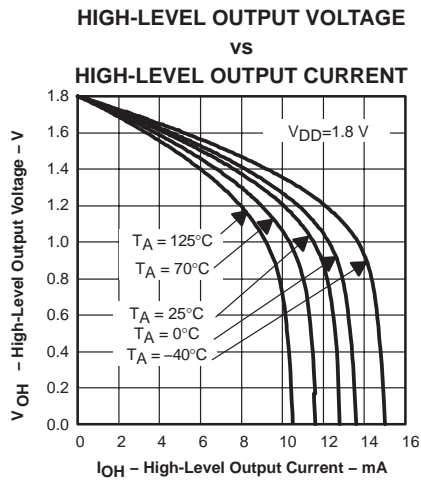


Figure 4

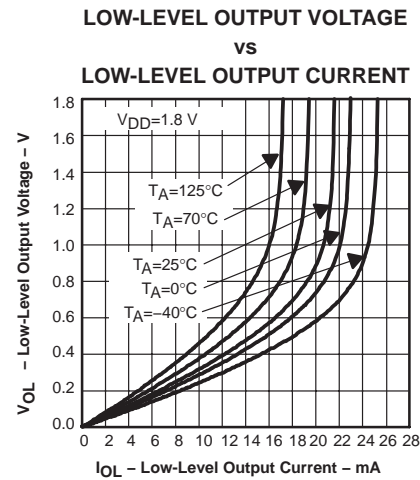


Figure 5

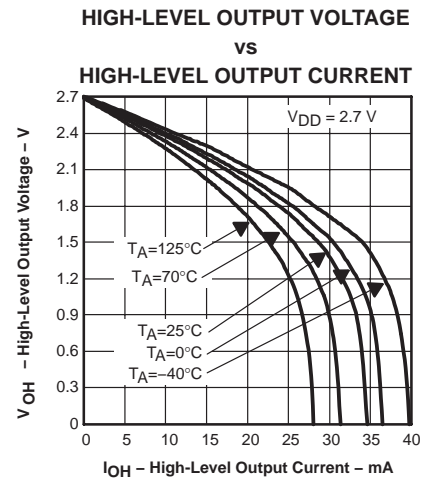


Figure 6

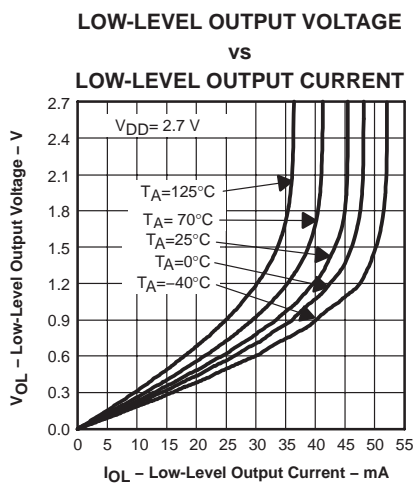


Figure 7

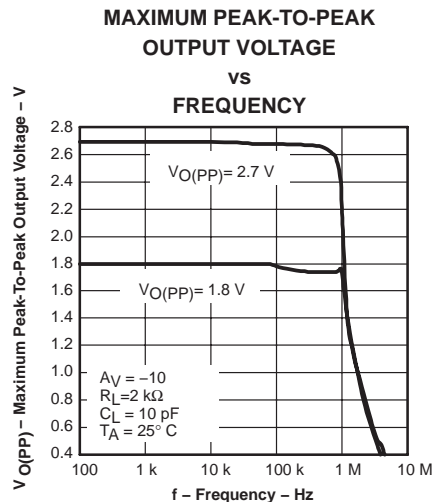


Figure 8

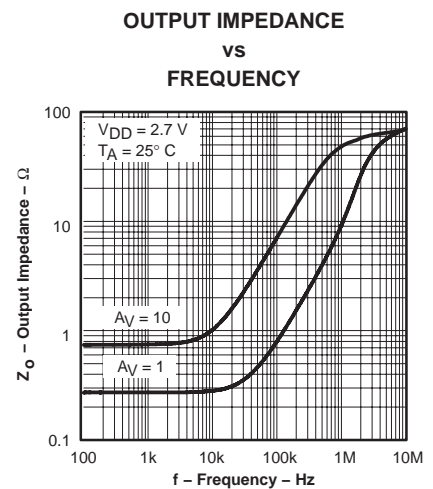


Figure 9

TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

SLOS245E – MARCH 2000 – REVISED JANUARY 2005

TYPICAL CHARACTERISTICS

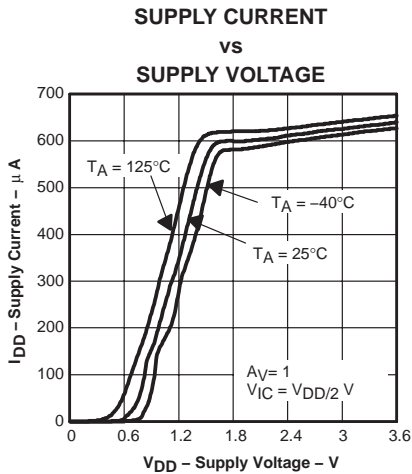


Figure 10

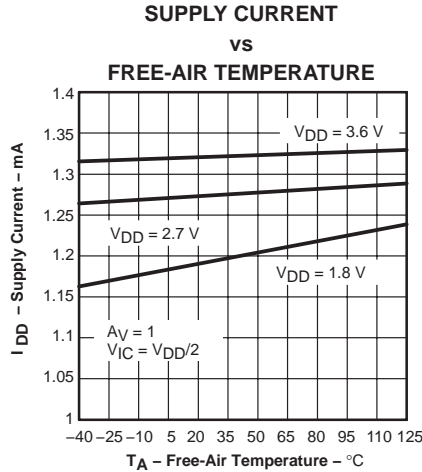


Figure 11

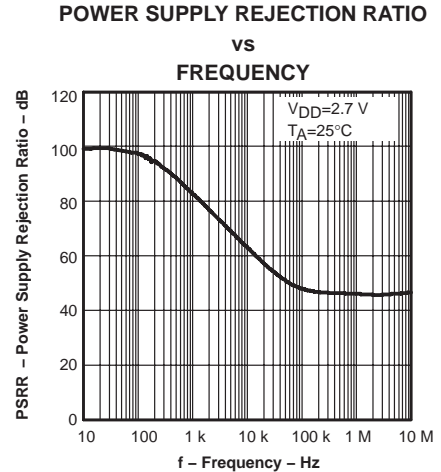


Figure 12

DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE

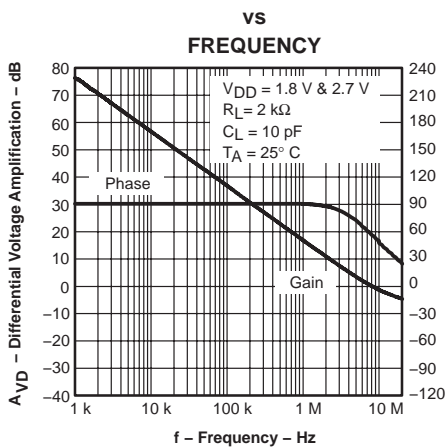


Figure 13

GAIN-BANDWIDTH PRODUCT

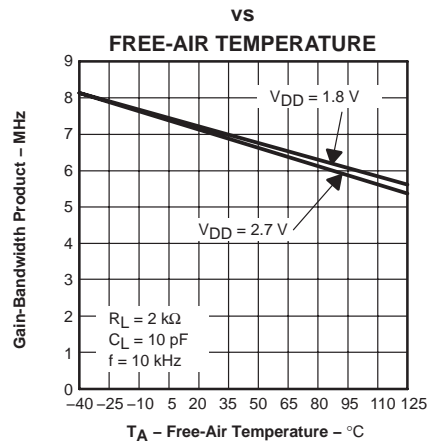


Figure 14

SLEW RATE

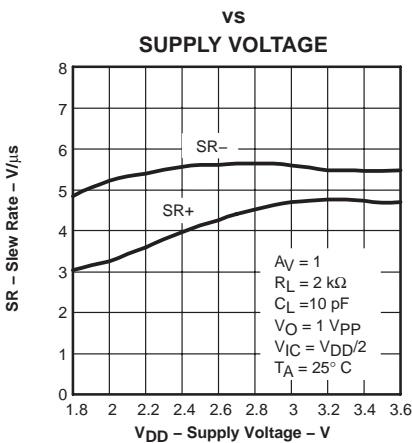


Figure 15

SLEW RATE

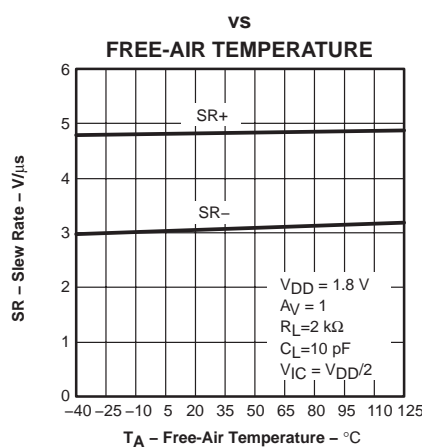


Figure 16

SLEW RATE

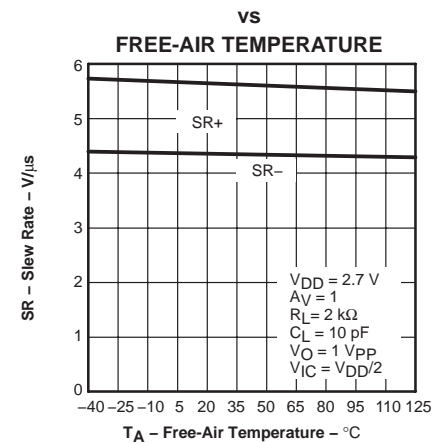


Figure 17

TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

SLOS245E – MARCH 2000 – REVISED JANUARY 2005

TYPICAL CHARACTERISTICS

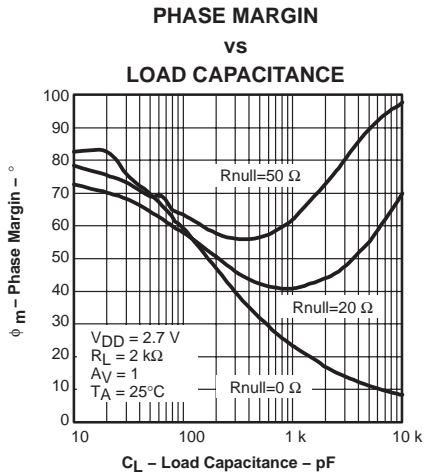


Figure 18

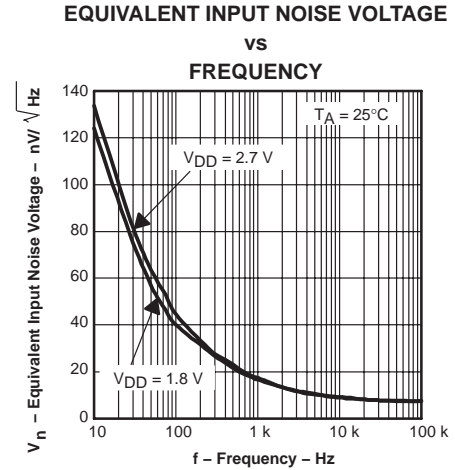


Figure 19

VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE

