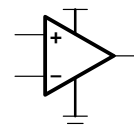


# TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

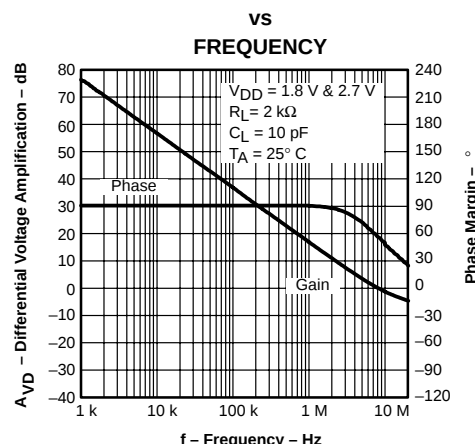
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- Supply Voltage Range . . . 1.8 V to 3.6 V
- Rail-to-Rail Input/Output
- High Bandwidth . . . 8 MHz
- High Slew Rate . . . 4.8 V/ $\mu$ s
- $V_{ICR}$  Exceeds Rails . . .  $-0.2$  V to  $V_{DD} + 0.2$
- Supply Current . . . 650  $\mu$ A/Channel
-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

## Operational Amplifier



## DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE



## 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 ( $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ ) while adding the rail-to-rail output swing feature. The TLV278x also provides 8 MHz bandwidth from only 650  $\mu$ A of supply current. The maximum recommended supply voltage is 3.6 V, which allows the devices to be operated from ( $\pm 1.8$  V supplies down to  $\pm 0.9$  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     | $V_{DD}$<br>[V] | $V_{IO}$<br>[ $\mu$ V] | $I_{DD}/\text{ch}$<br>[ $\mu$ A] | $I_{IB}$<br>[pA] | GBW<br>[MHz] | SLEW RATE<br>[V/ $\mu$ s] | $V_n$ , 1 kHz<br>[nV/ $\sqrt{\text{rt Hz}}$ ] | $I_O$<br>[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**

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# TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA

## FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT

### OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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#### TLV2780 and TLV2781 AVAILABLE OPTIONS

| T <sub>A</sub> | V <sub>IOmax</sub><br>AT 25°C | PACKAGED DEVICES                  |                            |              |                        |
|----------------|-------------------------------|-----------------------------------|----------------------------|--------------|------------------------|
|                |                               | SMALL OUTLINE<br>(D) <sup>†</sup> | SOT-23                     |              | PLASTIC DIP<br>(P)     |
|                |                               |                                   | (DBV) <sup>‡</sup>         | SYMBOL       |                        |
| 0°C to 70°C    | 3000 µV                       | TLV2780CD<br>TLV2781CD            | TLV2780CDBV<br>TLV2781CDBV | VAOC<br>VAPC | —<br>—                 |
|                |                               | TLV2780ID<br>TLV2781ID            | TLV2780IDBV<br>TLV2781IDBV | VAOI<br>VAPI | TLV2780IP<br>TLV2781IP |
| -40°C to 125°C | 3000 µV                       | TLV2780ID<br>TLV2781ID            | TLV2780IDBV<br>TLV2781IDBV | VAOI<br>VAPI | TLV2780IP<br>TLV2781IP |
|                | 2000 µV                       | TLV2780AID<br>TLV2781AID          | —<br>—                     | —<br>—       | —<br>—                 |

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

<sup>‡</sup> 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

| T <sub>A</sub> | V <sub>IO</sub> max<br>AT 25°C | PACKAGED DEVICES         |                  |              |                  |              |                       |                       |
|----------------|--------------------------------|--------------------------|------------------|--------------|------------------|--------------|-----------------------|-----------------------|
|                |                                | SMALL<br>OUTLINE†<br>(D) | MSOP             |              |                  |              | PLASTIC<br>DIP<br>(N) | PLASTIC<br>DIP<br>(P) |
|                |                                |                          | (DGK)†           | SYMBOL       | (DGS)†           | SYMBOL       |                       |                       |
| 0°C to 70°C    | 3000 μV                        | TLV2782CD<br>TLV2783CD   | TLV2782CDGK<br>— | xxTIAAI<br>— | —<br>TLV2783CDGS | —<br>xxTIAAK | —<br>—                | —<br>—                |
| –40°C to 125°C | 3000 μV                        | TLV2782ID<br>TLV2783ID   | TLV2782IDGK<br>— | xxTIAAJ<br>— | —<br>TLV2783IDGS | —<br>xxTIAAL | —<br>TLV2783IN        | TLV2782IP<br>—        |
|                | 2000 μV                        | TLV2782AID<br>TLV2783AID | —<br>—           | —<br>—       | —<br>—           | —<br>—       | —<br>—                | —<br>—                |

<sup>†</sup> 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

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

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

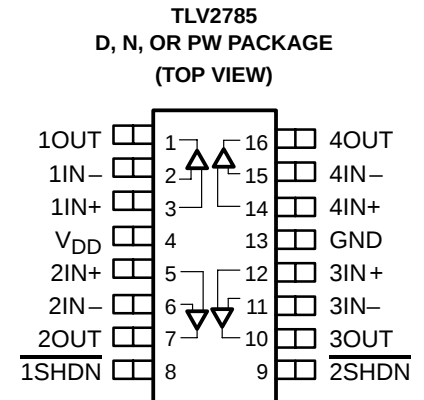
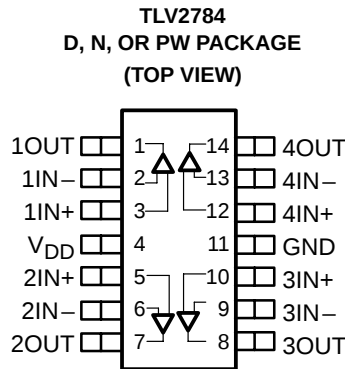
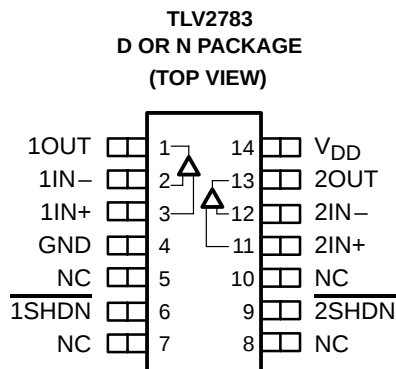
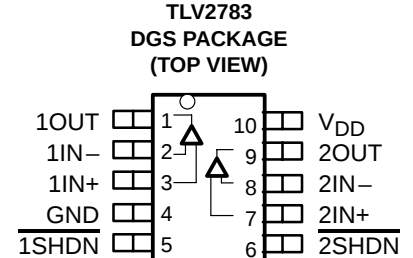
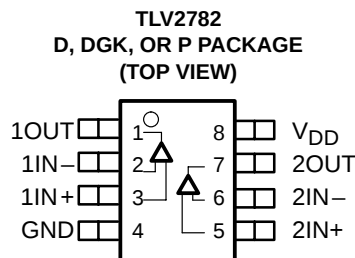
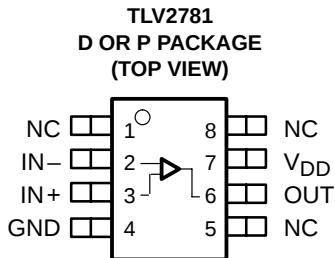
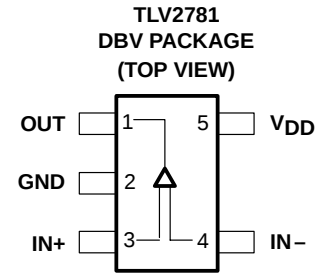
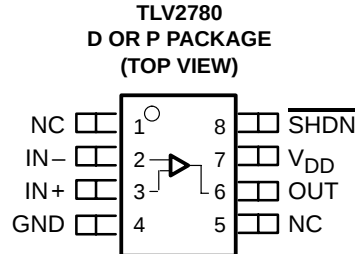
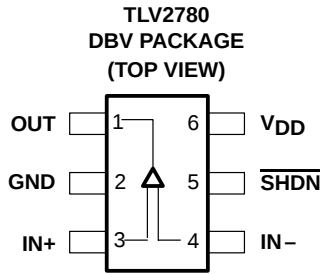


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# TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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## TLV278x PACKAGE PINOUTS



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

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

|                                                              |                              |
|--------------------------------------------------------------|------------------------------|
| Supply voltage, $V_{DD}$ (see Note 1)                        | 4 V                          |
| Differential input voltage, $V_{ID}$                         | $\pm V_{DD}$                 |
| Input current, $I_I$ (any input)                             | $\pm 10$ mA                  |
| Output current, $I_O$                                        | $\pm 10$ 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                        |

<sup>†</sup> 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    | $\theta_{JC}$<br>(°C/W) | $\theta_{JA}$<br>(°C/W) | $T_A \leq 25^\circ\text{C}$<br>POWER RATING | $T_A = 125^\circ\text{C}$<br>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  | $\pm 0.9$               | $\pm 1.8$    |      |
| 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 <sup>‡</sup> | $V_{IH}$      | $V_{DD} < 2.7$ V        | $0.75V_{DD}$ | V    |
|                                            |               | $V_{DD} = 2.7$ to 3.6 V | 2            |      |
|                                            | $V_{IL}$      |                         | 0.6          |      |

<sup>‡</sup> 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**

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

**dc performance**

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

$^\dagger$  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 <sub>A</sub> <sup>†</sup> | MIN | TYP  | MAX | UNIT |
|-------------------|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------|----------|-----------------------------|-----|------|-----|------|
| I <sub>IO</sub>   | Input offset current          | V <sub>IC</sub> = V <sub>DD</sub> /2,<br>V <sub>O</sub> = V <sub>DD</sub> /2,<br>R <sub>L</sub> = 2 kΩ,<br>R <sub>S</sub> = 50 Ω |          | 25°C                        |     | 2.5  | 15  | pA   |
|                   |                               |                                                                                                                                  | TLV278xC | Full range                  |     |      | 100 |      |
|                   |                               |                                                                                                                                  | TLV278xI | Full range                  |     |      | 300 |      |
| I <sub>IB</sub>   | Input bias current            |                                                                                                                                  |          | 25°C                        |     | 2.5  | 15  | pA   |
|                   |                               |                                                                                                                                  | TLV278xC | Full range                  |     |      | 100 |      |
|                   |                               |                                                                                                                                  | TLV278xI | Full range                  |     |      | 300 |      |
| r <sub>i(d)</sub> | Differential input resistance |                                                                                                                                  |          | 25°C                        |     | 1000 |     | GΩ   |
| C <sub>i(c)</sub> | Common-mode input capacitance | f = 1 kHz                                                                                                                        |          | 25°C                        |     | 19   |     | pF   |

$^\dagger$  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**

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**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    | $V_{IC} = V_{DD}/2$ ,<br>$I_{OH} = -1\text{ mA}$       | $V_{DD} = 1.8\text{ V}$ | 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 |     |      |
|                                       |                                                        |                         |               |      |      |     |      |
|                                       | $V_{IC} = V_{DD}/2$ ,<br>$I_{OH} = -5\text{ mA}$       | $V_{DD} = 1.8\text{ V}$ | 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     | $V_{IC} = V_{DD}/2$ ,<br>$I_{OL} = 1\text{ mA}$        |                         | 25°C          |      |      | 70  | mV   |
|                                       |                                                        |                         | Full range    |      |      | 80  |      |
|                                       | $V_{IC} = V_{DD}/2$ ,<br>$I_{OL} = 5\text{ mA}$        | $V_{DD} = 1.8\text{ V}$ | 25°C          |      | 180  | 240 |      |
|                                       |                                                        |                         | Full range    |      |      | 290 |      |
|                                       |                                                        | $V_{DD} = 2.7\text{ V}$ | 25°C          |      | 120  | 170 |      |
|                                       |                                                        |                         | Full range    |      |      | 200 |      |
| $I_O$ Output current                  | $V_{DD} = 1.8\text{ V}$ ,<br>$V_O = 0.5\text{ V from}$ | Positive rail           | 25°C          |      | 10   |     | mA   |
|                                       |                                                        | Negative rail           |               |      | 15   |     |      |
|                                       | $V_{DD} = 2.7\text{ V}$ ,<br>$V_O = 0.5\text{ V from}$ | 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   |     |      |

$^\dagger$  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 | $\mu\text{A}$ |
|                                                                                 |                                                                   |          | Full range    |     |     | 820 |               |
| $k_{SVR}$ Supply voltage rejection ratio<br>( $\Delta V_{DD} / \Delta V_{IO}$ ) | $V_{DD} = 1.8\text{ V to } 2.7\text{ V}$ ,<br>$V_{IC} = V_{DD}/2$ | No load, | 25°C          |     | 60  | 75  | dB            |
|                                                                                 |                                                                   |          | Full range    |     | 58  |     |               |
|                                                                                 | $V_{DD} = 2.7\text{ V to } 3.6\text{ V}$ ,<br>$V_{IC} = V_{DD}/2$ | No load, | 25°C          |     | 75  | 90  |               |
|                                                                                 |                                                                   |          | Full range    |     | 70  |     |               |
|                                                                                 | $V_{DD} = 1.8\text{ V to } 3.6\text{ V}$ ,<br>$V_{IC} = V_{DD}/2$ | No load, | 25°C          |     | 65  | 80  |               |
|                                                                                 |                                                                   |          | Full range    |     | 60  |     |               |

$^\dagger$  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.



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**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 <sub>A</sub> <sup>†</sup> | MIN  | TYP | MAX  | UNIT |
|----------------|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|-------------------------|-----------------------------|------|-----|------|------|
| UGBW           | Unity gain bandwidth             | R <sub>L</sub> = 2 kΩ,                                                                                                            | C <sub>L</sub> = 25 pF  | 25°C                        | 8    |     |      | MHz  |
| SR+            | Positive slew rate at unity gain | V <sub>O(PP)</sub> = 1 V,<br>R <sub>L</sub> = 2 kΩ,<br>C <sub>L</sub> = 50 pF                                                     | V <sub>DD</sub> = 1.8 V | 25°C                        | 3.3  | 4.3 | V/μs |      |
|                |                                  |                                                                                                                                   |                         | Full range                  | 3.1  |     |      |      |
|                |                                  |                                                                                                                                   | V <sub>DD</sub> = 2.7 V | 25°C                        | 3.8  | 4.8 |      |      |
|                |                                  |                                                                                                                                   |                         | Full range                  | 3.5  |     |      |      |
|                |                                  |                                                                                                                                   | V <sub>DD</sub> = 3.6 V | 25°C                        | 4    | 5   |      |      |
|                |                                  |                                                                                                                                   |                         | Full range                  | 3.6  |     |      |      |
| SR−            | Negative slew rate at unity gain | V <sub>O(PP)</sub> = 1 V,<br>R <sub>L</sub> = 2 kΩ,<br>C <sub>L</sub> = 50 pF                                                     | V <sub>DD</sub> = 1.8 V | 25°C                        | 2.1  | 2.8 |      |      |
|                |                                  |                                                                                                                                   |                         | Full range                  | 1.89 |     |      |      |
|                |                                  |                                                                                                                                   | V <sub>DD</sub> = 2.7 V | 25°C                        | 2.2  | 2.8 |      |      |
|                |                                  |                                                                                                                                   |                         | Full range                  | 1.97 |     |      |      |
|                |                                  |                                                                                                                                   | V <sub>DD</sub> = 3.6 V | 25°C                        | 3.5  | 4.2 |      |      |
|                |                                  |                                                                                                                                   |                         | Full range                  | 3.4  |     |      |      |
| φ <sub>m</sub> | Phase margin                     | R <sub>L</sub> = 2 kΩ,                                                                                                            | C <sub>L</sub> = 25 pF  | 25°C                        | 58°  |     |      | dB   |
|                | Gain margin                      |                                                                                                                                   |                         |                             | 8    |     |      |      |
| t <sub>s</sub> | Settling time                    | V <sub>DD</sub> = 1.8 V,<br>V <sub>(STEP)PP</sub> = 1 V,<br>A <sub>V</sub> = −1,<br>C <sub>L</sub> = 10 pF, R <sub>L</sub> = 2 kΩ | 0.1%                    | 25°C                        | 1.7  |     |      | μs   |
|                |                                  |                                                                                                                                   | 0.01%                   |                             | 2.8  |     |      |      |
|                |                                  | V <sub>DD</sub> = 2.7 V,<br>V <sub>(STEP)PP</sub> = 1 V,<br>A <sub>V</sub> = −1,<br>C <sub>L</sub> = 10 pF, R <sub>L</sub> = 2 kΩ | 0.1%                    |                             | 1.7  |     |      |      |
|                |                                  |                                                                                                                                   | 0.01%                   |                             | 2.4  |     |      |      |

$^\dagger$  Full range is  $0^\circ\text{C}$  to  $70^\circ\text{C}$  for the C suffix and  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for the I suffix. If not specified, full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .

**noise/distortion performance**

| PARAMETER      |                                      | TEST CONDITIONS                                                                  |                      | T <sub>A</sub> | MIN    | TYP | MAX | UNIT   |
|----------------|--------------------------------------|----------------------------------------------------------------------------------|----------------------|----------------|--------|-----|-----|--------|
| THD + N        | Total harmonic distortion plus noise | V <sub>O(PP)</sub> = V <sub>DD</sub> /2,<br>R <sub>L</sub> = 2 kΩ,<br>f = 10 kHz | A <sub>V</sub> = 1   | 25°C           | 0.055% |     |     |        |
|                |                                      |                                                                                  | A <sub>V</sub> = 10  |                | 0.08%  |     |     |        |
|                |                                      |                                                                                  | A <sub>V</sub> = 100 |                | 0.45%  |     |     |        |
| V <sub>n</sub> | Equivalent input noise voltage       | f = 1 kHz                                                                        |                      |                | 18     |     |     | nV/√Hz |
|                |                                      | f = 10 kHz                                                                       |                      |                | 9      |     |     |        |
| I <sub>n</sub> | Equivalent input noise current       | f = 1 kHz                                                                        |                      |                | 0.9    |     |     | fA/√Hz |

**shutdown characteristics**

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

$^\dagger$  Full range is  $0^\circ\text{C}$  to  $70^\circ\text{C}$  for the C suffix and  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for the I suffix. If not specified, full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .

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



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**TYPICAL CHARACTERISTICS**

**Table of Graphs**

|                |                                              |                              | <b>FIGURE</b> |
|----------------|----------------------------------------------|------------------------------|---------------|
| $V_{IO}$       | 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        |
| $\phi_m$       | 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