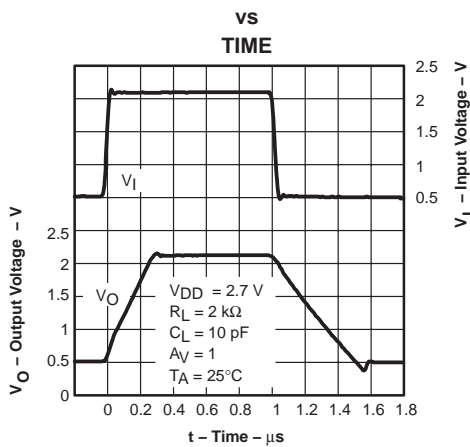


Figure 20

VOLTAGE-FOLLOWER SMALL-SIGNAL PULSE RESPONSE

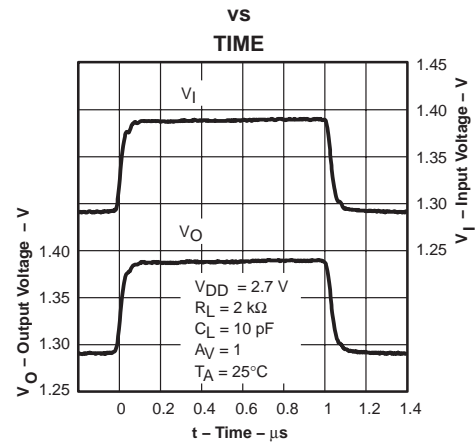


Figure 21

INVERTING LARGE-SIGNAL PULSE RESPONSE

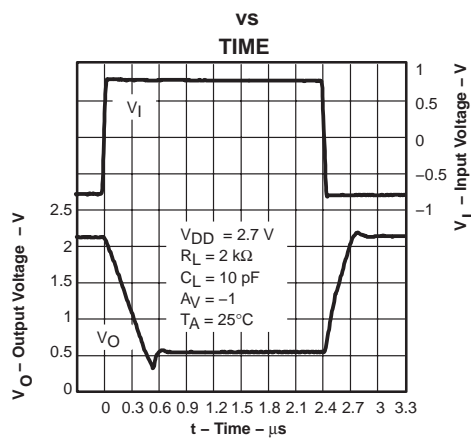


Figure 22

INVERTING SMALL-SIGNAL PULSE RESPONSE

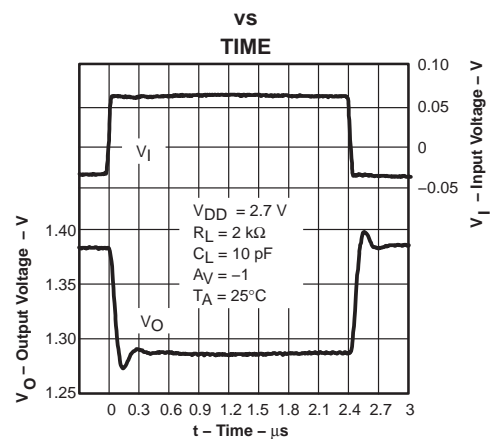
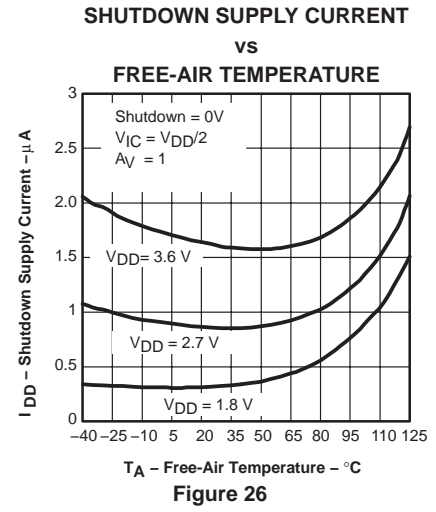
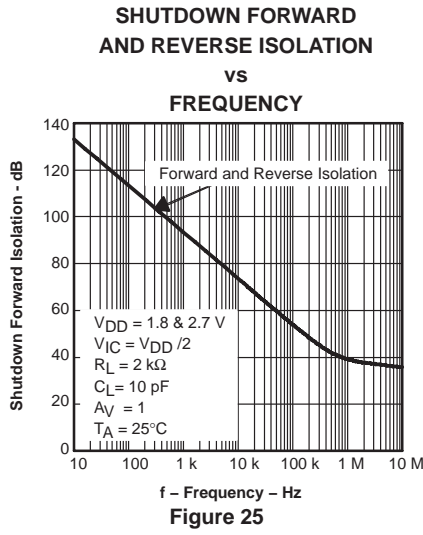
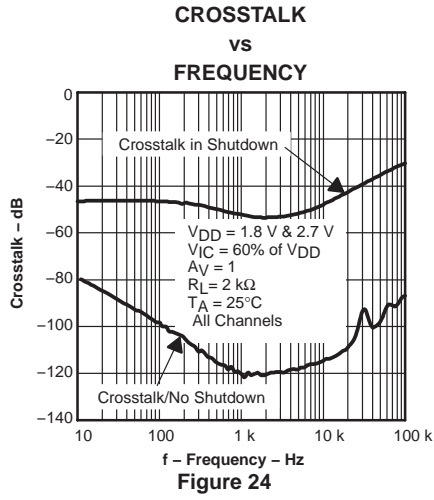


Figure 23

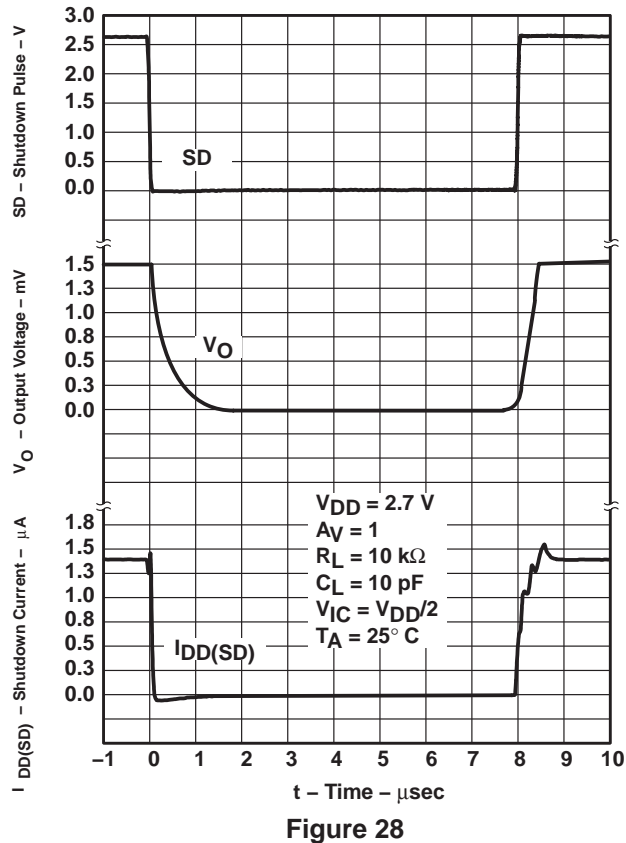
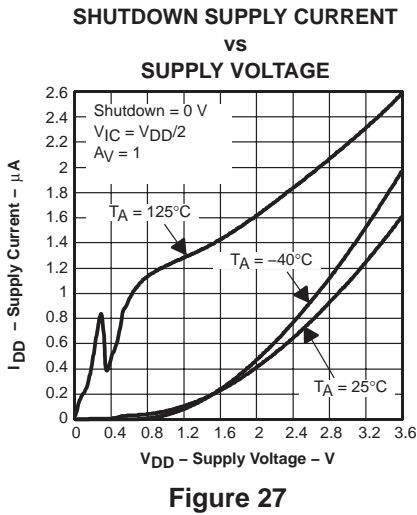
TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

SLOS245E – MARCH 2000 – REVISED JANUARY 2005

TYPICAL CHARACTERISTICS



SHUTDOWN SUPPLY CURRENT / OUTPUT VOLTAGE vs TIME



PARAMETER MEASUREMENT INFORMATION

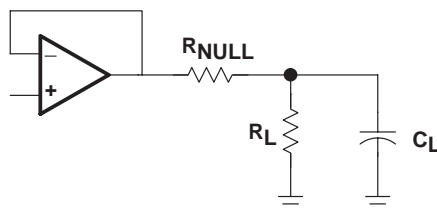


Figure 29

APPLICATION INFORMATION

driving a capacitive load

When the amplifier is configured in this manner, capacitive loading directly on the output will decrease the device's phase margin leading to high frequency ringing or oscillations. Therefore, for capacitive loads of greater than 10 pF, it is recommended that a resistor be placed in series (R_{NULL}) with the output of the amplifier, as shown in Figure 30.

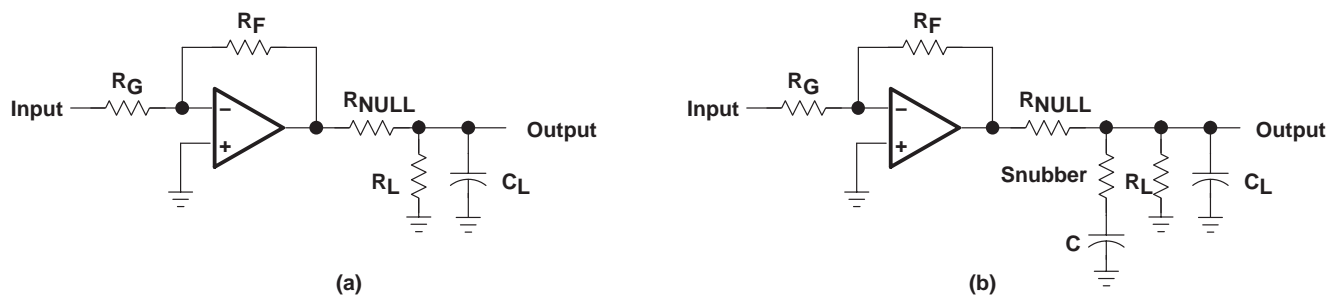


Figure 30. Driving a Capacitive Load

offset voltage

The output offset voltage, (V_{OO}) is the sum of the input offset voltage (V_{IO}) and both input bias currents (I_{IB}) times the corresponding gains. The following schematic and formula can be used to calculate the output offset voltage:

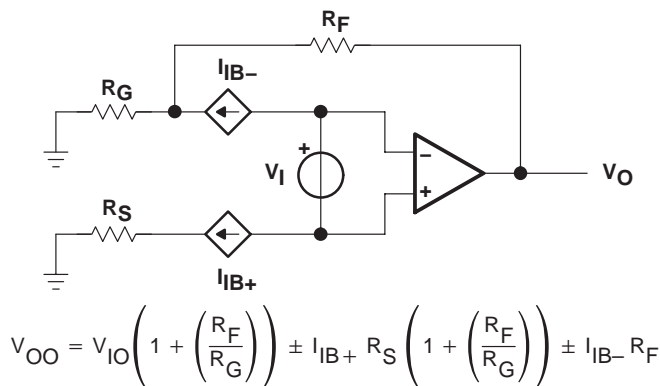


Figure 31. Output Offset Voltage Model

TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA
FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT
OPERATIONAL AMPLIFIERS WITH SHUTDOWN

SLOS245E – MARCH 2000 – REVISED JANUARY 2005

APPLICATION INFORMATION

general configurations

When receiving low-level signals, limiting the bandwidth of the incoming signals into the system is often required. The simplest way to accomplish this is to place an RC filter at the noninverting terminal of the amplifier (see Figure 32).

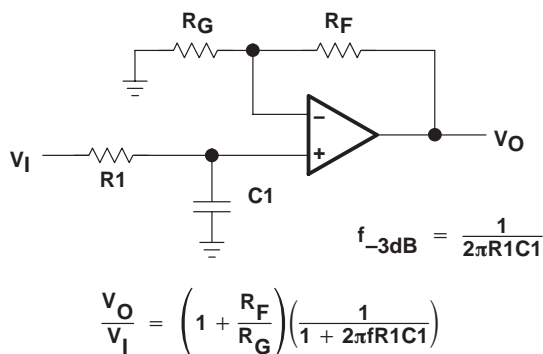


Figure 32. Single-Pole Low-Pass Filter

If even more attenuation is needed, a multiple pole filter is required. The Sallen-Key filter can be used for this task. For best results, the amplifier should have a bandwidth that is 8 to 10 times the filter frequency bandwidth. Failure to do this can result in phase shift of the amplifier.

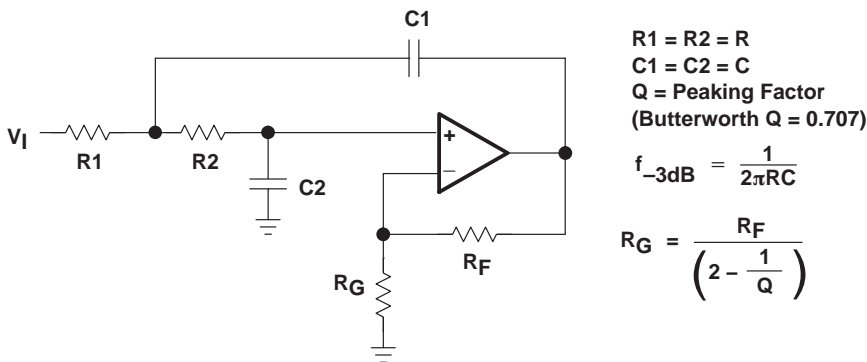


Figure 33. 2-Pole Low-Pass Sallen-Key Filter

APPLICATION INFORMATION

circuit layout considerations

To achieve the levels of high performance of the TLV278x, follow proper printed-circuit board design techniques. A general set of guidelines is given in the following.

- Ground planes – It is highly recommended that a ground plane be used on the board to provide all components with a low inductive ground connection. However, in the areas of the amplifier inputs and output, the ground plane can be removed to minimize the stray capacitance.
- Proper power supply decoupling – Use a 6.8- μ F tantalum capacitor in parallel with a 0.1- μ F ceramic capacitor on each supply terminal. It may be possible to share the tantalum among several amplifiers depending on the application, but a 0.1- μ F ceramic capacitor should always be used on the supply terminal of every amplifier. In addition, the 0.1- μ F capacitor should be placed as close as possible to the supply terminal. As this distance increases, the inductance in the connecting trace makes the capacitor less effective. The designer should strive for distances of less than 0.1 inches between the device power terminals and the ceramic capacitors.
- Sockets – Sockets can be used but are not recommended. The additional lead inductance in the socket pins will often lead to stability problems. Surface-mount packages soldered directly to the printed-circuit board is the best implementation.
- Short trace runs/compact part placements – Optimum high performance is achieved when stray series inductance has been minimized. To realize this, the circuit layout should be made as compact as possible, thereby minimizing the length of all trace runs. Particular attention should be paid to the inverting input of the amplifier. Its length should be kept as short as possible. This will help to minimize stray capacitance at the input of the amplifier.
- Surface-mount passive components – Using surface-mount passive components is recommended for high performance amplifier circuits for several reasons. First, because of the extremely low lead inductance of surface-mount components, the problem with stray series inductance is greatly reduced. Second, the small size of surface-mount components naturally leads to a more compact layout, thereby minimizing both stray inductance and capacitance. If leaded components are used, it is recommended that the lead lengths be kept as short as possible.

shutdown function

Three members of the TLV278x family (TLV2780/3/5) have a shutdown terminal for conserving battery life in portable applications. When the shutdown terminal is tied low, the supply current is reduced to 900 nA/channel, the amplifier is disabled, and the outputs are placed in a high impedance mode. To enable the amplifier, the shutdown terminal can either be left floating or pulled high. When the shutdown terminal is left floating, care should be taken to ensure that parasitic leakage current at the shutdown terminal does not inadvertently place the operational amplifier into shutdown.

TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

SLOS245E – MARCH 2000 – REVISED JANUARY 2005

APPLICATION INFORMATION

general power dissipation considerations

For a given θ_{JA} , the maximum power dissipation is shown in Figure 34 and is calculated by the following formula:

$$P_D = \left(\frac{T_{MAX} - T_A}{\theta_{JA}} \right)$$

Where:

P_D = Maximum power dissipation of TLV278x IC (watts)

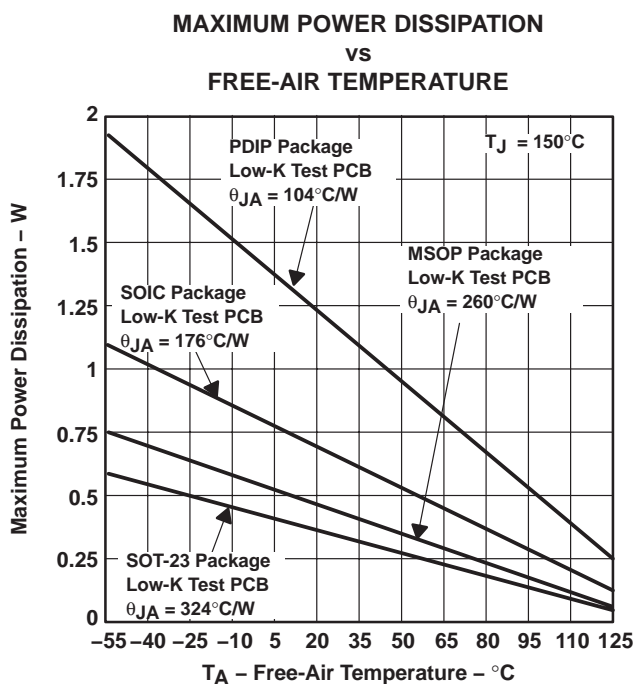
T_{MAX} = Absolute maximum junction temperature (150°C)

T_A = Free-ambient air temperature (°C)

θ_{JA} = $\theta_{JC} + \theta_{CA}$

θ_{JC} = Thermal coefficient from junction to case

θ_{CA} = Thermal coefficient from case to ambient air (°C/W)



NOTE A: Results are with no air flow and using JEDEC Standard Low-K test PCB.