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## TYPICAL CHARACTERISTICS

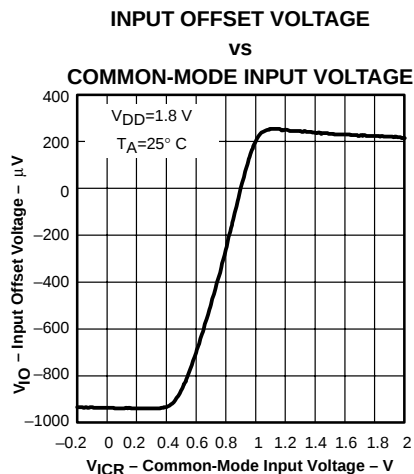


Figure 1

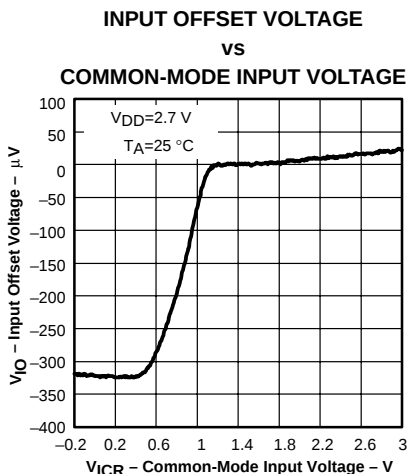


Figure 2

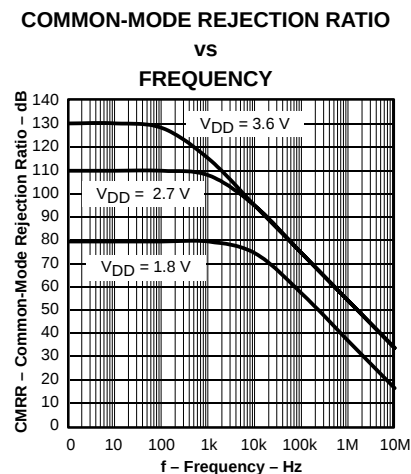


Figure 3

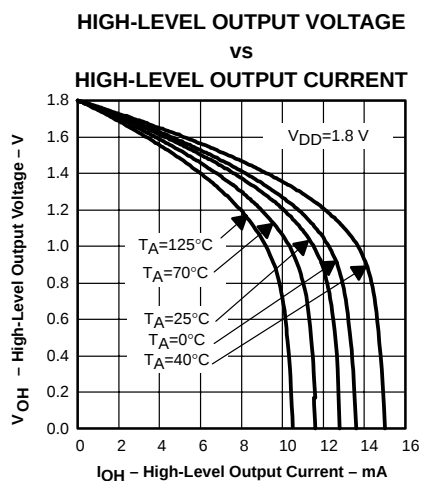


Figure 4

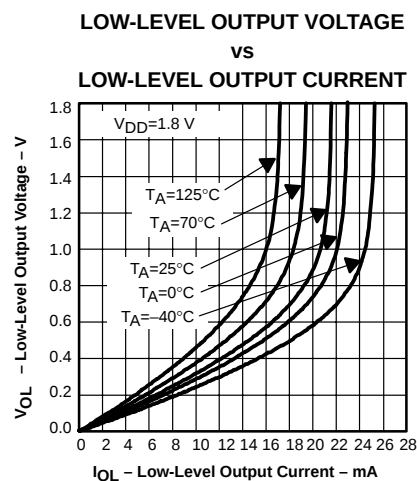


Figure 5

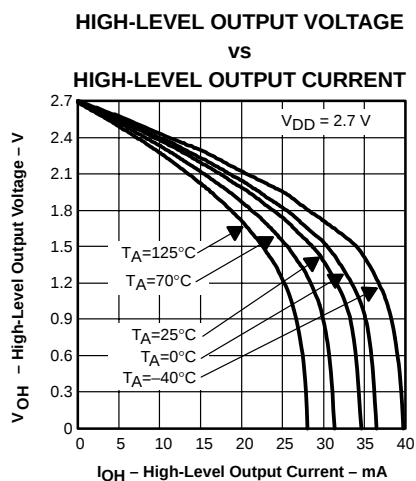


Figure 6

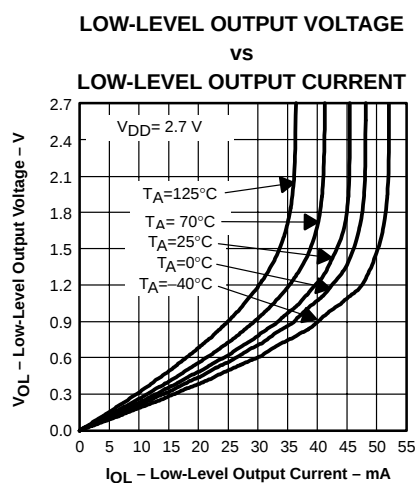


Figure 7

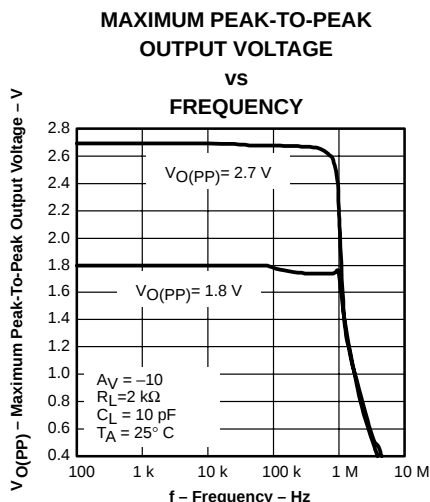


Figure 8

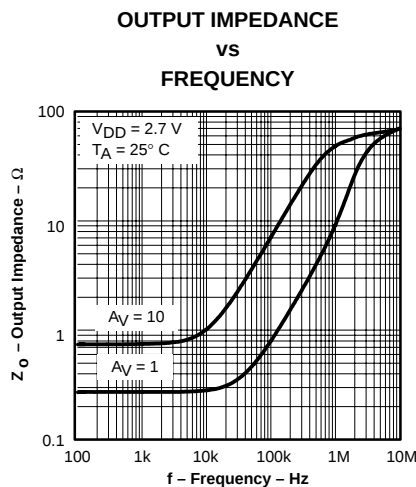


Figure 9



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

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## TYPICAL CHARACTERISTICS

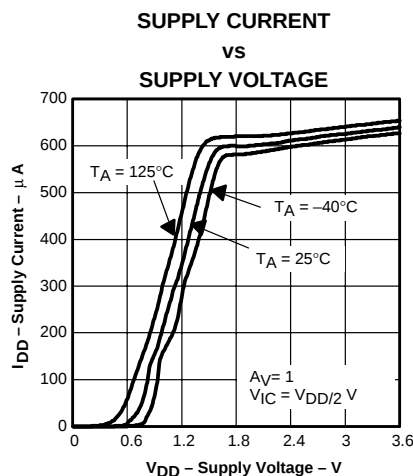


Figure 10

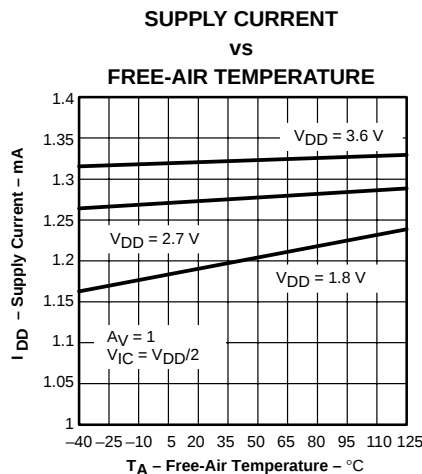


Figure 11

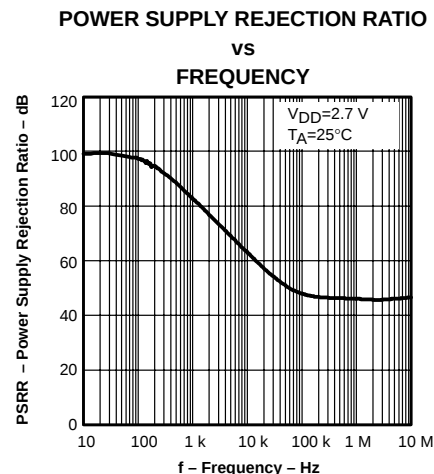


Figure 12

## DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE

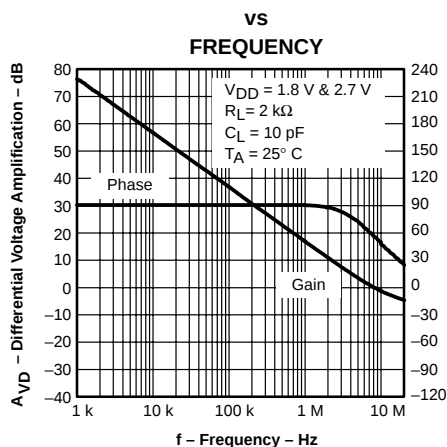


Figure 13

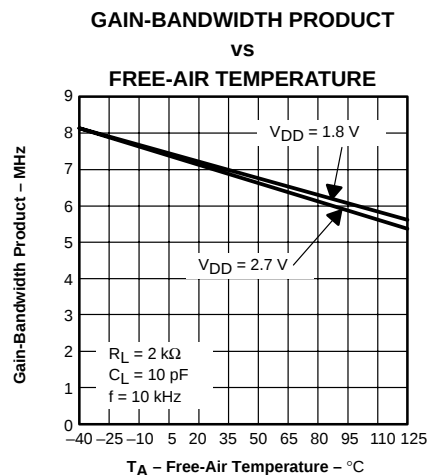


Figure 14

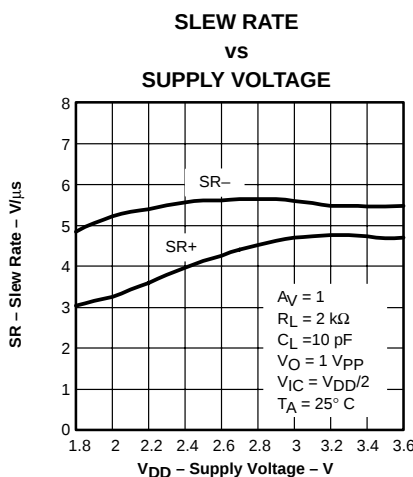


Figure 15

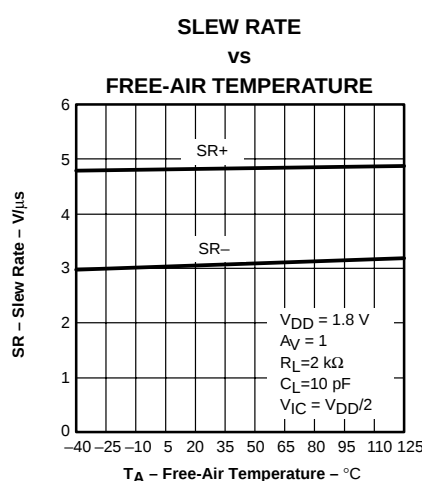


Figure 16

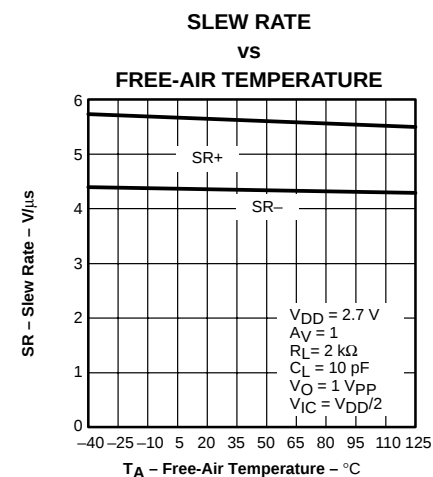


Figure 17



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## TYPICAL CHARACTERISTICS

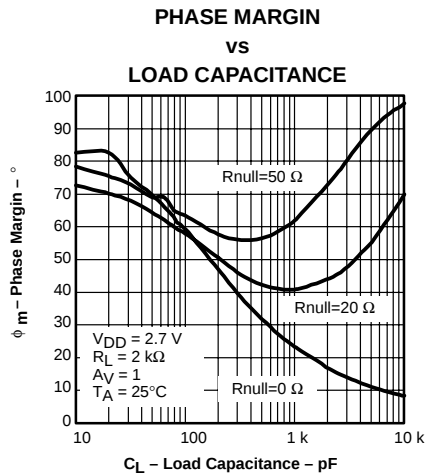


Figure 18

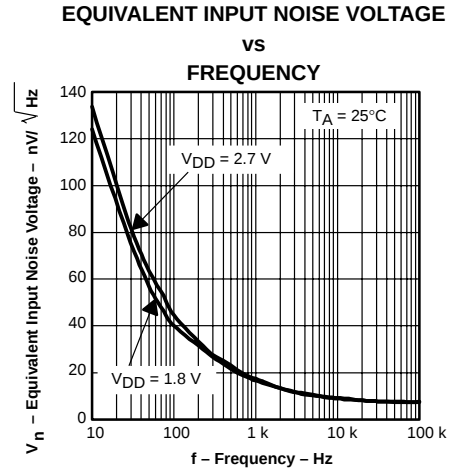


Figure 19

### VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE

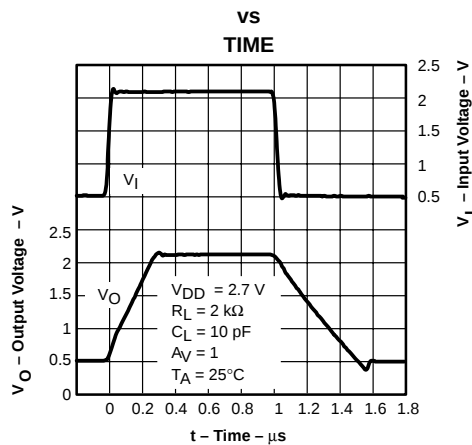


Figure 20

### VOLTAGE-FOLLOWER SMALL-SIGNAL PULSE RESPONSE

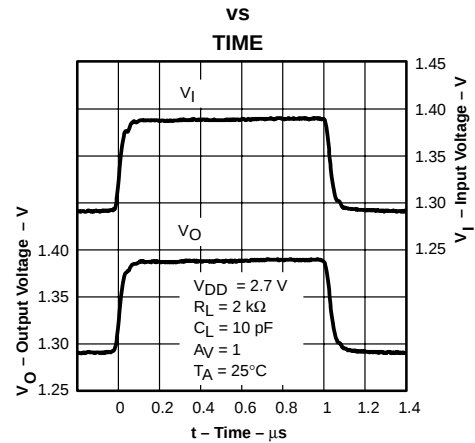


Figure 21

### INVERTING LARGE-SIGNAL PULSE RESPONSE

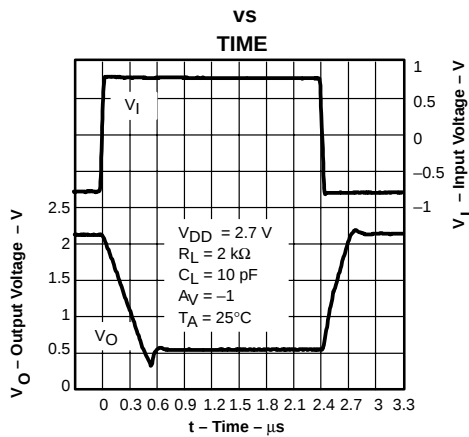


Figure 22

### INVERTING SMALL-SIGNAL PULSE RESPONSE

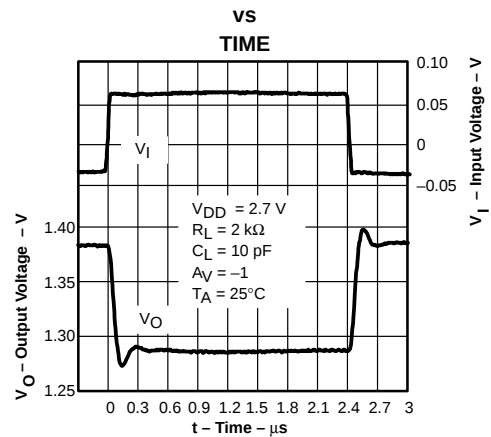
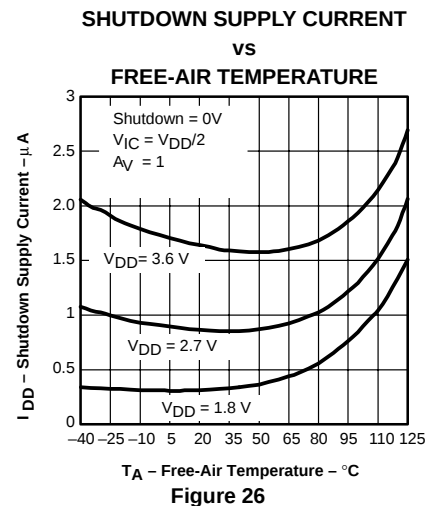
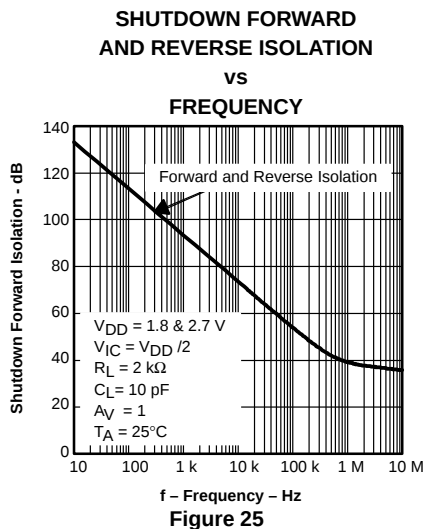
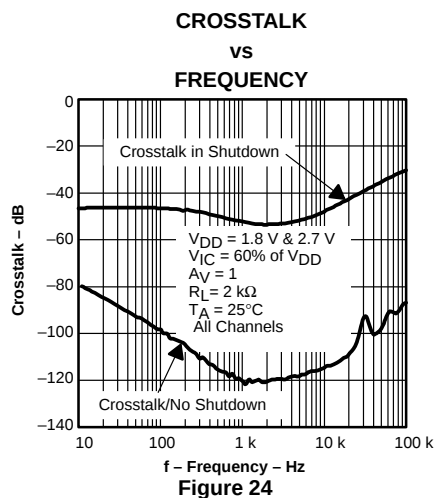


Figure 23

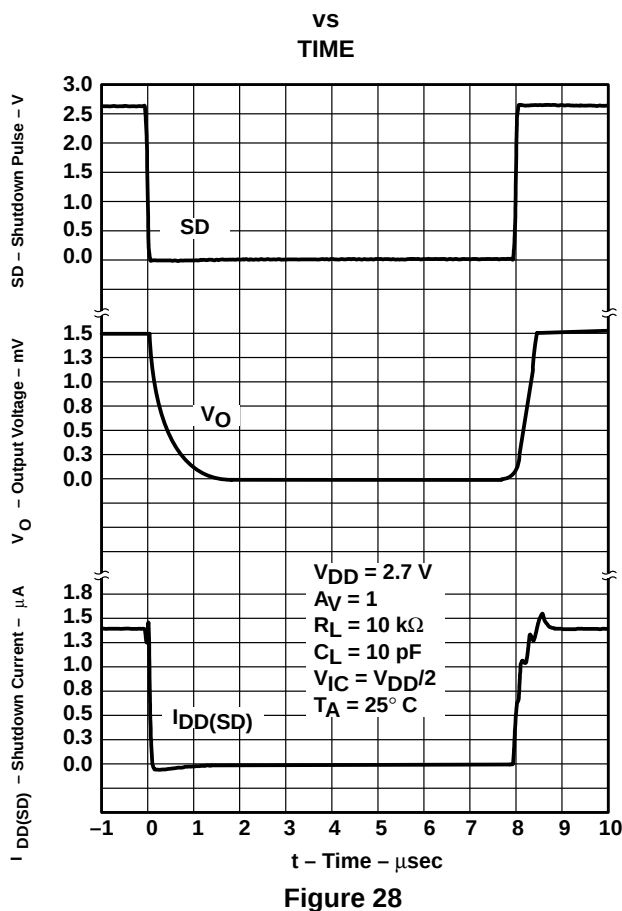
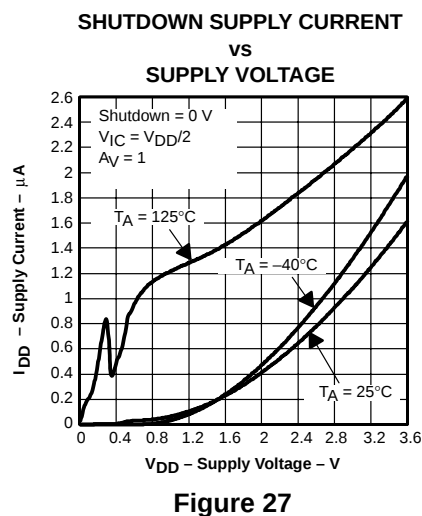
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## TYPICAL CHARACTERISTICS



## SHUTDOWN SUPPLY CURRENT / OUTPUT VOLTAGE



## PARAMETER MEASUREMENT INFORMATION

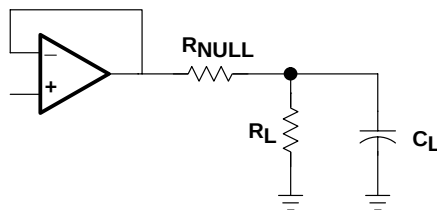


Figure 29

## 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.

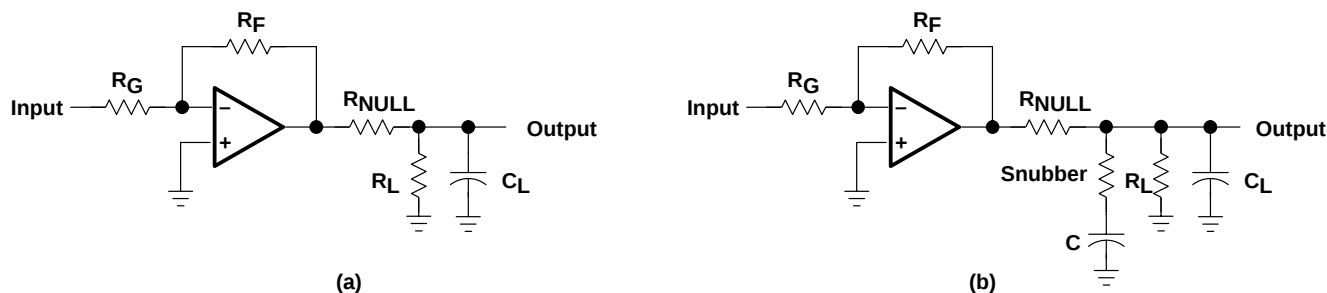


Figure 30. Driving a Capacitive Load

### 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:

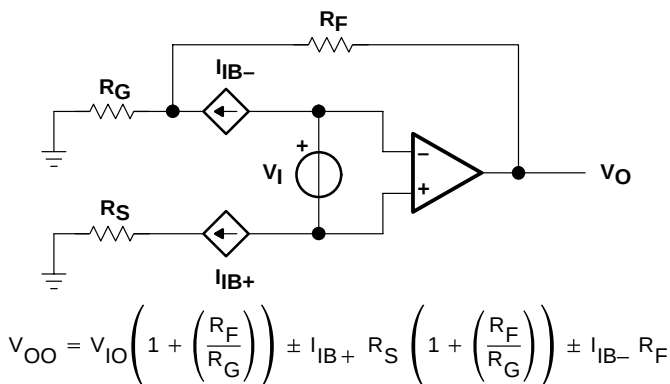


Figure 31. Output Offset Voltage Model

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## 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).