Figure 34. Maximum Power Dissipation vs Free-Air Temperature

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| TLV2780CDBVR | ACTIVE | SOT-23 | DBV | 6 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | VASC | Samples |
| TLV2780CDBVRG4 | ACTIVE | SOT-23 | DBV | 6 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | VASC | Samples |
| TLV2780CDBVT | ACTIVE | SOT-23 | DBV | 6 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | VASC | Samples |
| TLV2780CDBVTG4 | ACTIVE | SOT-23 | DBV | 6 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | VASC | Samples |
| TLV2780IDBVR | ACTIVE | SOT-23 | DBV | 6 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | VASI | Samples |
| TLV2780IDBVRG4 | ACTIVE | SOT-23 | DBV | 6 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | VASI | Samples |
| TLV2780IDBVT | ACTIVE | SOT-23 | DBV | 6 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | VASI | Samples |
| TLV2780IDBVTG4 | ACTIVE | SOT-23 | DBV | 6 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | VASI | Samples |
| TLV2780IDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | T2780I | Samples |
| TLV2780IDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | T2780I | Samples |
| TLV2781CDBVR | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | VATC | Samples |
| TLV2781CDBVRG4 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | VATC | Samples |
| TLV2781CDBVT | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | VATC | Samples |
| TLV2781CDBVTG4 | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | VATC | Samples |
| TLV2781ID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | T2781I | Samples |
| TLV2781IDBVR | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | VATI | Samples |
| TLV2781IDBVRG4 | ACTIVE | SOT-23 | DBV | 5 | 3000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | VATI | Samples |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|----------------------------|----------------------|--------------|-------------------------|-------------------------|
| TLV2781IDBVT | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | VATI | Samples |
| TLV2781IDBVTG4 | ACTIVE | SOT-23 | DBV | 5 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | VATI | Samples |
| TLV2781IDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | T2781I | Samples |
| TLV2781IDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | T2781I | Samples |
| TLV2781IDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | T2781I | Samples |
| TLV2782AID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2782AI | Samples |
| TLV2782AIDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2782AI | Samples |
| TLV2782CD | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 2782C | Samples |
| TLV2782CDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 2782C | Samples |
| TLV2782CDGK | ACTIVE | VSSOP | DGK | 8 | 80 | Green (RoHS & no Sb/Br) | CU NIPDAU CU NIPDAUAG | Level-1-260C-UNLIM | 0 to 70 | ADL | Samples |
| TLV2782CDGKG4 | ACTIVE | VSSOP | DGK | 8 | 80 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | ADL | Samples |
| TLV2782CDGKR | ACTIVE | VSSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU CU NIPDAUAG | Level-1-260C-UNLIM | 0 to 70 | ADL | Samples |
| TLV2782CDGKRG4 | ACTIVE | VSSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | ADL | Samples |
| TLV2782CDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 2782C | Samples |
| TLV2782CDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 2782C | Samples |
| TLV2782ID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2782I | Samples |
| TLV2782IDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2782I | Samples |
| TLV2782IDGK | ACTIVE | VSSOP | DGK | 8 | 80 | Green (RoHS & no Sb/Br) | CU NIPDAU CU NIPDAUAG | Level-1-260C-UNLIM | -40 to 125 | ADM | Samples |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|-------------------------|----------------------------|----------------------|--------------|-------------------------|-------------------------|
| TLV2782IDGKG4 | ACTIVE | VSSOP | DGK | 8 | 80 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | ADM | Samples |
| TLV2782IDGKR | ACTIVE | VSSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU CU NIPDAUAG | Level-1-260C-UNLIM | -40 to 125 | ADM | Samples |
| TLV2782IDGKRG4 | ACTIVE | VSSOP | DGK | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | ADM | Samples |
| TLV2782IDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2782I | Samples |
| TLV2782IDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2782I | Samples |
| TLV2782IP | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg Type | -40 to 125 | TLV2782IP | Samples |
| TLV2782IPE4 | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg Type | -40 to 125 | TLV2782IP | Samples |
| TLV2783CDR | ACTIVE | SOIC | D | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | TLV2783C | Samples |
| TLV2783CDRG4 | ACTIVE | SOIC | D | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | TLV2783C | Samples |
| TLV2783ID | ACTIVE | SOIC | D | 14 | 50 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TLV2783I | Samples |
| TLV2783IDG4 | ACTIVE | SOIC | D | 14 | 50 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TLV2783I | Samples |
| TLV2783IDGS | ACTIVE | VSSOP | DGS | 10 | 80 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | ADO | Samples |
| TLV2783IDGSG4 | ACTIVE | VSSOP | DGS | 10 | 80 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | ADO | Samples |
| TLV2783IDGSR | ACTIVE | VSSOP | DGS | 10 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | ADO | Samples |
| TLV2783IDGSRG4 | ACTIVE | VSSOP | DGS | 10 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | ADO | Samples |
| TLV2783IN | ACTIVE | PDIP | N | 14 | 25 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg Type | -40 to 125 | TLV2783I | Samples |
| TLV2783INE4 | ACTIVE | PDIP | N | 14 | 25 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg Type | -40 to 125 | TLV2783I | Samples |
| TLV2784AID | ACTIVE | SOIC | D | 14 | 50 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2784AI | Samples |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| TLV2784AIDG4 | ACTIVE | SOIC | D | 14 | 50 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2784AI | Samples |
| TLV2784AIDR | ACTIVE | SOIC | D | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2784AI | Samples |
| TLV2784AIDRG4 | ACTIVE | SOIC | D | 14 | | TBD | Call TI | Call TI | -40 to 125 | | Samples |
| TLV2784CPWR | ACTIVE | TSSOP | PW | 14 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 2784C | Samples |
| TLV2784CPWRG4 | ACTIVE | TSSOP | PW | 14 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 2784C | Samples |
| TLV2784ID | ACTIVE | SOIC | D | 14 | 50 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TLV2784I | Samples |
| TLV2784IDG4 | ACTIVE | SOIC | D | 14 | 50 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TLV2784I | Samples |
| TLV2784IDR | ACTIVE | SOIC | D | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TLV2784I | Samples |
| TLV2784IDRG4 | ACTIVE | SOIC | D | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TLV2784I | Samples |
| TLV2784IPW | ACTIVE | TSSOP | PW | 14 | 90 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2784I | Samples |
| TLV2784IPWG4 | ACTIVE | TSSOP | PW | 14 | 90 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2784I | Samples |
| TLV2784IPWR | ACTIVE | TSSOP | PW | 14 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2784I | Samples |
| TLV2784IPWRG4 | ACTIVE | TSSOP | PW | 14 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2784I | Samples |
| TLV2785AID | ACTIVE | SOIC | D | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2785AI | Samples |
| TLV2785AIDG4 | ACTIVE | SOIC | D | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2785AI | Samples |
| TLV2785CPWR | ACTIVE | TSSOP | PW | 16 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 2785C | Samples |
| TLV2785CPWRG4 | ACTIVE | TSSOP | PW | 16 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 2785C | Samples |
| TLV2785IDR | ACTIVE | SOIC | D | 16 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TLV2785I | Samples |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|-------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| TLV2785IDRG4 | ACTIVE | SOIC | D | 16 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TLV2785I | Samples |
| TLV2785IN | ACTIVE | PDIP | N | 16 | 25 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg Type | -40 to 125 | TLV2785I | Samples |
| TLV2785INE4 | ACTIVE | PDIP | N | 16 | 25 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg Type | -40 to 125 | TLV2785I | Samples |
| TLV2785IPWR | ACTIVE | TSSOP | PW | 16 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2785I | Samples |
| TLV2785IPWRG4 | ACTIVE | TSSOP | PW | 16 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2785I | Samples |

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

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

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

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

OBSELETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

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.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

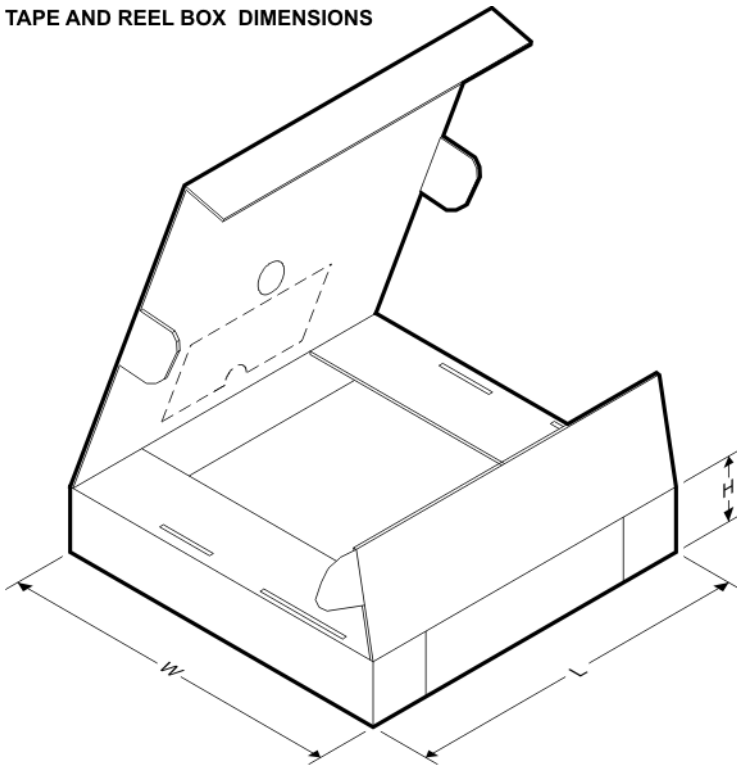
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TLV2780CDBVR | SOT-23 | DBV | 6 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV2780CDBVT | SOT-23 | DBV | 6 | 250 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV2780IDBVR | SOT-23 | DBV | 6 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV2780IDBVT | SOT-23 | DBV | 6 | 250 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV2780IDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| TLV2781CDBVR | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV2781CDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV2781IDBVR | SOT-23 | DBV | 5 | 3000 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV2781IDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 9.0 | 3.15 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV2781IDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| TLV2782CDGKR | VSSOP | DGK | 8 | 2500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| TLV2782CDGKR | VSSOP | DGK | 8 | 2500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| TLV2782CDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| TLV2782IDGKR | VSSOP | DGK | 8 | 2500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| TLV2782IDGKR | VSSOP | DGK | 8 | 2500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |
| TLV2782IDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| TLV2783CDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| TLV2783IDGSR | VSSOP | DGS | 10 | 2500 | 330.0 | 12.4 | 5.3 | 3.4 | 1.4 | 8.0 | 12.0 | Q1 |

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TLV2784AIDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| TLV2784CPWR | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| TLV2784IDR | SOIC | D | 14 | 2500 | 330.0 | 16.4 | 6.5 | 9.0 | 2.1 | 8.0 | 16.0 | Q1 |
| TLV2784IPWR | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| TLV2785CPWR | TSSOP | PW | 16 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| TLV2785IDR | SOIC | D | 16 | 2500 | 330.0 | 16.4 | 6.5 | 10.3 | 2.1 | 8.0 | 16.0 | Q1 |
| TLV2785IPWR | TSSOP | PW | 16 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS