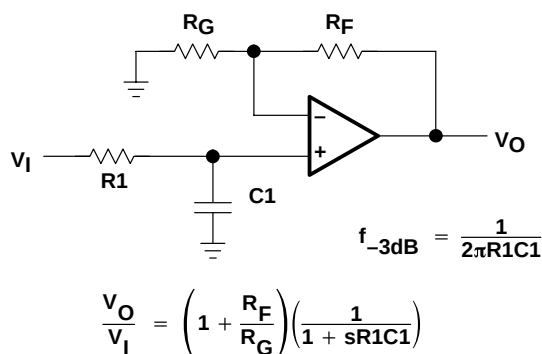


Figure 32. Single-Pole Low-Pass Filter

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.

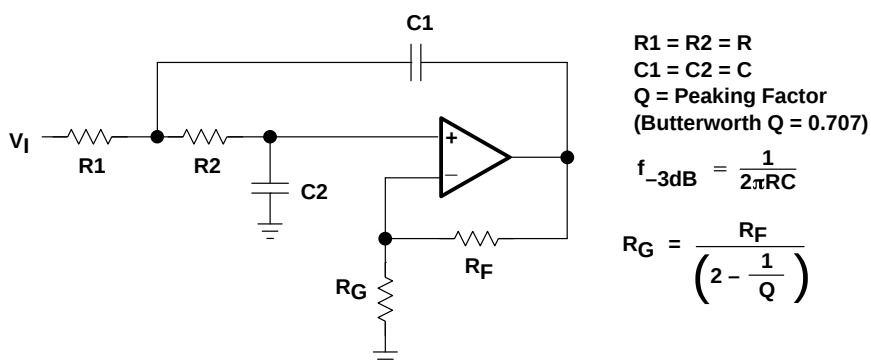


Figure 33. 2-Pole Low-Pass Sallen-Key Filter

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## 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- $\mu$ F tantalum capacitor in parallel with a 0.1- $\mu$ 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- $\mu$ F ceramic capacitor should always be used on the supply terminal of every amplifier. In addition, the 0.1- $\mu$ 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.

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## APPLICATION INFORMATION

### general power dissipation considerations

For a given  $\theta_{JA}$ , 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)

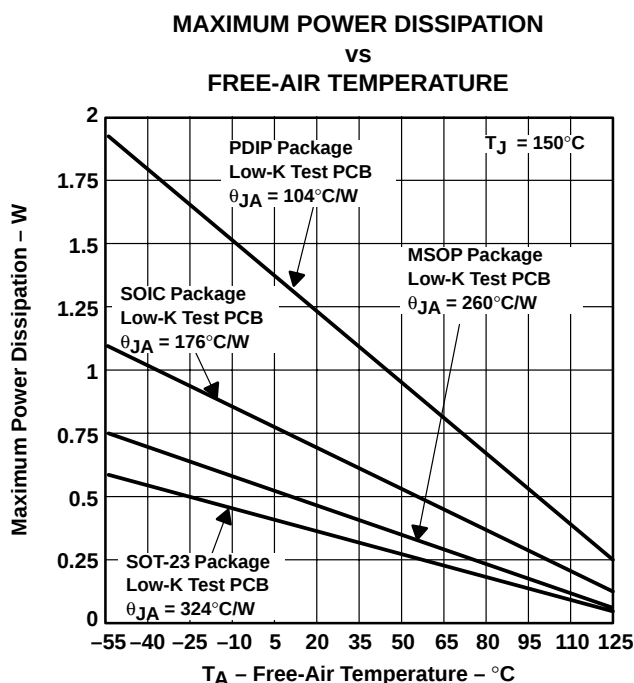
$T_{MAX}$  = Absolute maximum junction temperature (150°C)

$T_A$  = Free-ambient air temperature (°C)

$\theta_{JA}$  =  $\theta_{JC} + \theta_{CA}$

$\theta_{JC}$  = Thermal coefficient from junction to case

$\theta_{CA}$  = 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**

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## macromodel information

- Maximum positive output voltage swing
- Maximum negative output voltage swing
- Slew rate
- Quiescent power dissipation
- Input bias current
- Open-loop voltage amplification
- Unity-gain frequency
- Common-mode rejection ratio
- Phase margin
- DC output resistance
- AC output resistance
- Short-circuit output current limit

[illegible]

|        |     |                                          |                 |
|--------|-----|------------------------------------------|-----------------|
| ga     | 6   | 0                                        | 11 12 544.75E-6 |
| gcm    | 0   | 6                                        | 10 99 1.1538E-9 |
| iss    | 10  | 4                                        | dc 56.957E-6    |
| hlim   | 90  | 0                                        | vlim 1K         |
| j1     | 11  | 2                                        | 10 jx1          |
| J2     | 12  | 1                                        | 10 jx2          |
| r2     | 6   | 9                                        | 100.00E3        |
| rd1    | 3   | 11                                       | 1.8357E3        |
| rd2    | 3   | 12                                       | 1.8357E3        |
| ro1    | 8   | 5                                        | 10              |
| ro2    | 7   | 99                                       | 10              |
| rp     | 3   | 4                                        | 2.1845E3        |
| rss    | 10  | 99                                       | 3.5114E6        |
| vb     | 9   | 0                                        | dc 0            |
| vc     | 3   | 53                                       | dc .81911       |
| ve     | 54  | 4                                        | dc .81911       |
| vlim   | 7   | 8                                        | dc 0            |
| vlp    | 91  | 0                                        | dc 45.400       |
| vln    | 0   | 92                                       | dc 45.400       |
| .model | dx  | D(Is=800.00E-18)                         |                 |
| .model | dy  | D(Is=800.00E-18 Rs=1m Cjo=10p)           |                 |
| .model | jx1 | NJF(Is=500.00E-15 Beta=5.2102E-3 Vto=-1) |                 |
| .model | jx2 | NJF(Is=500.00E-15 Beta=5.2102E-3 Vto=-1) |                 |
| .ends  |     |                                          |                 |

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

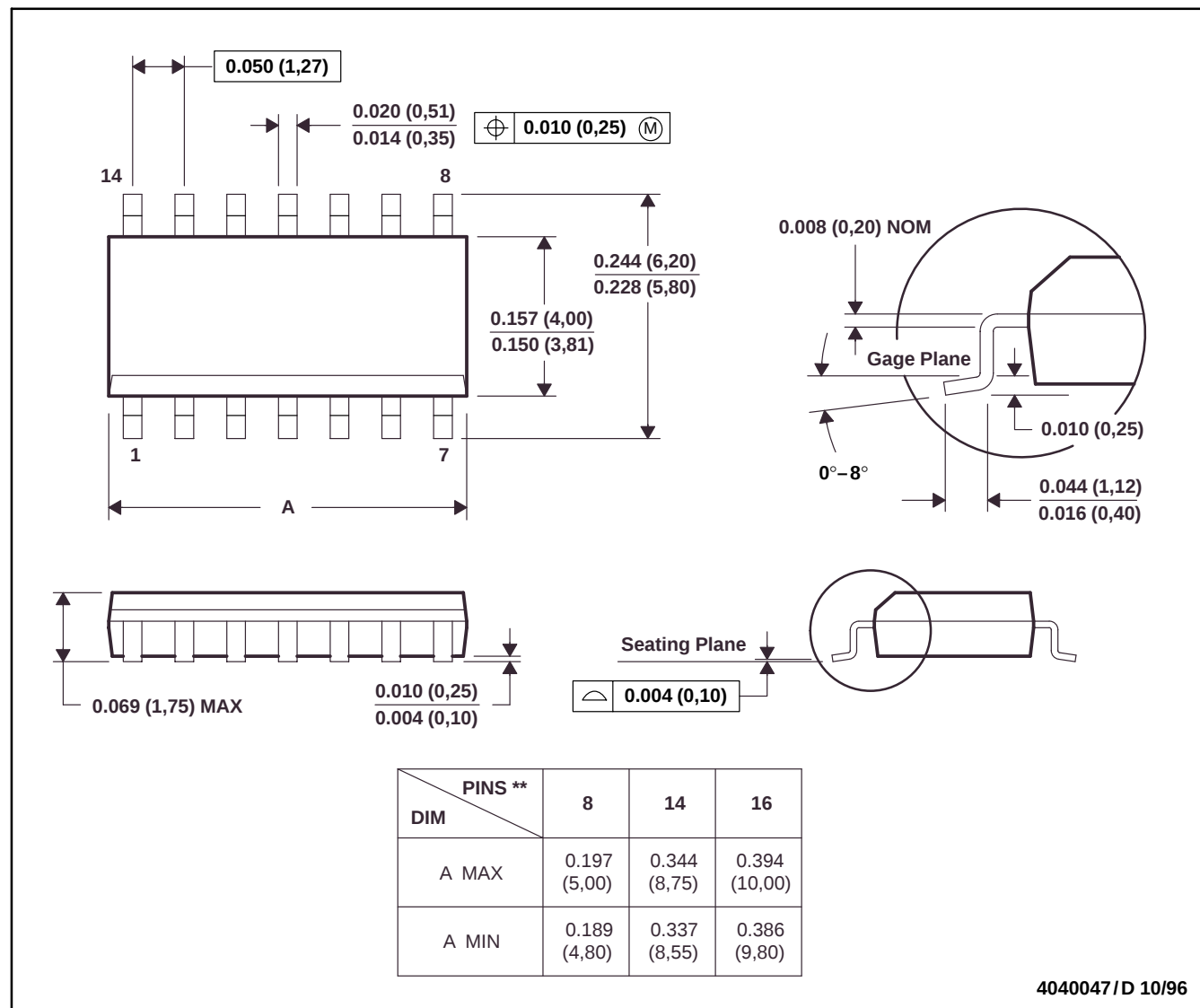
SLOS245C – MARCH 2000 – REVISED MARCH 2001

**MECHANICAL DATA**

**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. Falls within JEDEC MS-012

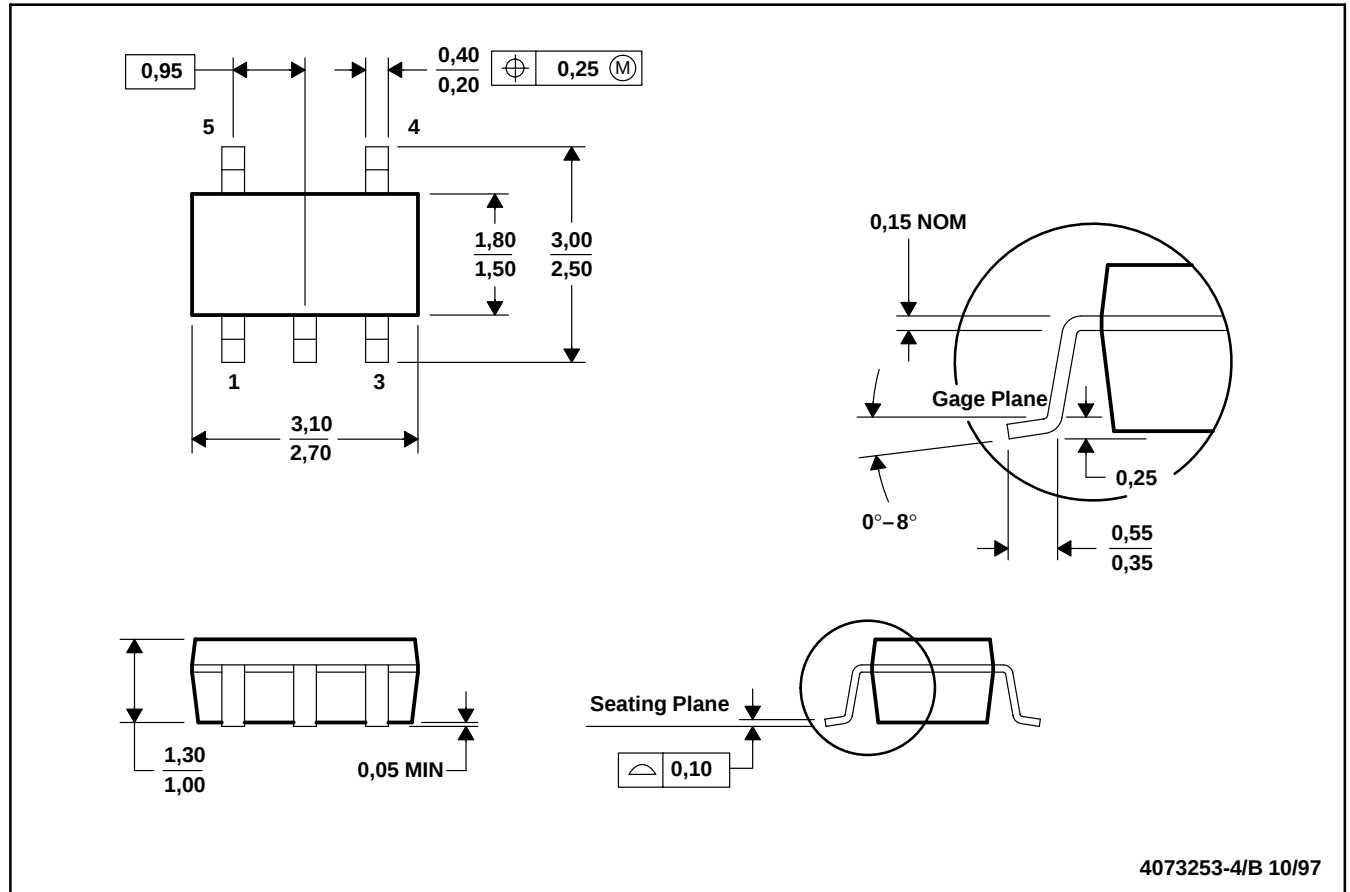
TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA  
 FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT  
 OPERATIONAL AMPLIFIERS WITH SHUTDOWN

SLOS245C – MARCH 2000 – REVISED MARCH 2001

MECHANICAL DATA

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES: A. All linear dimensions are in millimeters.  
 B. This drawing is subject to change without notice.  
 C. Body dimensions include mold flash or protrusion.

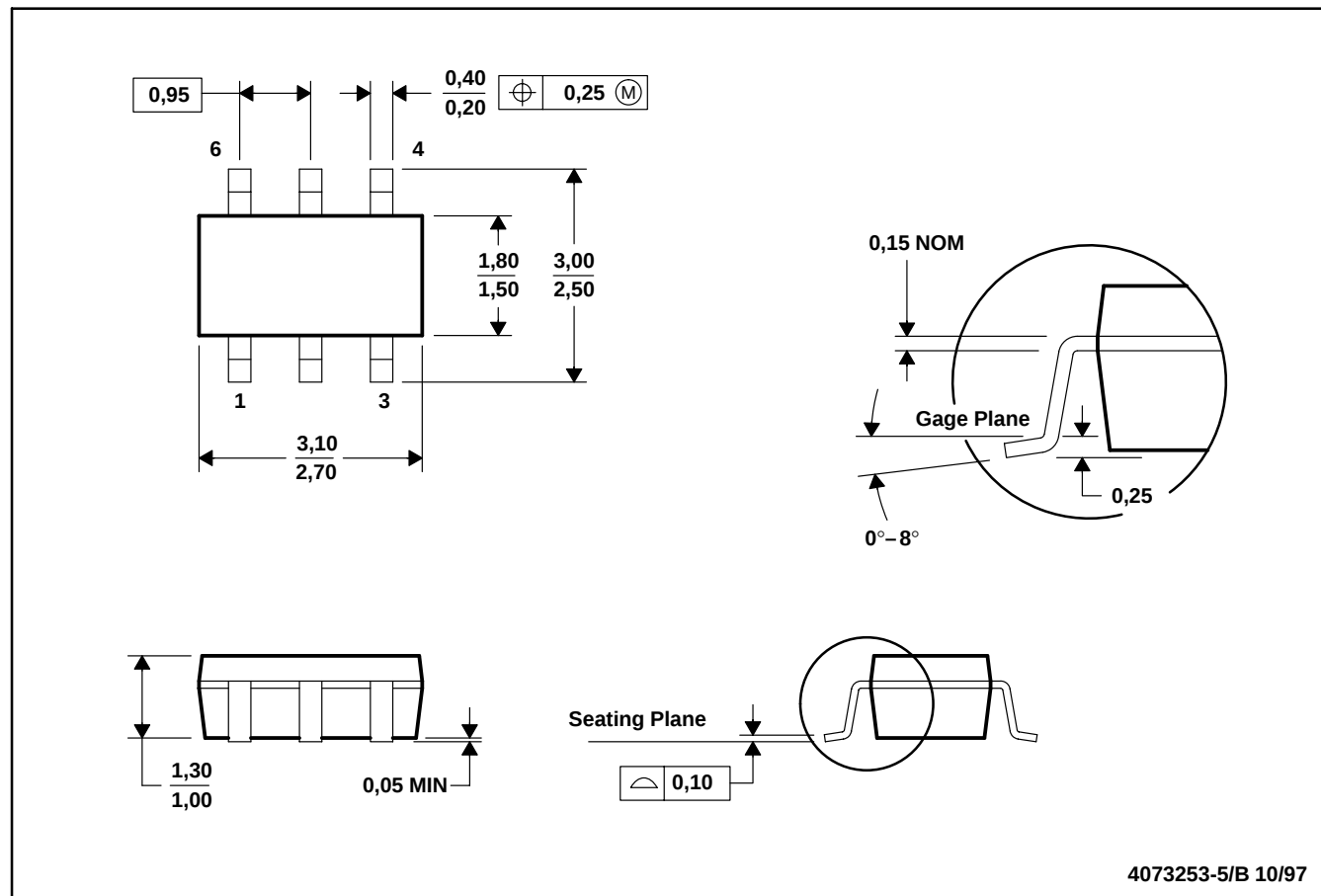
**TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA**  
**FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT**  
**OPERATIONAL AMPLIFIERS WITH SHUTDOWN**

SLOS245C – MARCH 2000 – REVISED MARCH 2001

**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 include mold flash or protrusion.

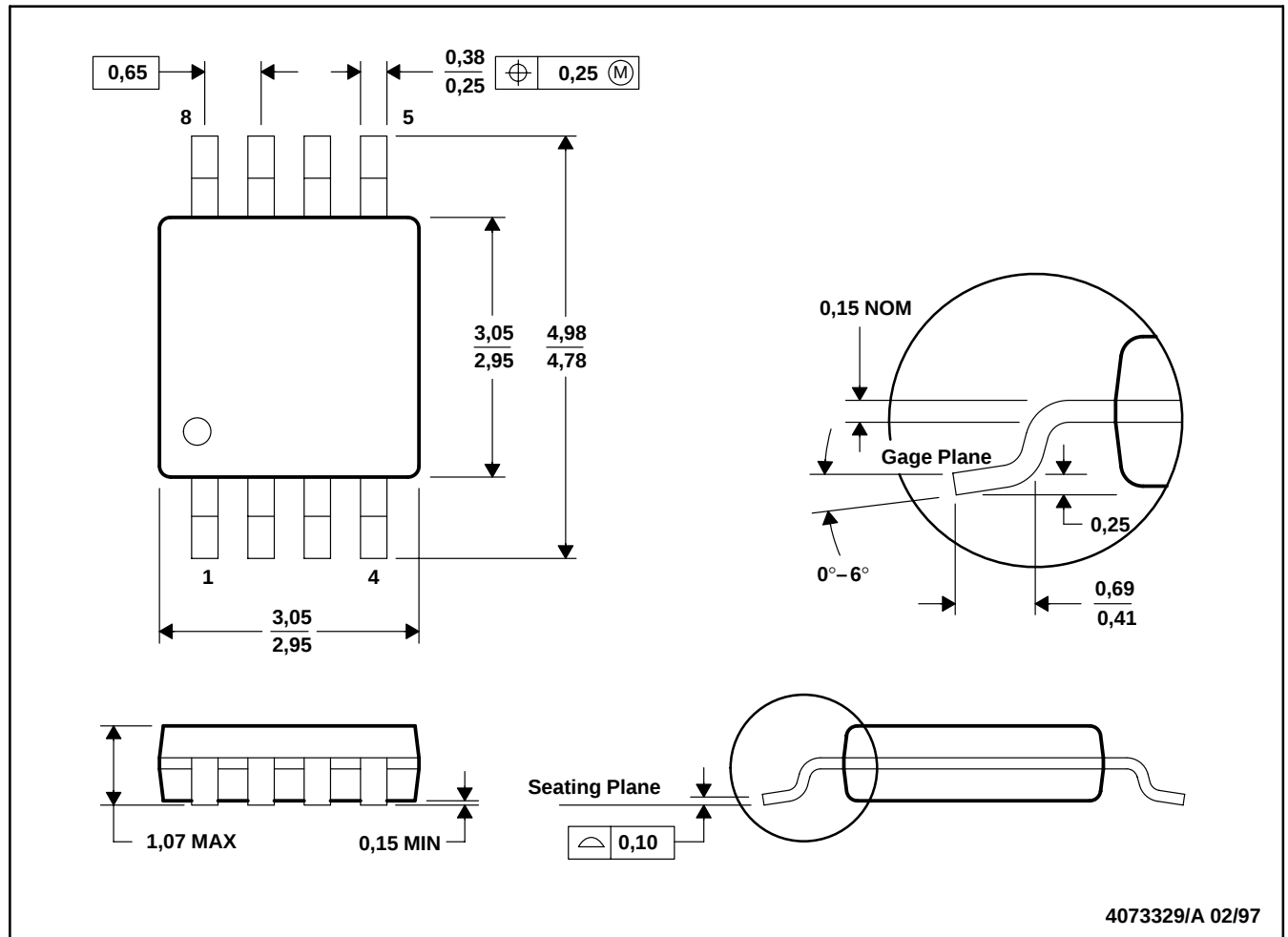
TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA  
FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT  
OPERATIONAL AMPLIFIERS WITH SHUTDOWN

SLOS245C – MARCH 2000 – REVISED MARCH 2001

MECHANICAL DATA

DGK (R-PDSO-G8)

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

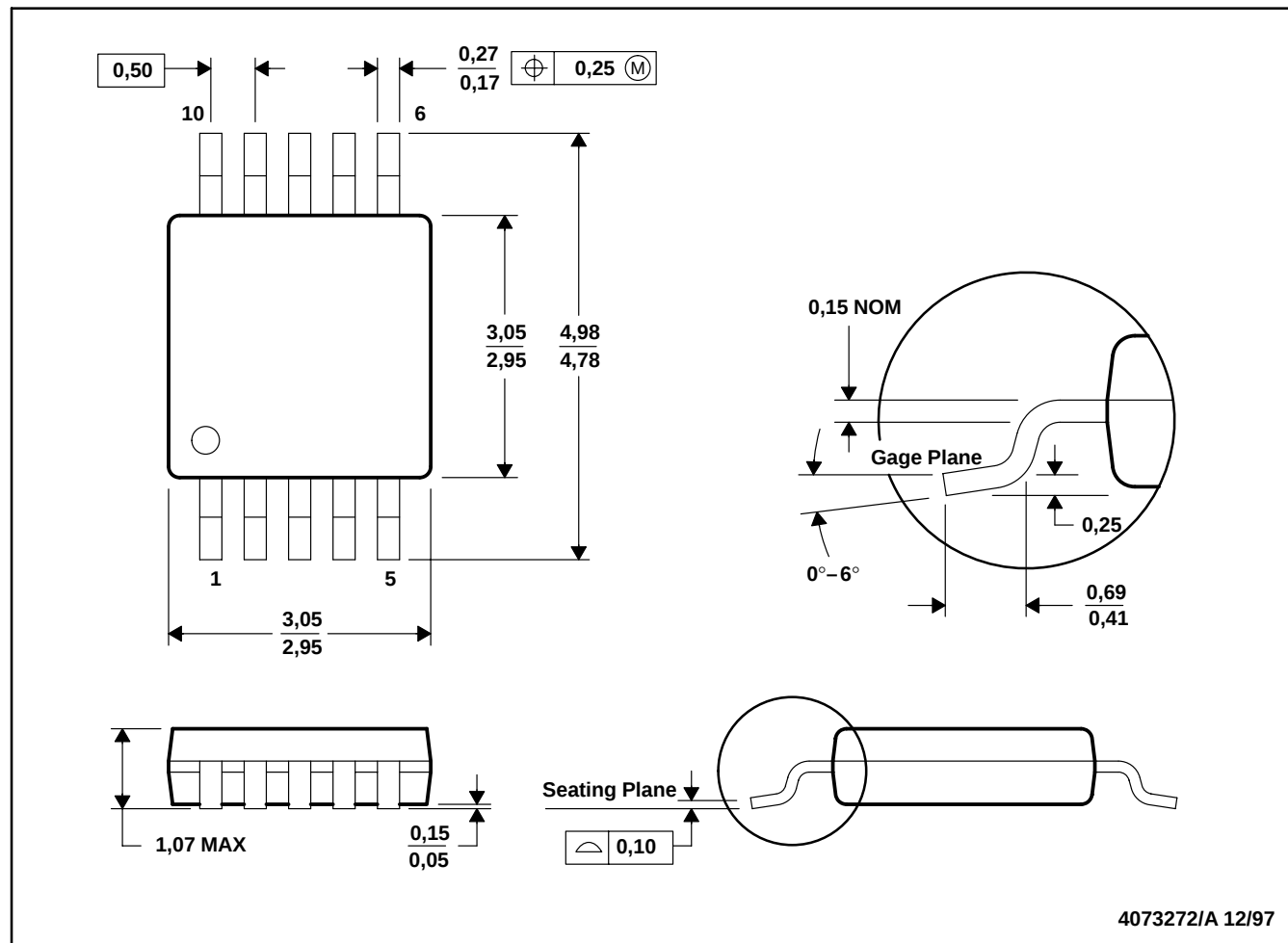
**TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA**  
**FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT**  
**OPERATIONAL AMPLIFIERS WITH SHUTDOWN**

SLOS245C – MARCH 2000 – REVISED MARCH 2001

**MECHANICAL DATA**

**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.

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

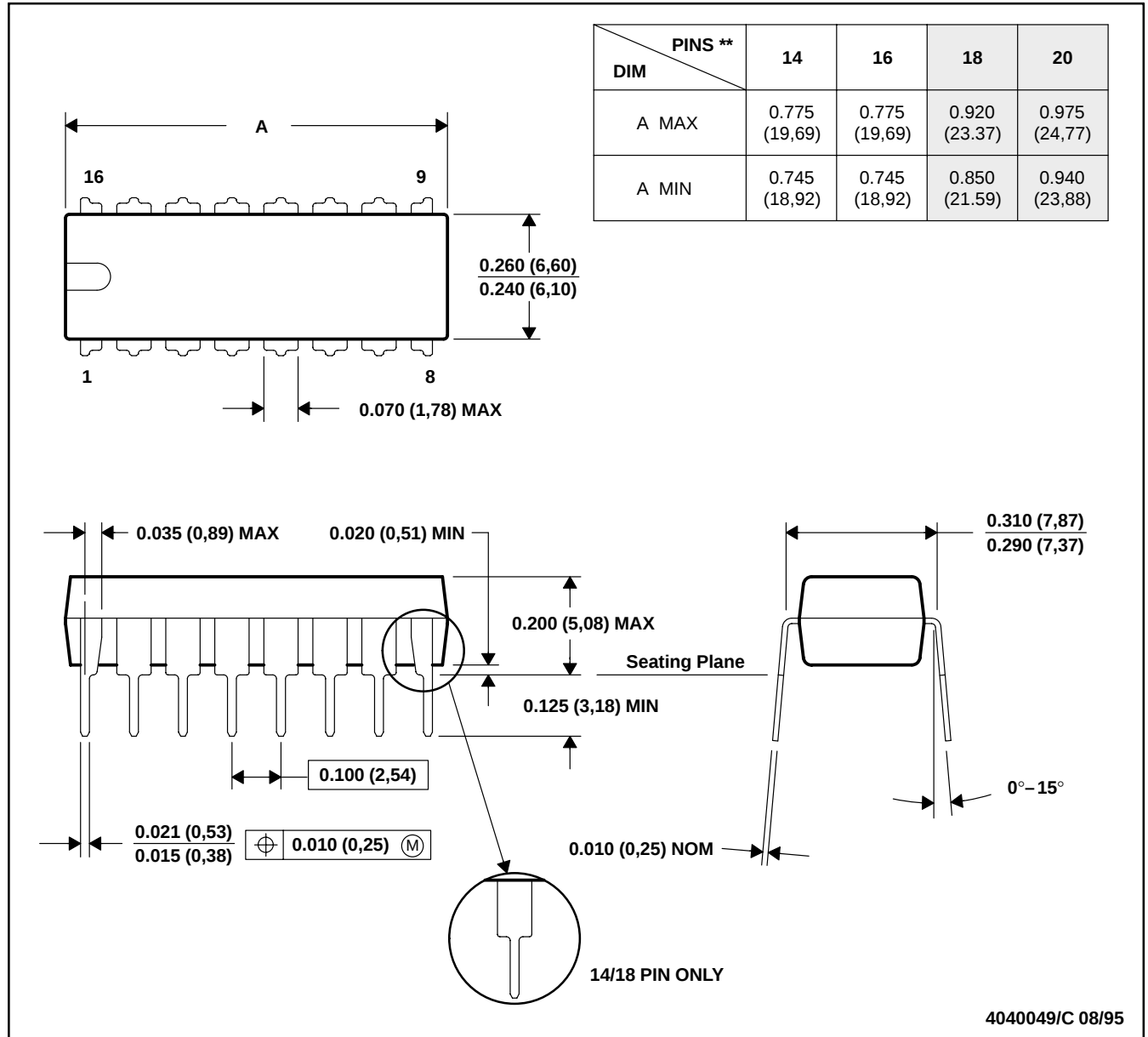
SLOS245C – MARCH 2000 – REVISED MARCH 2001