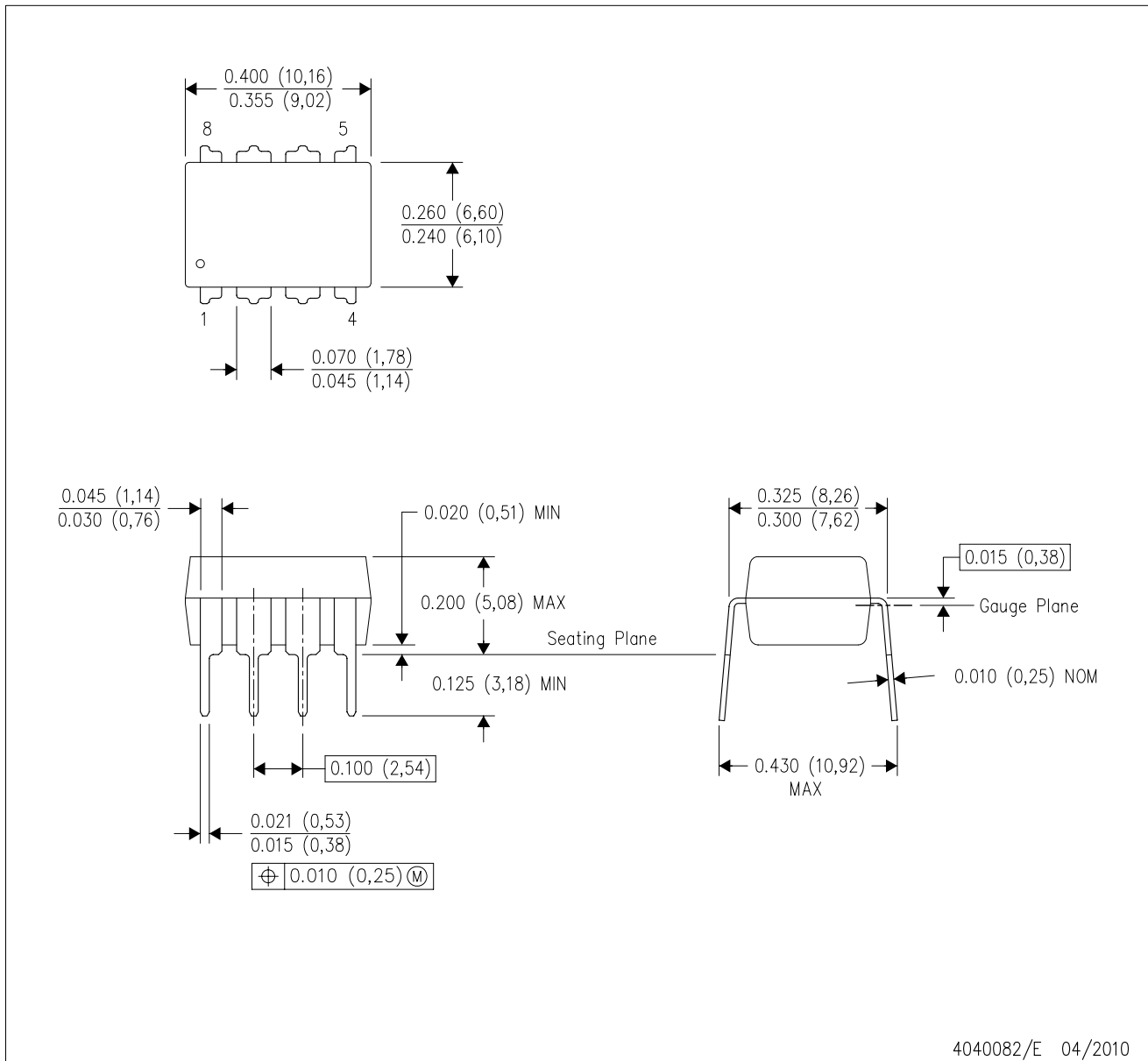
*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TLV2780CDBVR | SOT-23 | DBV | 6 | 3000 | 182.0 | 182.0 | 20.0 |
| TLV2780CDBVT | SOT-23 | DBV | 6 | 250 | 182.0 | 182.0 | 20.0 |
| TLV2780IDBVR | SOT-23 | DBV | 6 | 3000 | 182.0 | 182.0 | 20.0 |
| TLV2780IDBVT | SOT-23 | DBV | 6 | 250 | 182.0 | 182.0 | 20.0 |
| TLV2780IDR | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| TLV2781CDBVR | SOT-23 | DBV | 5 | 3000 | 182.0 | 182.0 | 20.0 |
| TLV2781CDBVT | SOT-23 | DBV | 5 | 250 | 182.0 | 182.0 | 20.0 |
| TLV2781IDBVR | SOT-23 | DBV | 5 | 3000 | 182.0 | 182.0 | 20.0 |
| TLV2781IDBVT | SOT-23 | DBV | 5 | 250 | 182.0 | 182.0 | 20.0 |
| TLV2781IDR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TLV2782CDGKR | VSSOP | DGK | 8 | 2500 | 364.0 | 364.0 | 27.0 |
| TLV2782CDGKR | VSSOP | DGK | 8 | 2500 | 358.0 | 335.0 | 35.0 |
| TLV2782CDR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| TLV2782IDGKR | VSSOP | DGK | 8 | 2500 | 364.0 | 364.0 | 27.0 |
| TLV2782IDGKR | VSSOP | DGK | 8 | 2500 | 358.0 | 335.0 | 35.0 |
| TLV2782IDR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| TLV2783CDR | SOIC | D | 14 | 2500 | 367.0 | 367.0 | 38.0 |
| TLV2783IDGSR | VSSOP | DGS | 10 | 2500 | 358.0 | 335.0 | 35.0 |
| TLV2784AIDR | SOIC | D | 14 | 2500 | 367.0 | 367.0 | 38.0 |
| TLV2784CPWR | TSSOP | PW | 14 | 2000 | 367.0 | 367.0 | 35.0 |
| TLV2784IDR | SOIC | D | 14 | 2500 | 367.0 | 367.0 | 38.0 |
| TLV2784IPWR | TSSOP | PW | 14 | 2000 | 367.0 | 367.0 | 35.0 |
| TLV2785CPWR | TSSOP | PW | 16 | 2000 | 367.0 | 367.0 | 35.0 |
| TLV2785IDR | SOIC | D | 16 | 2500 | 367.0 | 367.0 | 38.0 |
| TLV2785IPWR | TSSOP | PW | 16 | 2000 | 367.0 | 367.0 | 35.0 |

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE

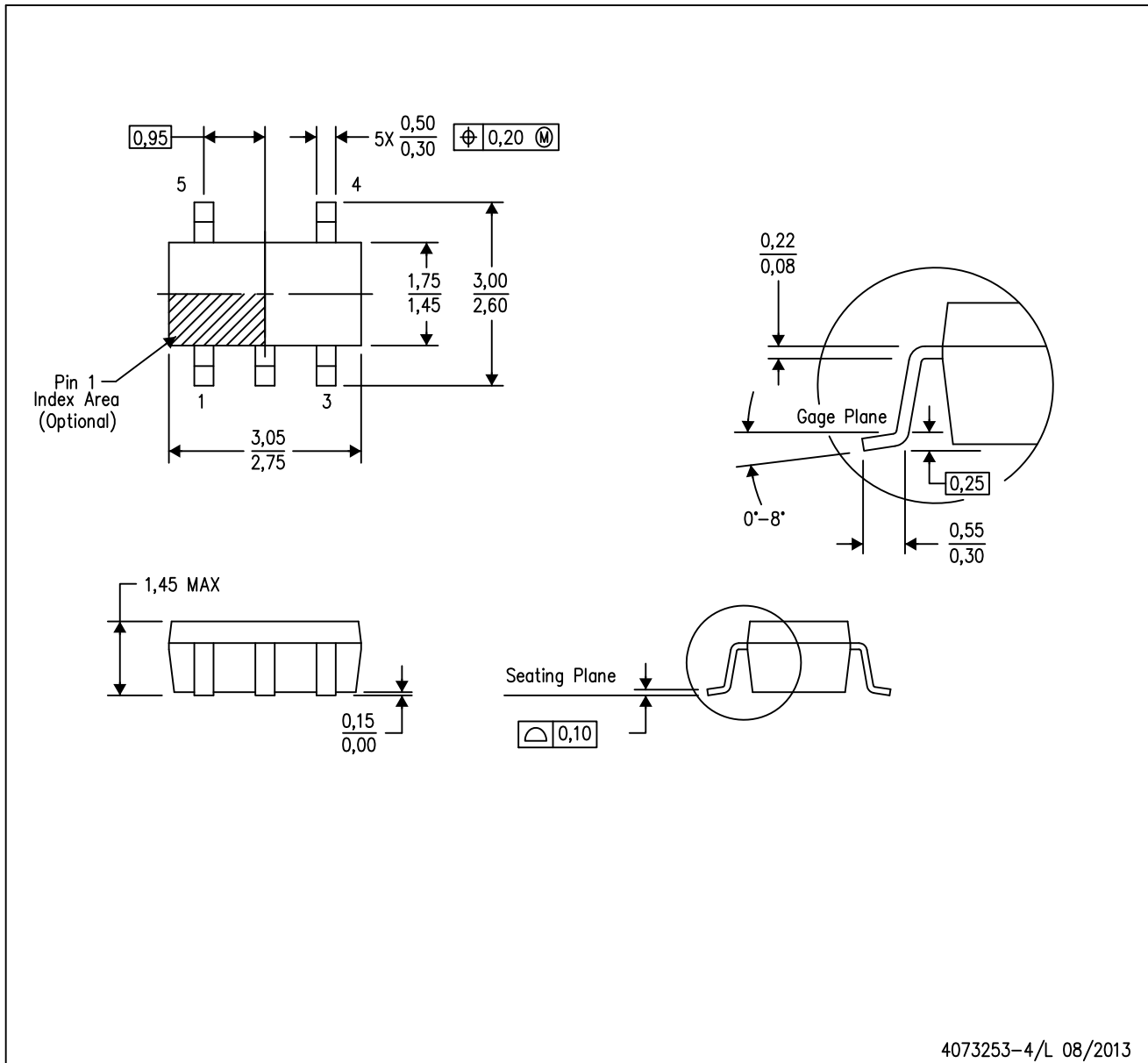


- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. Falls within JEDEC MS-001 variation BA.

MECHANICAL DATA

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE



4073253-4/L 08/2013

- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
 - D. Falls within JEDEC MO-178 Variation AA.

DBV (R-PDSO-G5)

PLASTIC SMALL OUTLINE

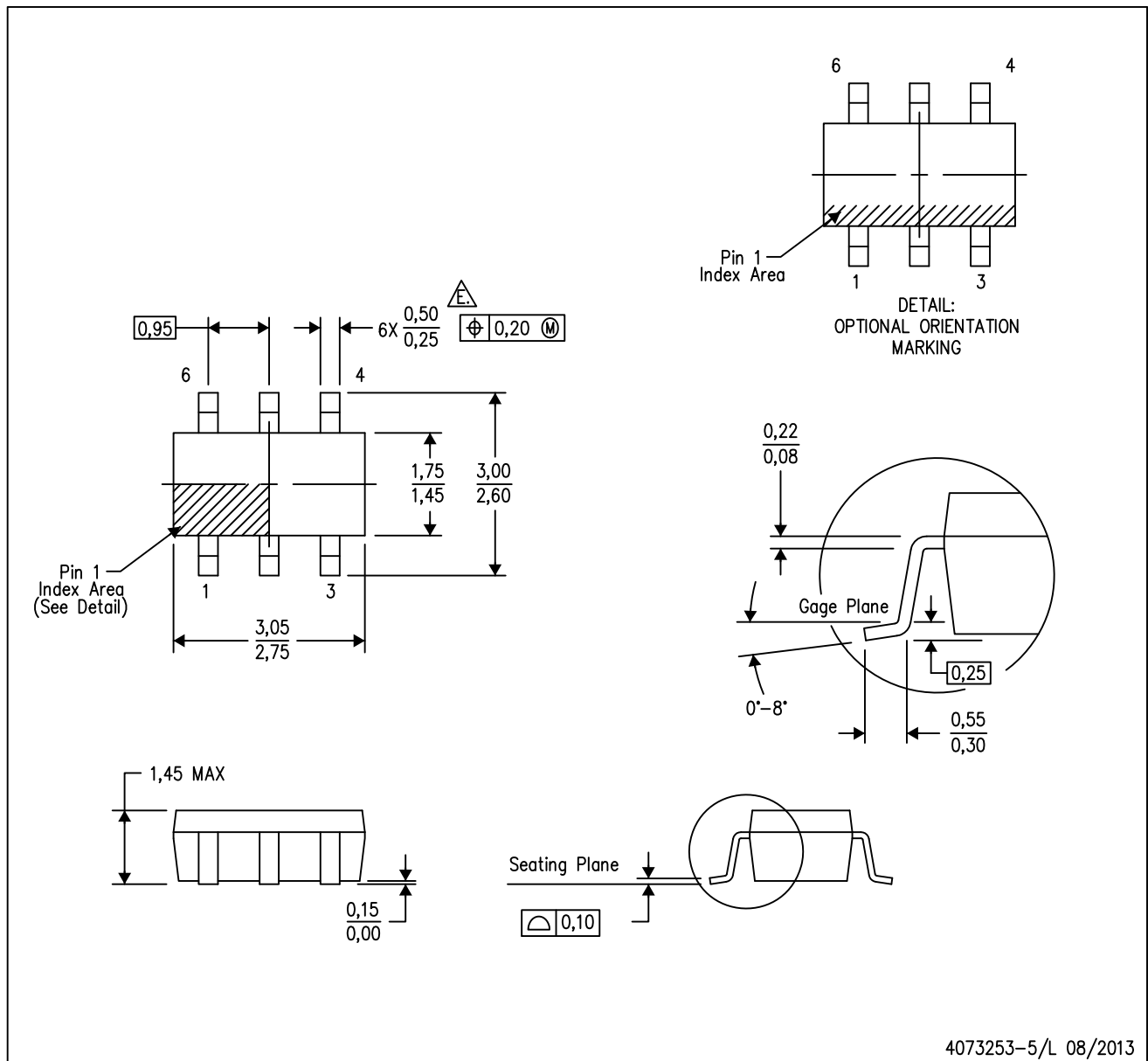


- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
 - D. Publication IPC-7351 is recommended for alternate designs.
 - E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.

MECHANICAL DATA

DBV (R-PDSO-G6)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
 - D. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
- Falls within JEDEC MO-178 Variation AB, except minimum lead width.

DBV (R-PDSO-G6)

PLASTIC SMALL OUTLINE



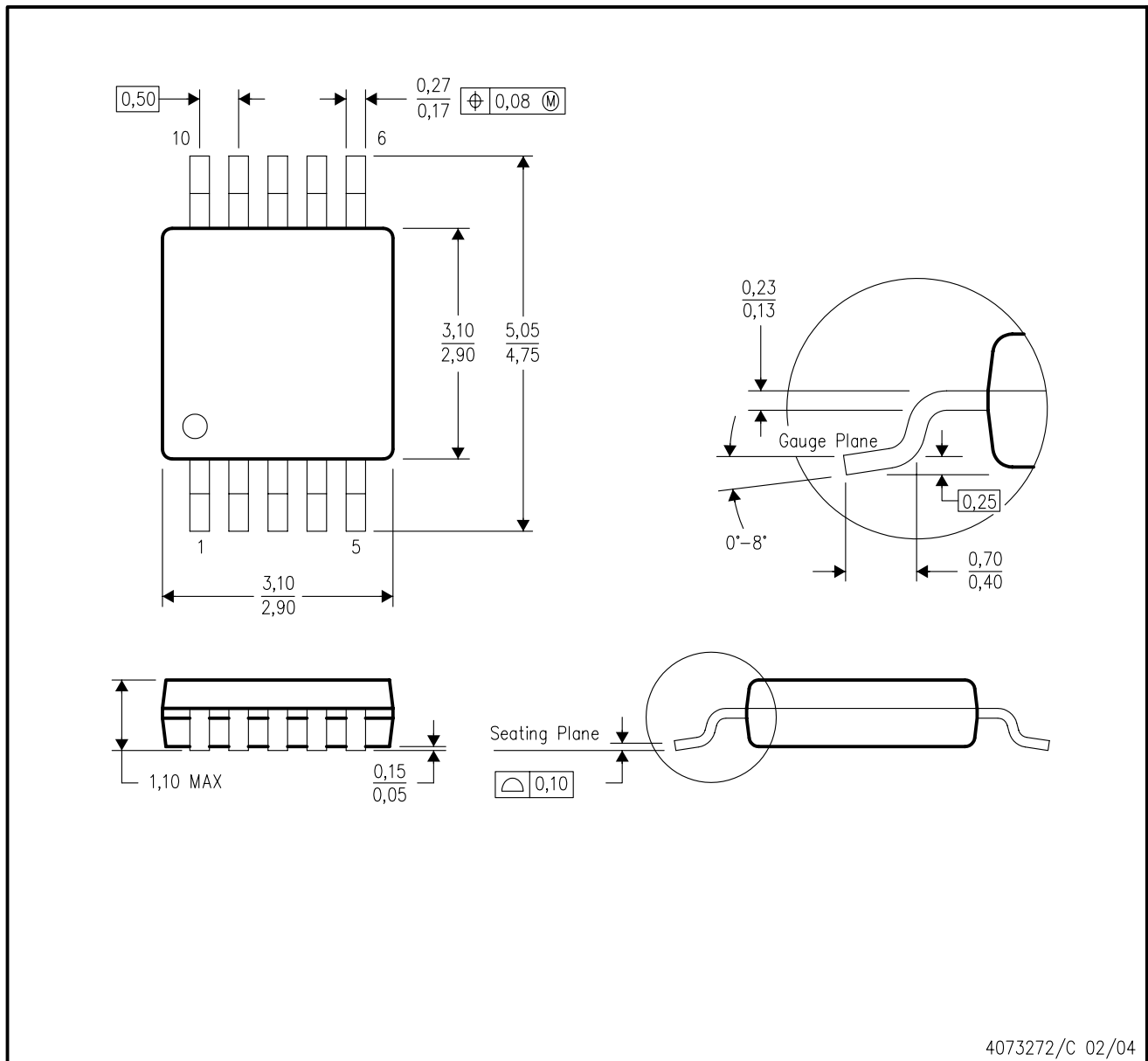
- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
 - D. Publication IPC-7351 is recommended for alternate designs.
 - E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Publication IPC-7351 is recommended for alternate designs.
 - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
 - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

DGS (S-PDSO-G10)

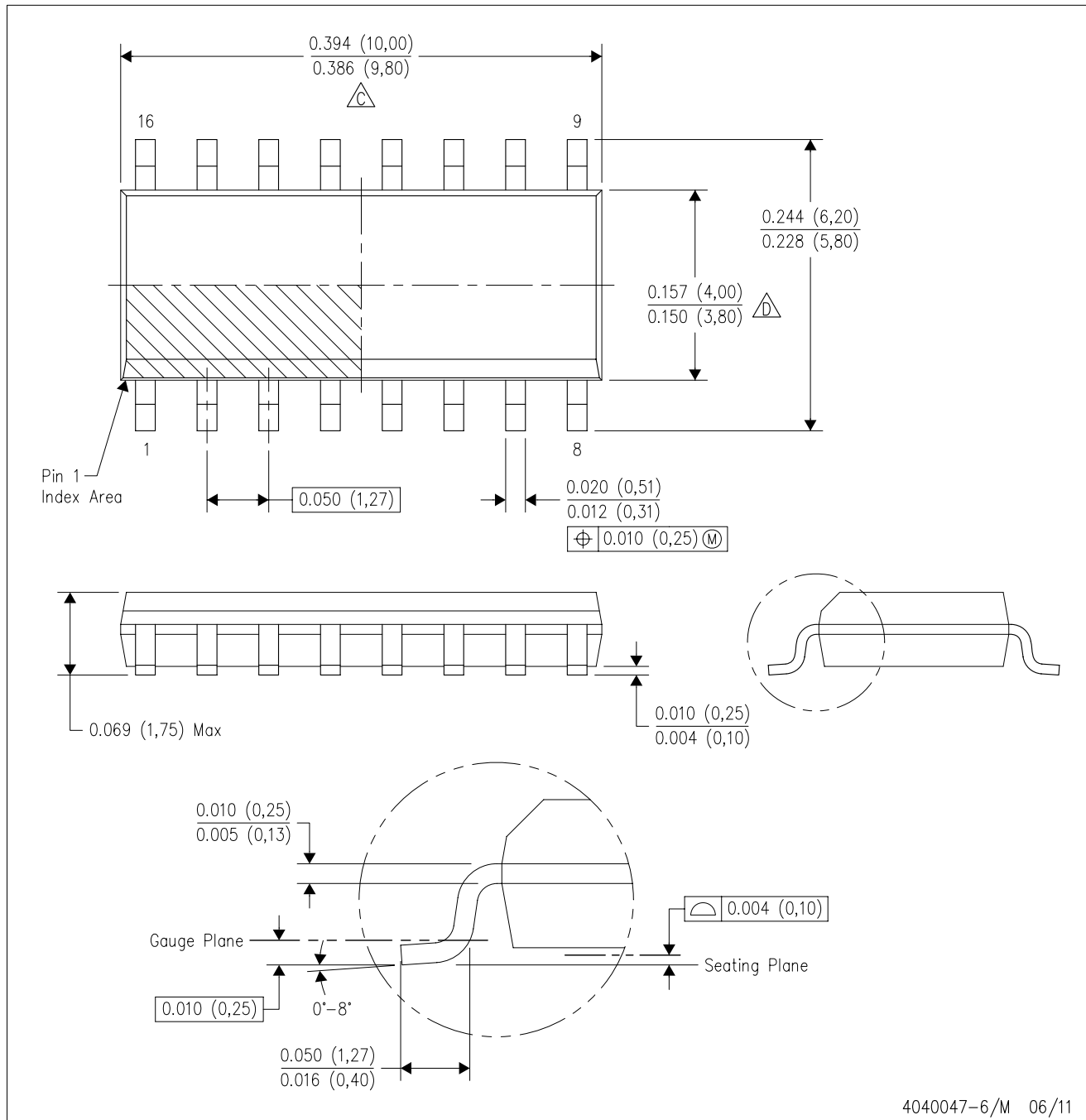
PLASTIC SMALL-OUTLINE PACKAGE





- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold flash or protrusion.
 - D. Falls within JEDEC MO-187 variation BA.