**MECHANICAL DATA**

**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.)

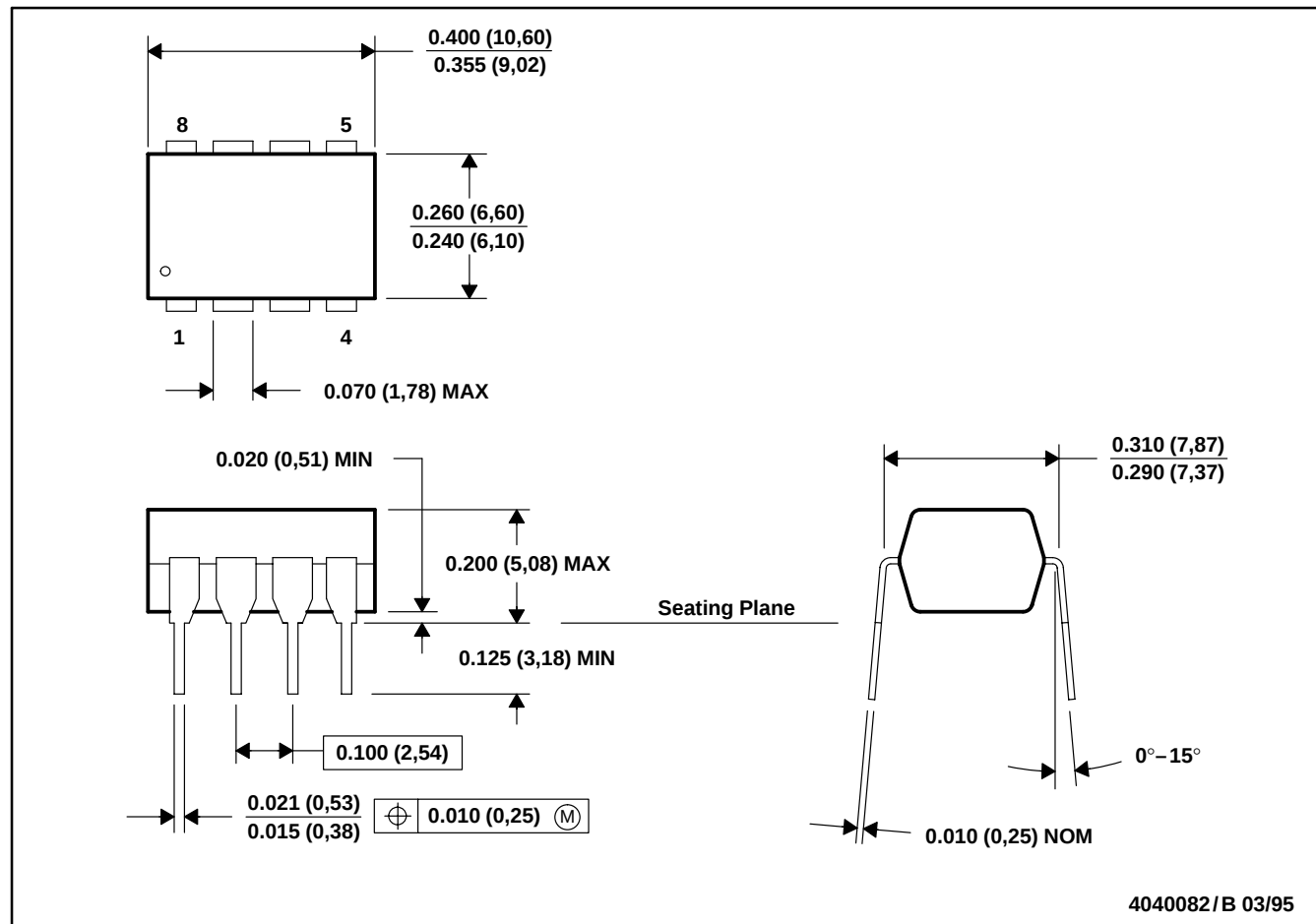
**TLV2780, TLV2781, TLV2782, TLV2783, TLV2784, TLV2785, TLV278xA**  
**FAMILY OF 1.8 V HIGH-SPEED RAIL-TO-RAIL INPUT/OUTPUT**  
**OPERATIONAL AMPLIFIERS WITH SHUTDOWN**

SLOS245C – MARCH 2000 – REVISED MARCH 2001

**MECHANICAL DATA**

**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

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

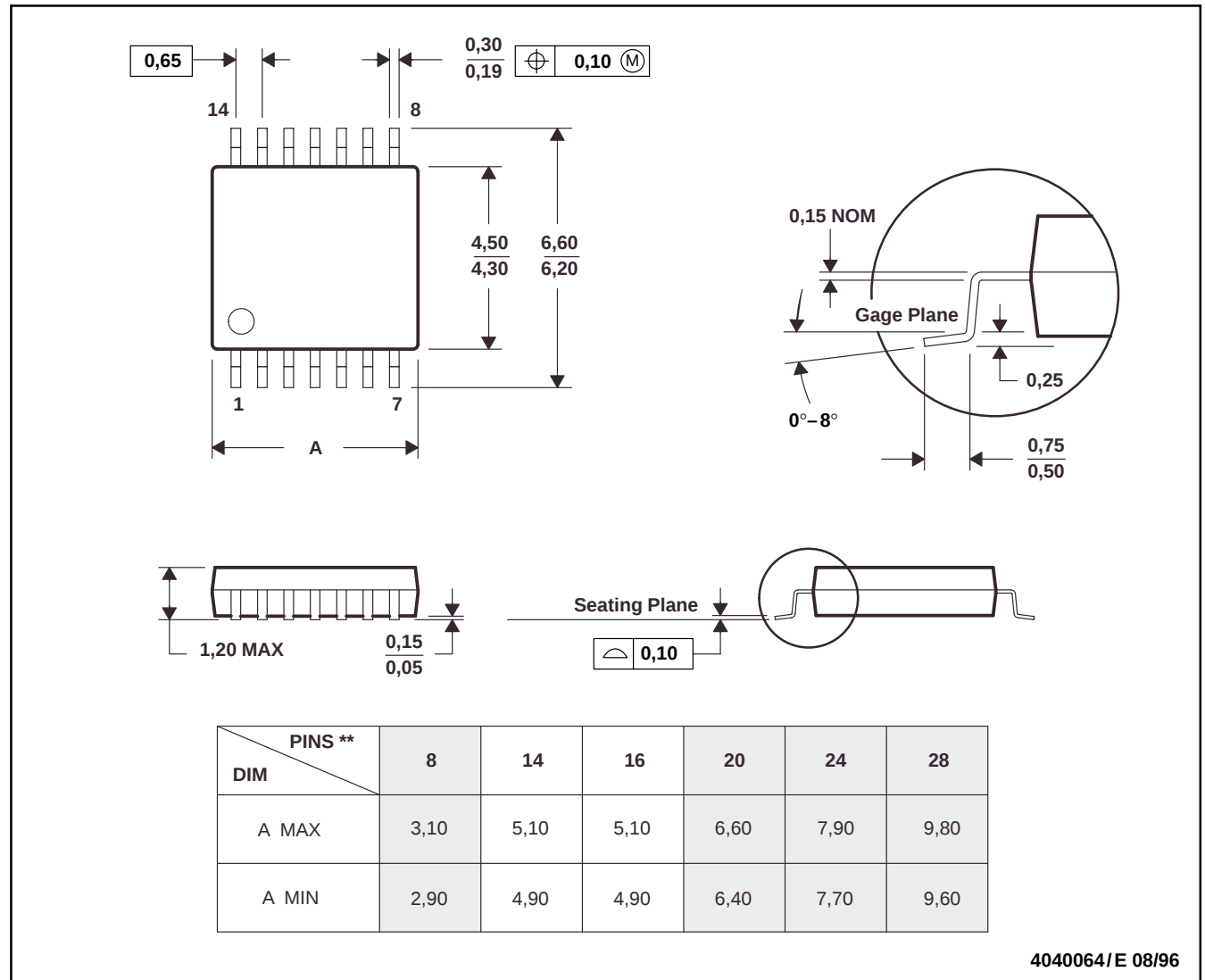
SLOS245C – MARCH 2000 – REVISED MARCH 2001

**MECHANICAL DATA**

**PW (R-PDSO-G\*\*)**

**PLASTIC SMALL-OUTLINE PACKAGE**

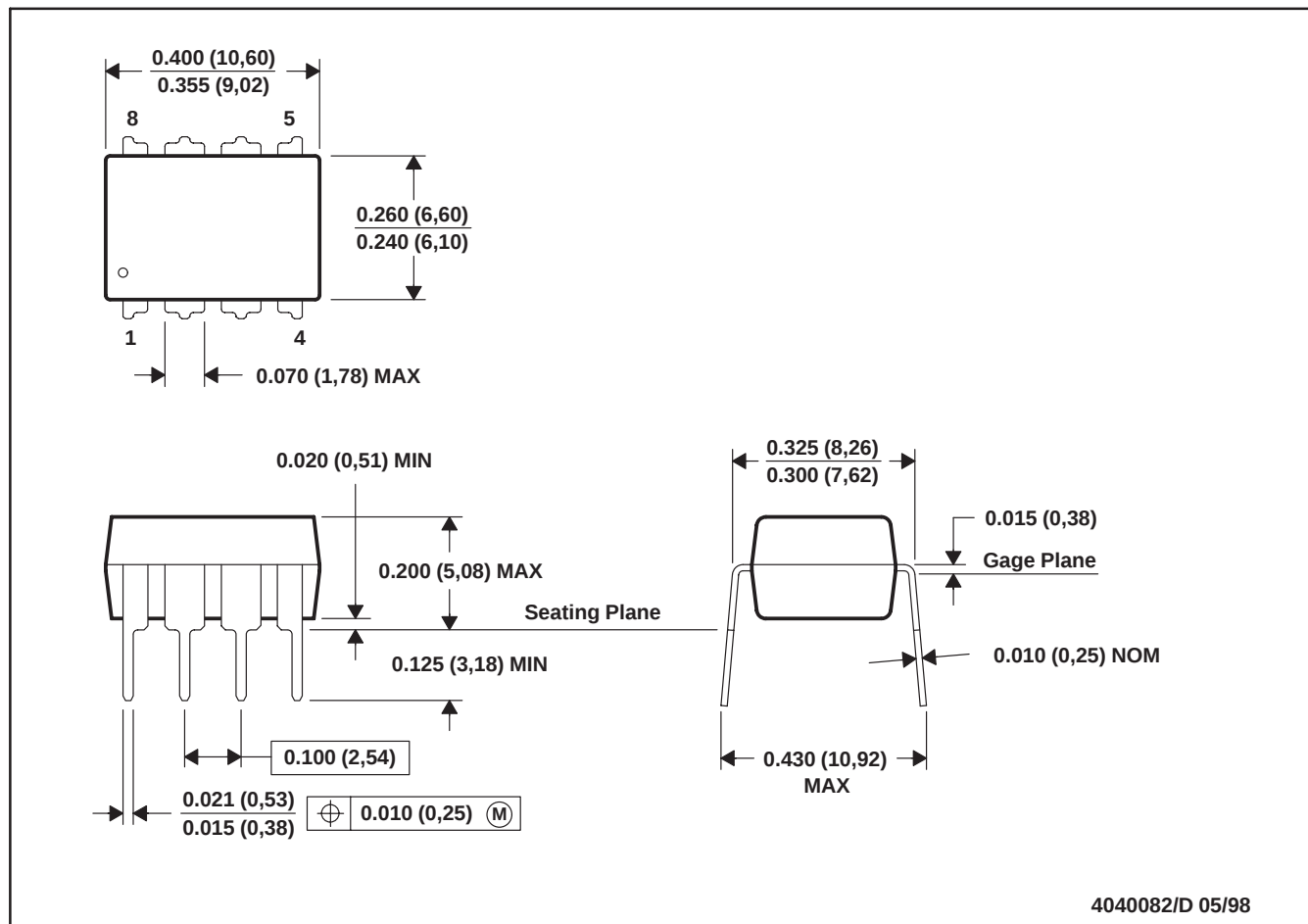
**14 PIN SHOWN**



- NOTES: A. All linear dimensions are in millimeters.  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.  
 D. Falls within JEDEC MO-153