D (R-PDSO-G16)

PLASTIC SMALL OUTLINE



4040047-6/M 06/11

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

D (R-PDSO-G16)

PLASTIC SMALL OUTLINE

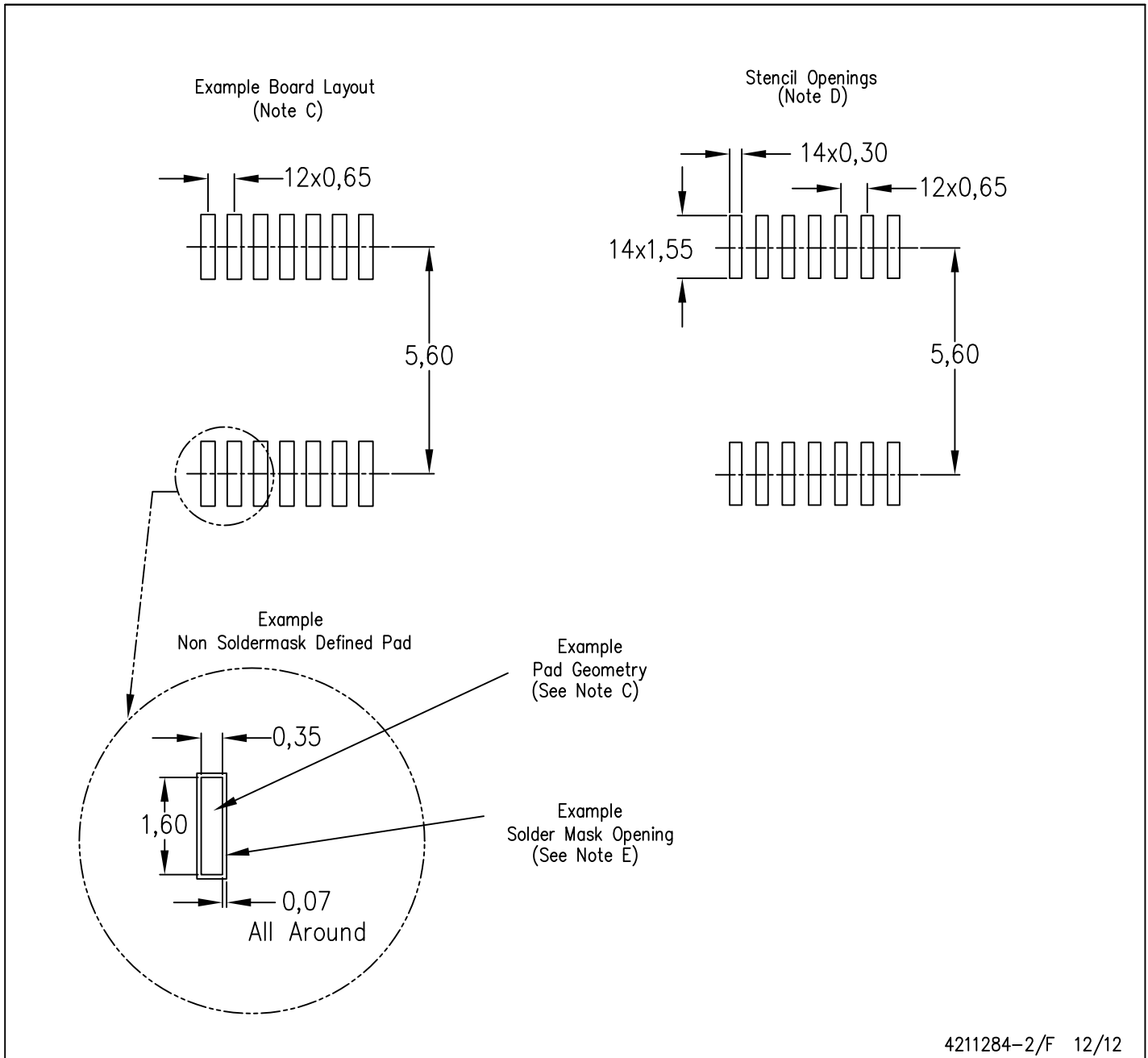


4211283-4/E 08/12

- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Publication IPC-7351 is recommended for alternate designs.
 - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
 - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

PW (R-PDSO-G14)

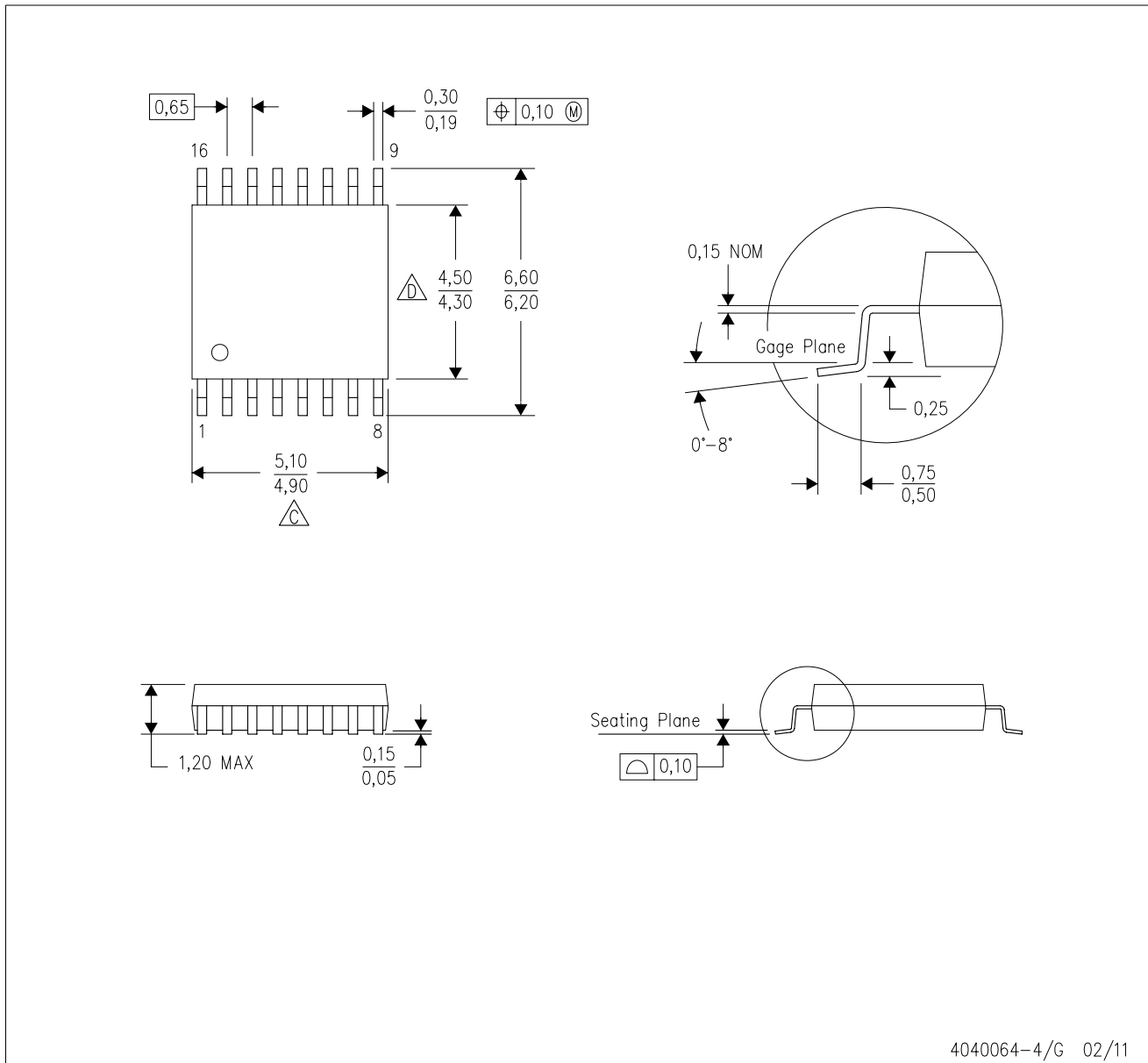
PLASTIC SMALL OUTLINE



- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Publication IPC-7351 is recommended for alternate designs.
 - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
 - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

PW (R-PDSO-G16)

PLASTIC SMALL OUTLINE

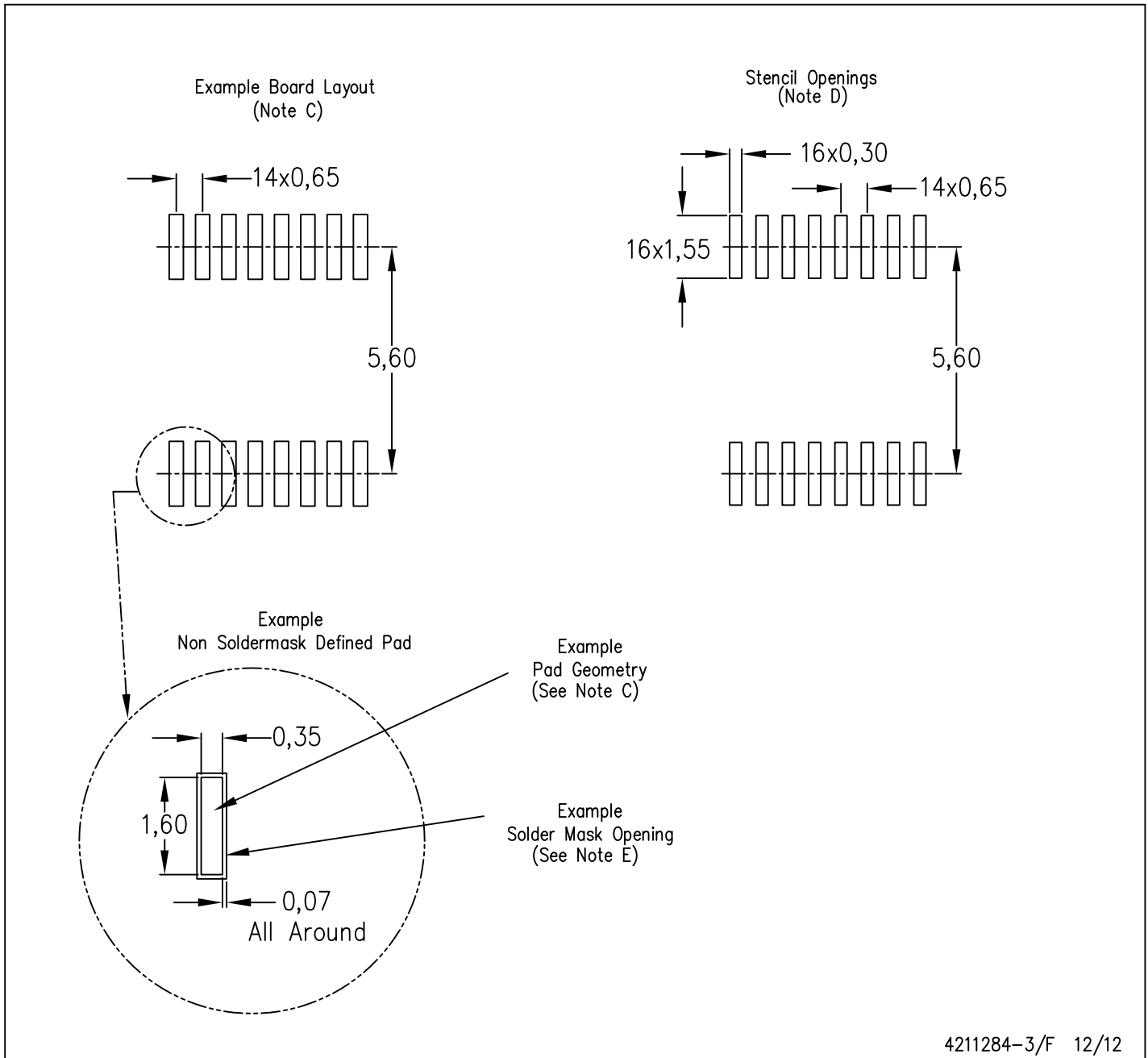


4040064-4/G 02/11

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

PW (R-PDSO-G16)

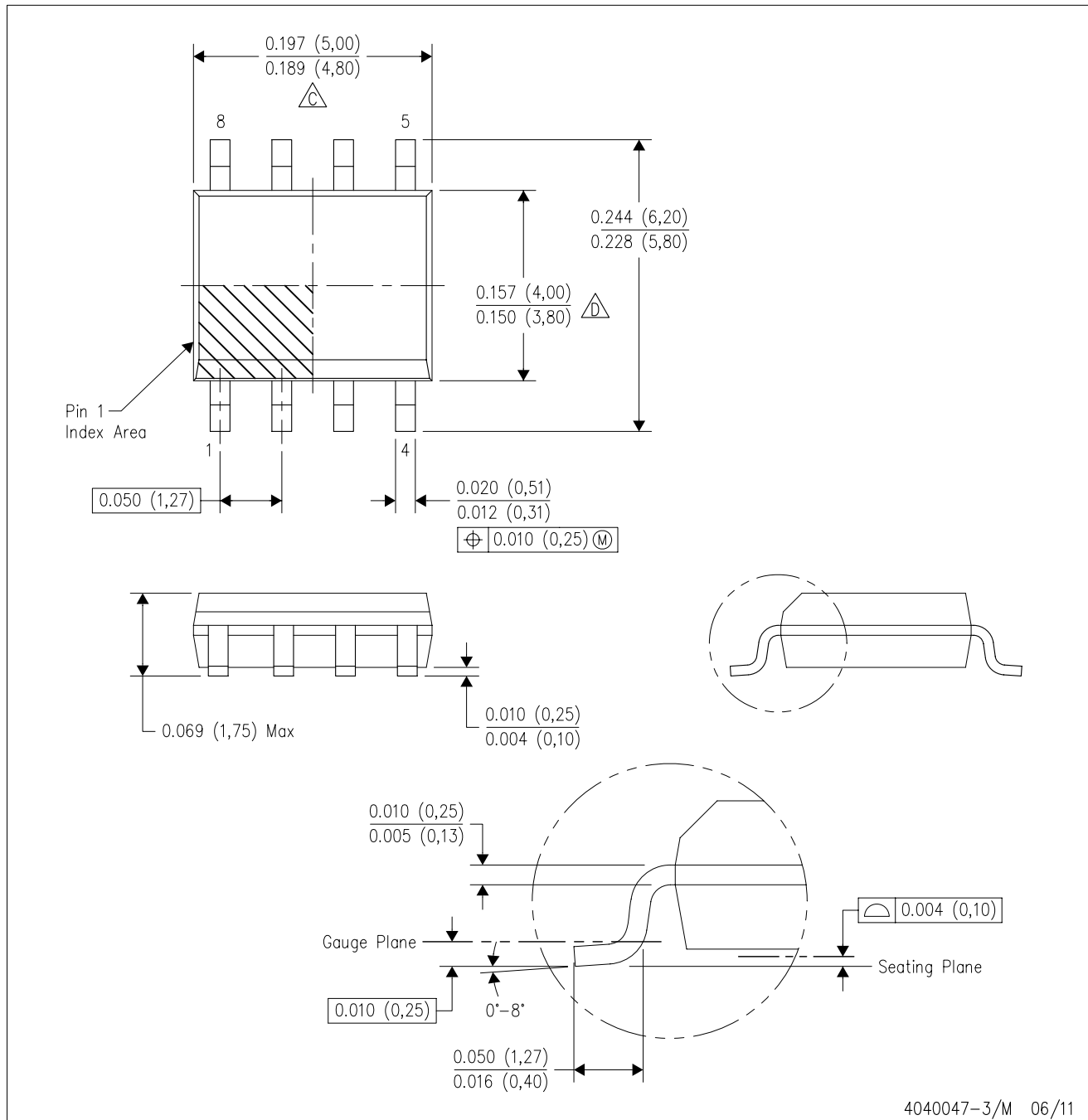
PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Publication IPC-7351 is recommended for alternate designs.
 - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
 - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

D (R-PDSO-G8)

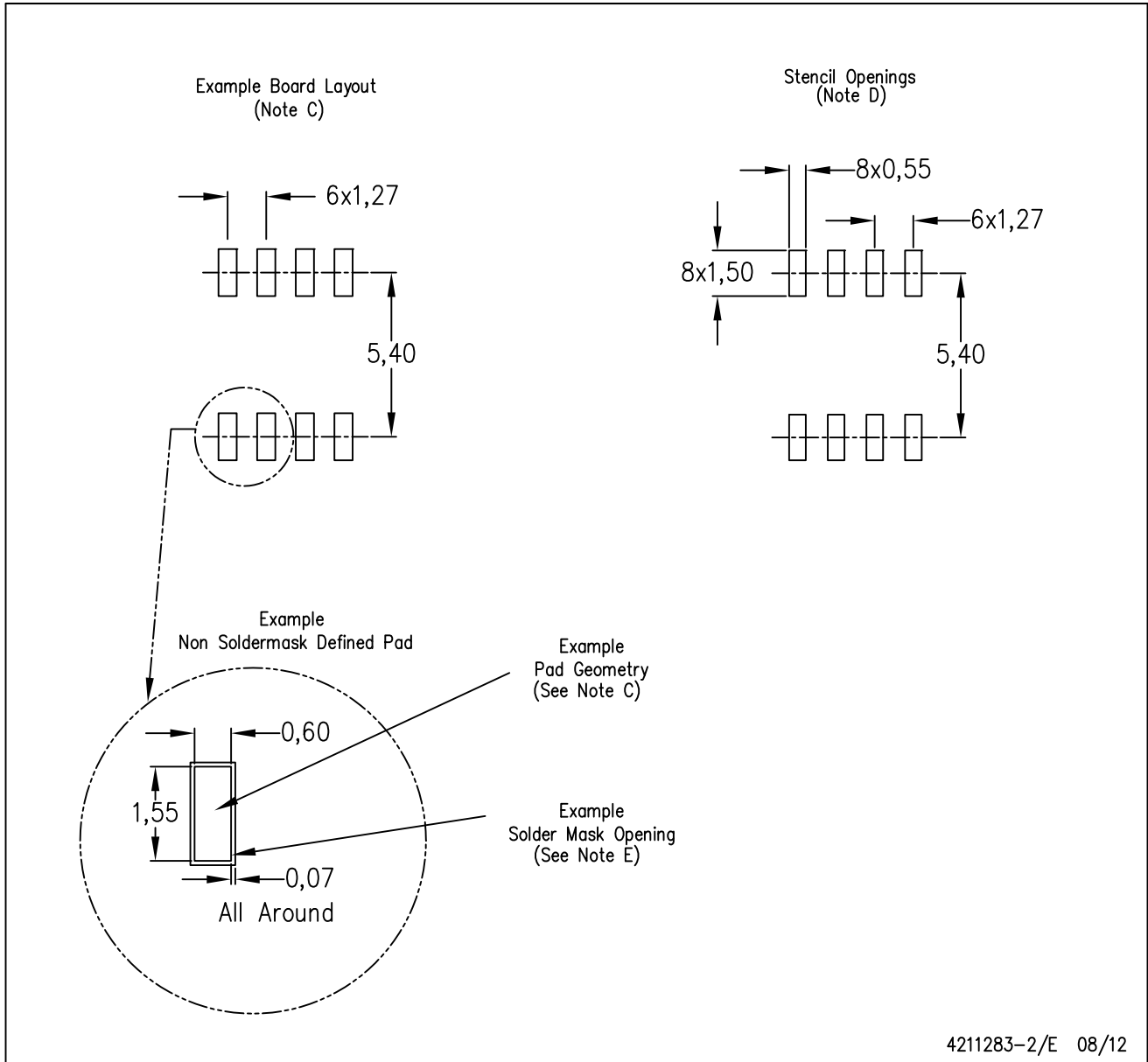
PLASTIC SMALL OUTLINE



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

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Publication IPC-7351 is recommended for alternate designs.
 - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
 - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

| | |
|------------------------------|--|
| Audio | www.ti.com/audio |
| Amplifiers | amplifier.ti.com |
| Data Converters | dataconverter.ti.com |
| DLP® Products | www.dlp.com |
| DSP | dsp.ti.com |
| Clocks and Timers | www.ti.com/clocks |
| Interface | interface.ti.com |
| Logic | logic.ti.com |
| Power Mgmt | power.ti.com |
| Microcontrollers | microcontroller.ti.com |
| RFID | www.ti-rfid.com |
| OMAP Applications Processors | www.ti.com/omap |
| Wireless Connectivity | www.ti.com/wirelessconnectivity |

Applications

| | |
|-------------------------------|--|
| Automotive and Transportation | www.ti.com/automotive |
| Communications and Telecom | www.ti.com/communications |
| Computers and Peripherals | www.ti.com/computers |
| Consumer Electronics | www.ti.com/consumer-apps |
| Energy and Lighting | www.ti.com/energy |
| Industrial | www.ti.com/industrial |
| Medical | www.ti.com/medical |
| Security | www.ti.com/security |
| Space, Avionics and Defense | www.ti.com/space-avionics-defense |
| Video and Imaging | www.ti.com/video |

TI E2E Community

e2e.ti.com