## P (R-PDIP-T8)

## PLASTIC DUAL-IN-LINE



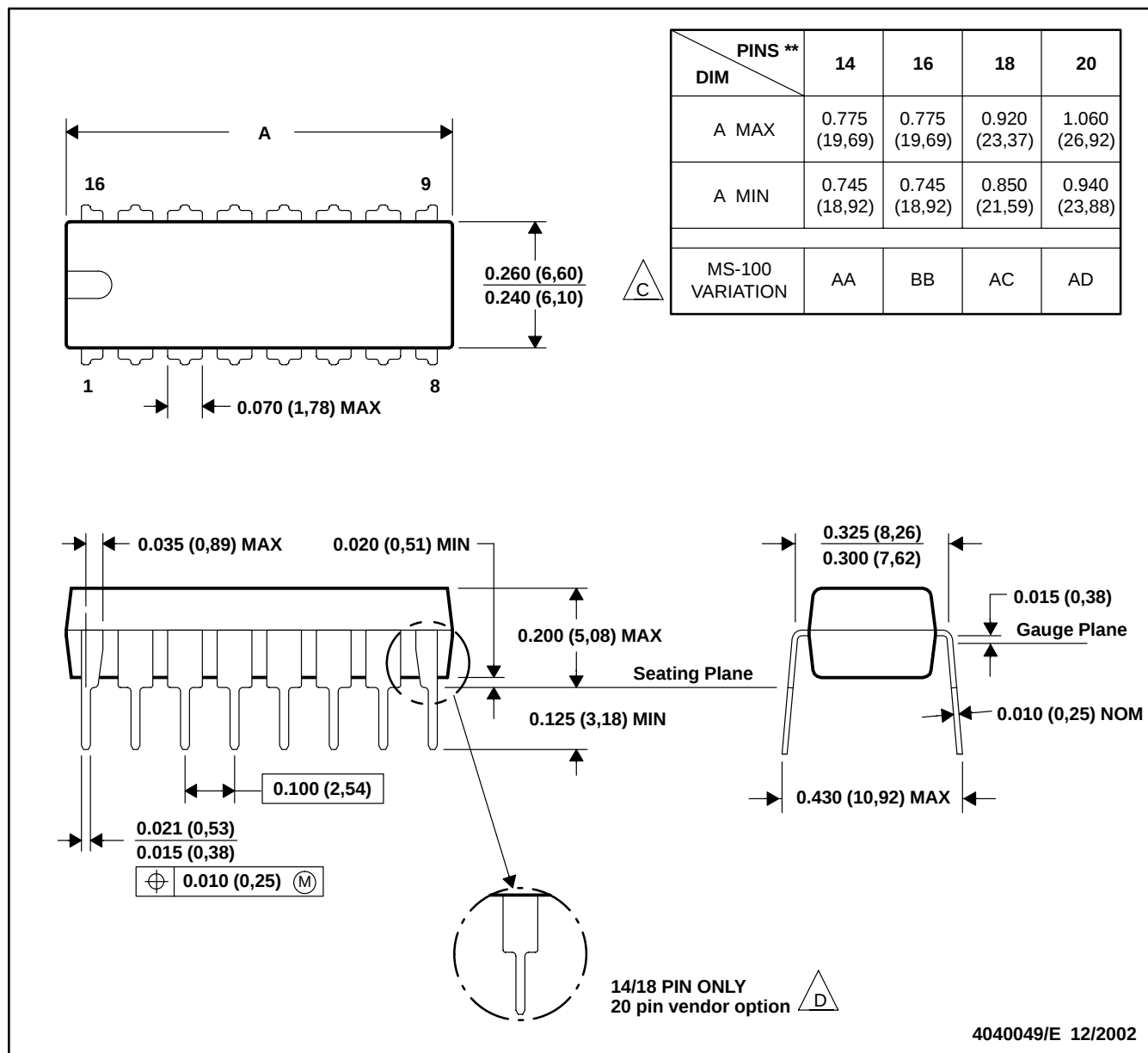
NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. Falls within JEDEC MS-001

For the latest package information, go to [http://www.ti.com/sc/docs/package/pkg\\_info.htm](http://www.ti.com/sc/docs/package/pkg_info.htm)

## N (R-PDIP-T\*\*)

## PLASTIC DUAL-IN-LINE PACKAGE

16 PINS SHOWN



NOTES: A. All linear dimensions are in inches (millimeters).

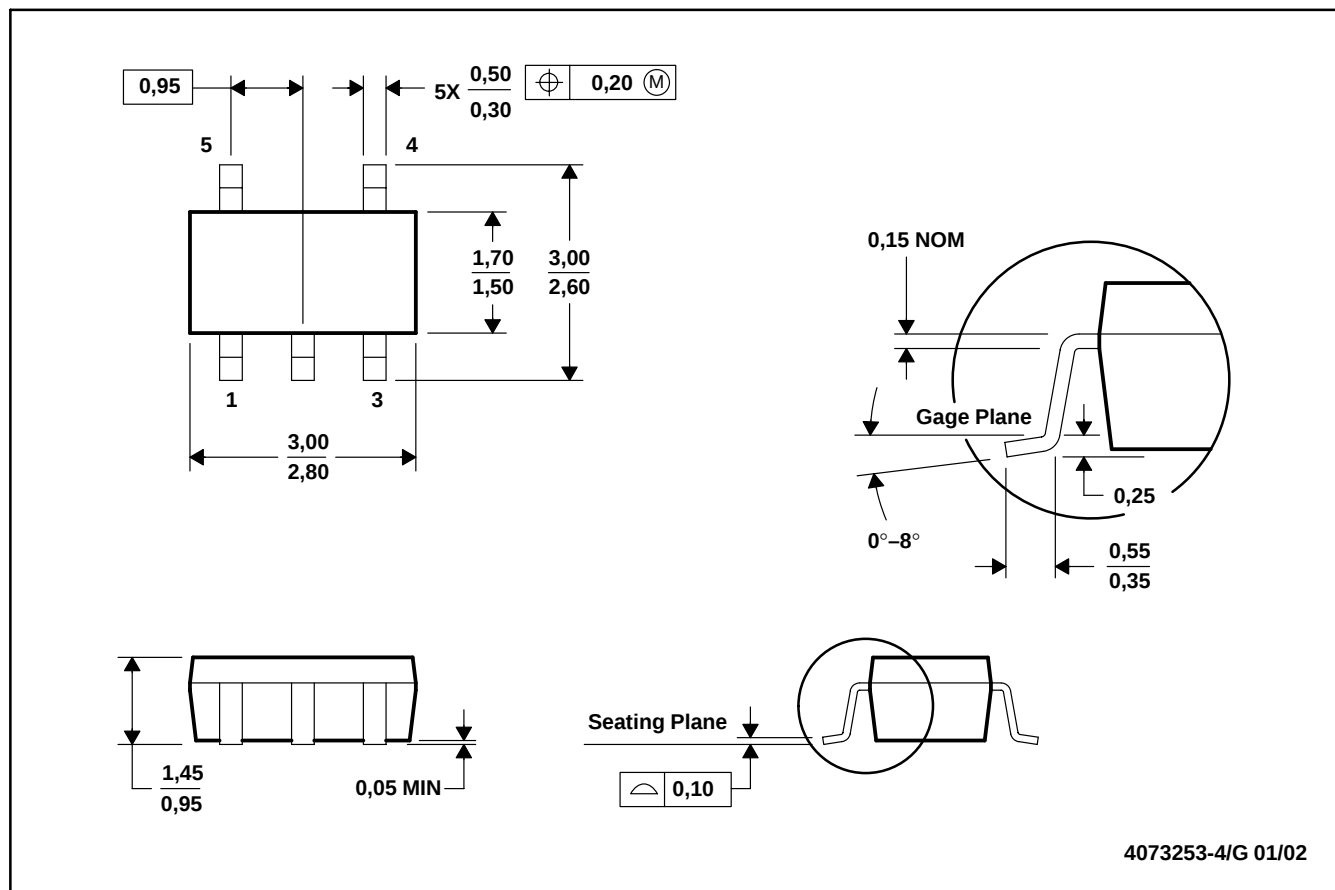
B. This drawing is subject to change without notice.

C Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).

D The 20 pin end lead shoulder width is a vendor option, either half or full width.

## DBV (R-PDSO-G5)

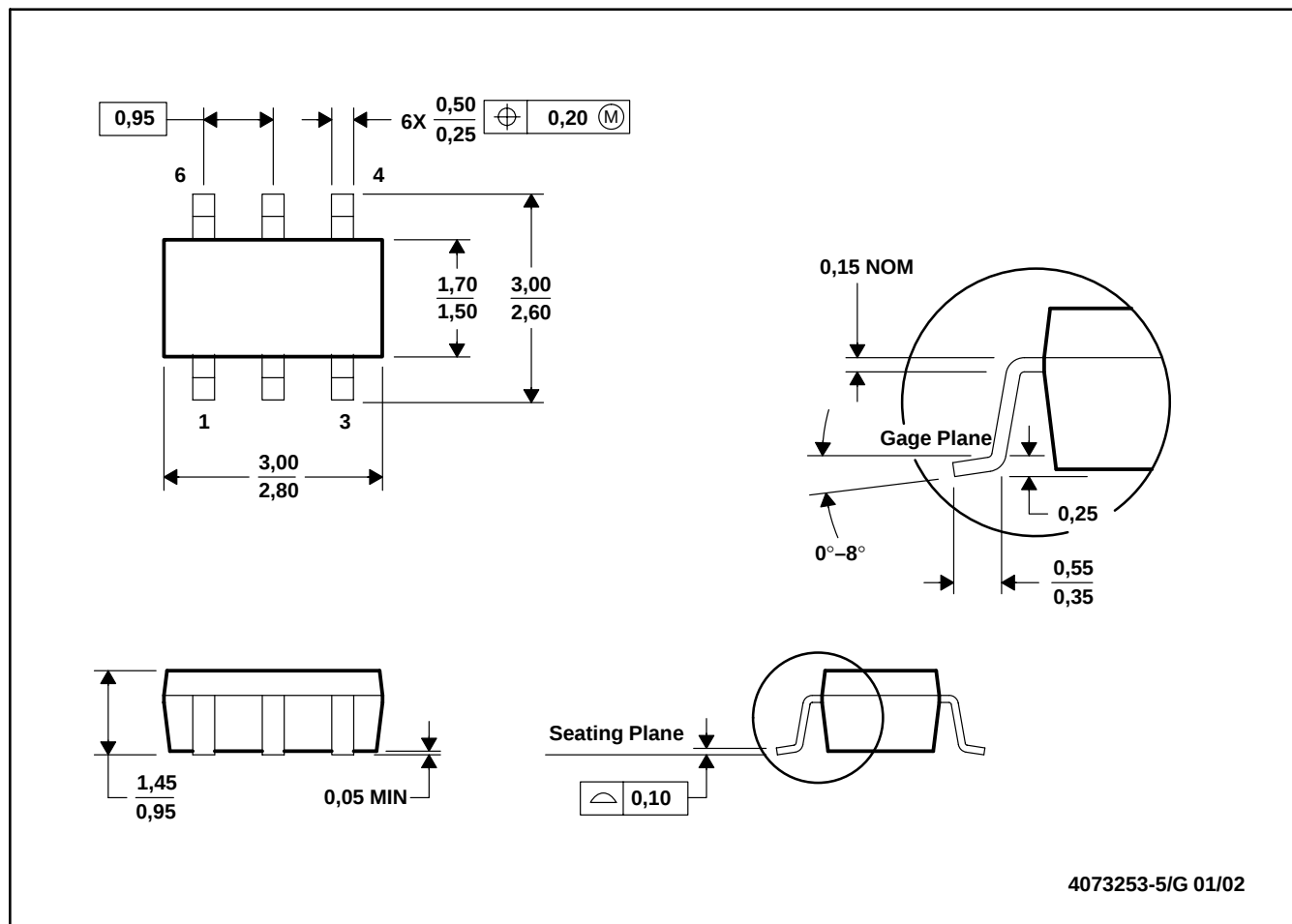
## PLASTIC SMALL-OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion.
  - D. Falls within JEDEC MO-178

DBV (R-PDSO-G6)

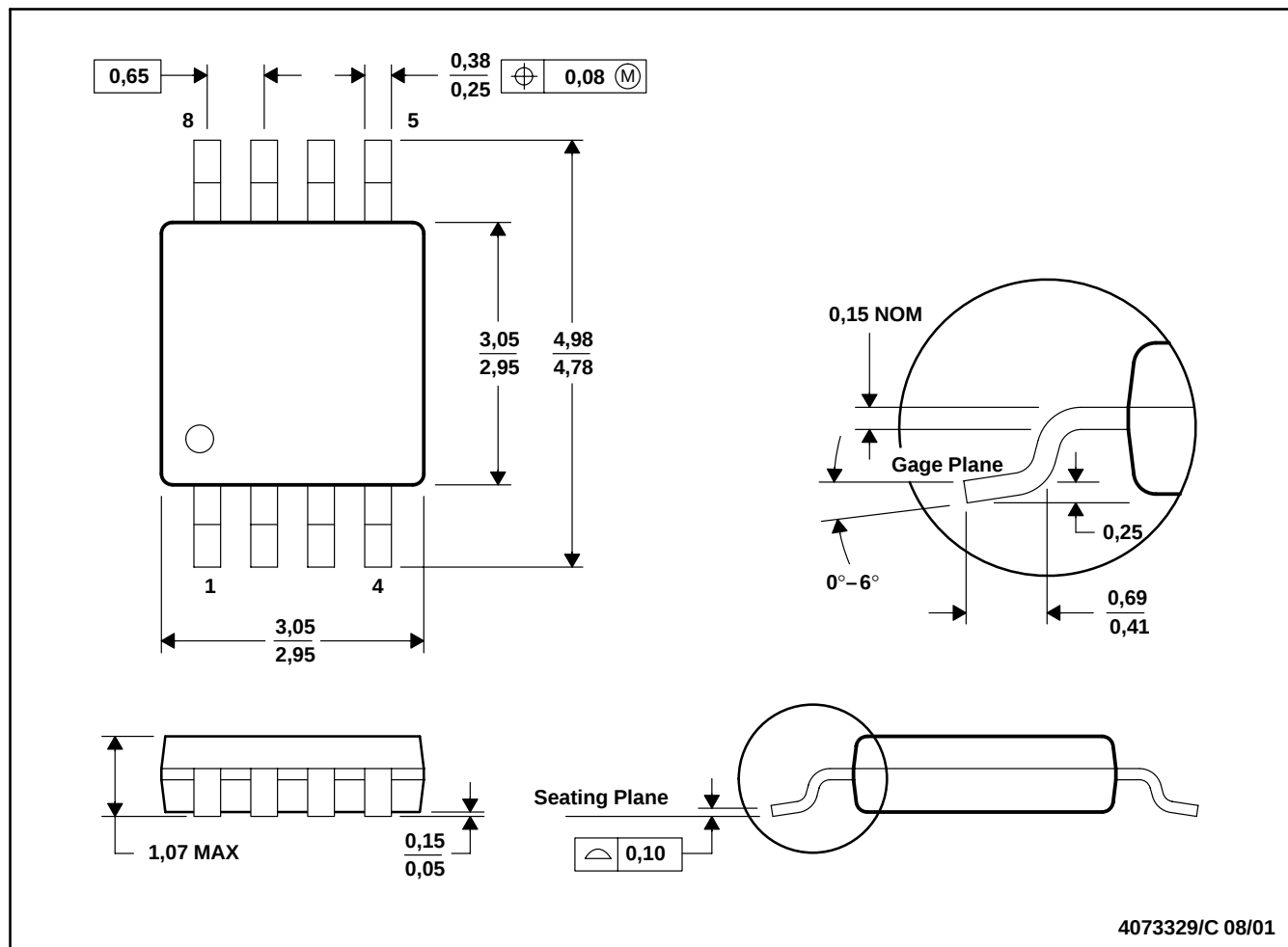
PLASTIC SMALL-OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion.
  - D. Leads 1, 2, 3 may be wider than leads 4, 5, 6 for package orientation.

## DGK (R-PDSO-G8)

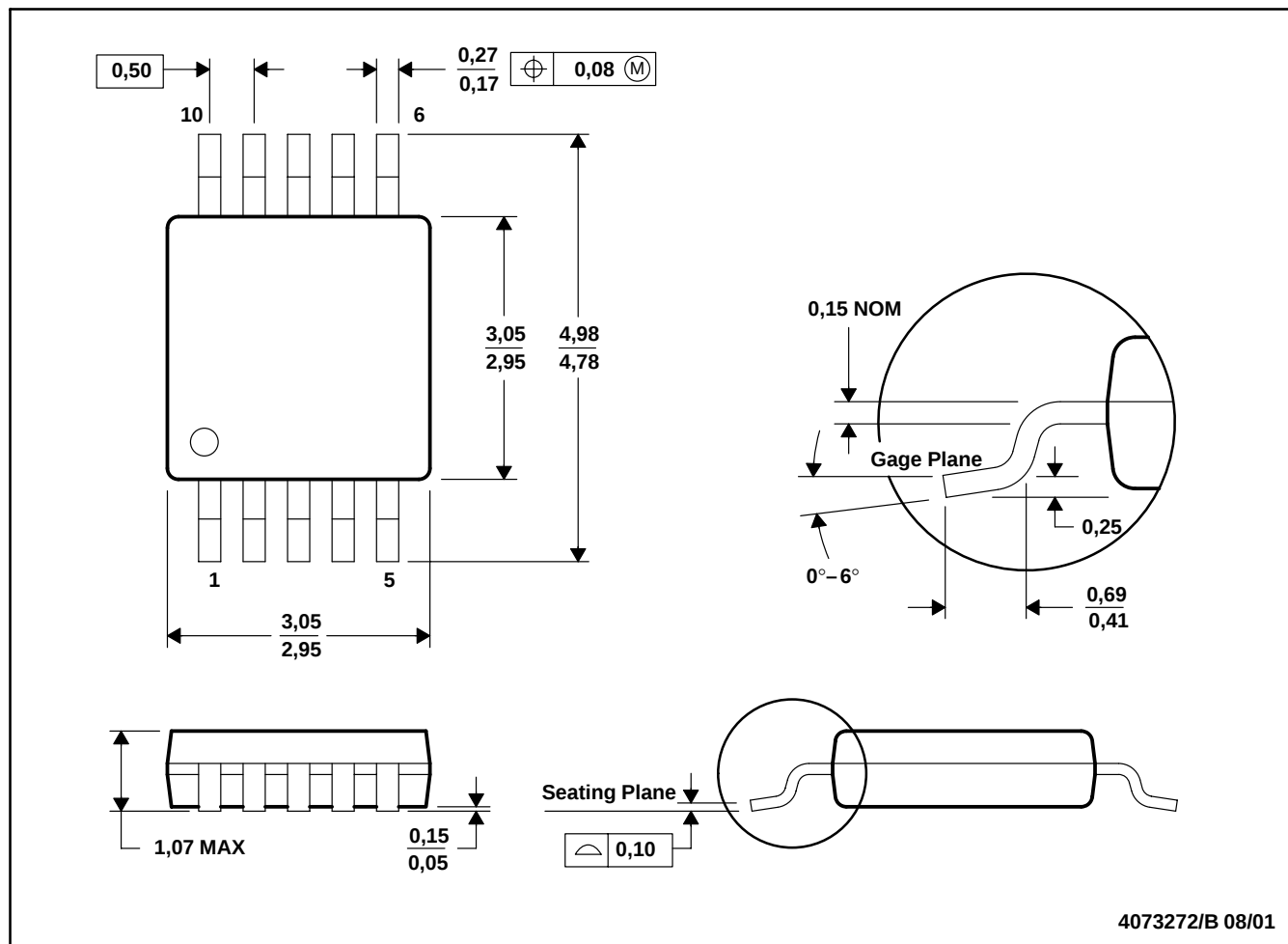
## PLASTIC SMALL-OUTLINE PACKAGE



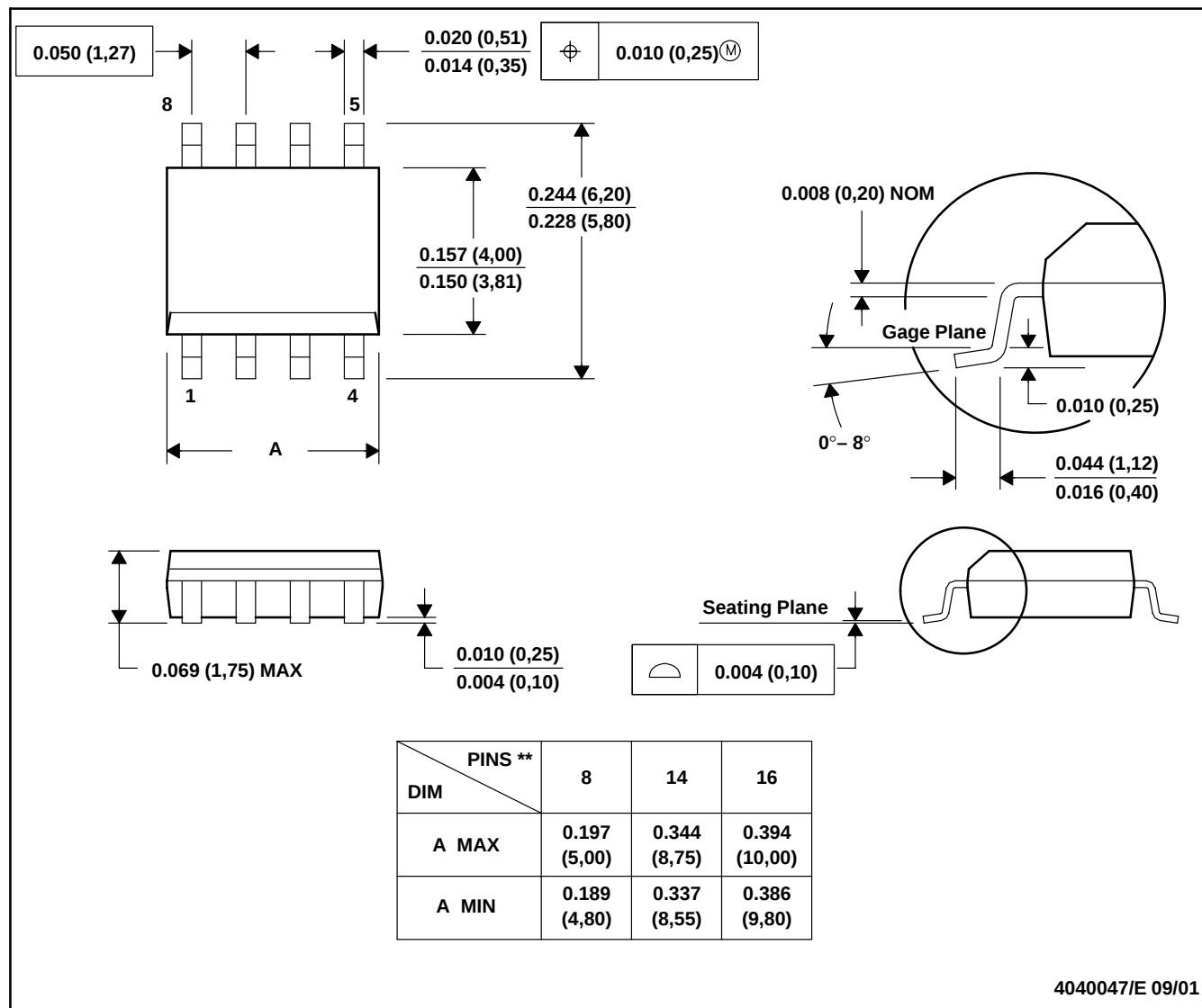
- NOTES: A. All linear dimensions are in millimeters.  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion.  
 D. Falls within JEDEC MO-187

## 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

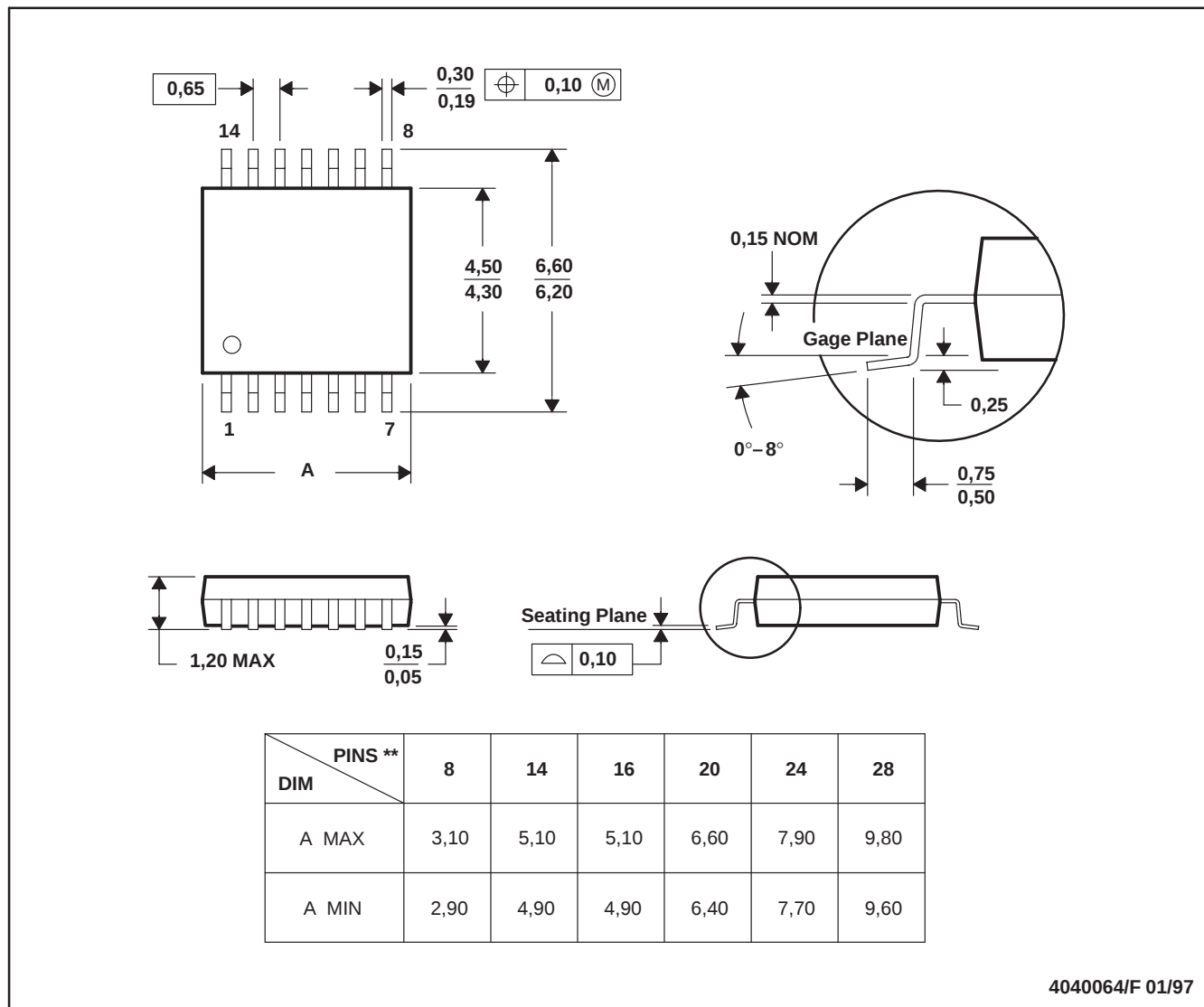
**D (R-PDSO-G\*\*)****PLASTIC SMALL-OUTLINE PACKAGE****8 PINS SHOWN**

- 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. Falls within JEDEC MS-012

## PW (R-PDSO-G\*\*)

## PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



- NOTES: A. All linear dimensions are in millimeters.  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.  
 D. Falls within JEDEC MO-153

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