



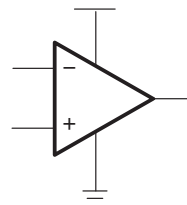
# THE DATASHEET OF TLV2451IDBVT

# TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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- Supply Current . . . 23  $\mu$ A/Channel
- Gain-Bandwidth Product . . . 220 kHz
- Output Drive Capability . . .  $\pm 10$  mA
- Input Offset Voltage . . . 20  $\mu$ V (typ)
- $V_{DD}$  Range . . . 2.7 V to 6 V
- Power Supply Rejection Ratio . . . 106 dB
- Ultralow-Power Shutdown Mode  
 $I_{DD}$  . . . 16 nA/ch
- Rail-To-Rail Input/Output (RRIO)
- Ultrasmall Packaging
  - 5 or 6 Pin SOT-23 (TLV2450/1)
  - 8 or 10 Pin MSOP (TLV2452/3)

Operational Amplifier



## description

The TLV245x is a family of rail-to-rail input/output operational amplifiers that sets a new performance point for supply current and ac performance. These devices consume a mere 23  $\mu$ A/channel while offering 220 kHz of gain-bandwidth product, much higher than competitive devices with similar supply current levels. Along with increased ac performance, the amplifier provides high output drive capability, solving a major shortcoming of older micropower rail-to-rail input/output operational amplifiers. The TLV245x can swing to within 250 mV of each supply rail while driving a 2.5-mA load. Both the inputs and outputs swing rail-to-rail for increased dynamic range in low-voltage applications. This performance makes the TLV245x family ideal for portable medical equipment, patient monitoring systems, and data acquisition circuits.

FAMILY PACKAGE TABLE

| DEVICE  | NUMBER OF CHANNELS | PACKAGE TYPES |      |        |       |      | SHUTDOWN | UNIVERSAL EVM BOARD                             |
|---------|--------------------|---------------|------|--------|-------|------|----------|-------------------------------------------------|
|         |                    | PDIP          | SOIC | SOT-23 | TSSOP | MSOP |          |                                                 |
| TLV2450 | 1                  | 8             | 8    | 6      | —     | —    | Yes      | Refer to the EVM Selection Guide (Lit# SLOU060) |
| TLV2451 | 1                  | 8             | 8    | 5      | —     | —    | —        |                                                 |
| TLV2452 | 2                  | 8             | 8    | —      | —     | 8    | —        |                                                 |
| TLV2453 | 2                  | 14            | 14   | —      | —     | 10   | Yes      |                                                 |
| TLV2454 | 4                  | 14            | 14   | —      | 14    | —    | —        |                                                 |
| TLV2455 | 4                  | 16            | 16   | —      | 16    | —    | Yes      |                                                 |

A SELECTION OF SINGLE-SUPPLY OPERATIONAL AMPLIFIER PRODUCTS<sup>†</sup>

| DEVICE  | $V_{DD}$ (V) | BW (MHz) | SLEW RATE (V/ $\mu$ s) | $I_{DD}$ (per channel) ( $\mu$ A) | RAIL-TO-RAIL |
|---------|--------------|----------|------------------------|-----------------------------------|--------------|
| TLV245X | 2.7 – 6.0    | 0.22     | 0.11                   | 23                                | I/O          |
| TLV247X | 2.7 – 6.0    | 2.8      | 1.5                    | 600                               | I/O          |
| TLV246X | 2.7 – 6.0    | 6.4      | 1.6                    | 550                               | I/O          |
| TLV277X | 2.5 – 6.0    | 5.1      | 10.5                   | 1000                              | O            |

<sup>†</sup> All specifications measured at 5 V.



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# TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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## description (continued)

Three members of the family (TLV2450/3/5) offer a shutdown terminal for conserving battery life in portable applications. During shutdown, the outputs are placed in a high-impedance state and the amplifier consumes only 16 nA/channel. The family is fully specified at 3 V and 5 V across an expanded industrial temperature range ( $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ ). The singles and duals are available in the SOT23 and MSOP packages, while the quads are available in TSSOP. The TLV2450 offers an amplifier with shutdown functionality all in a 6-pin SOT23 package, making it perfect for high density circuits.

TLV2450 and TLV2451 AVAILABLE OPTIONS

| T <sub>A</sub>                                 | PACKAGED DEVICES                  |                            |              |                          |
|------------------------------------------------|-----------------------------------|----------------------------|--------------|--------------------------|
|                                                | SMALL OUTLINE<br>(D) <sup>†</sup> | SOT-23                     |              | PLASTIC DIP<br>(P)       |
|                                                |                                   | (DBV)                      | SYMBOL       |                          |
| 0°C to 70°C                                    | TLV2450CD<br>TLV2451CD            | TLV2450CDBV<br>TLV2451CDBV | VAQC<br>VARC | TLV2450CP<br>TLV2451CP   |
| $-40^{\circ}\text{C}$ to $125^{\circ}\text{C}$ | TLV2450ID<br>TLV2451ID            | TLV2450IDBV<br>TLV2451IDBV | VAQI<br>VARI | TLV2450IP<br>TLV2451IP   |
|                                                | TLV2450AID<br>TLV2451AID          | —<br>—                     | —<br>—       | TLV2450AIP<br>TLV2451AIP |

<sup>†</sup> This package is available taped and reeled. To order this packaging option, add an R suffix to the part number (e.g., TLV2450CDR).

TLV2452 and TLV2453 AVAILABLE OPTIONS

| T <sub>A</sub>                                 | PACKAGED DEVICES                  |                    |                     |                    |                     |                    |                    |
|------------------------------------------------|-----------------------------------|--------------------|---------------------|--------------------|---------------------|--------------------|--------------------|
|                                                | SMALL OUTLINE<br>(D) <sup>†</sup> | MSOP               |                     |                    |                     | PLASTIC DIP<br>(N) | PLASTIC DIP<br>(P) |
|                                                |                                   | (DGK) <sup>†</sup> | SYMBOL <sup>‡</sup> | (DGS) <sup>†</sup> | SYMBOL <sup>‡</sup> |                    |                    |
| 0°C to 70°C                                    | TLV2452CD<br>TLV2453CD            | TLV2452CDGK<br>—   | xxTIABI<br>—        | —<br>TLV2453CDGS   | —<br>xxTIABK        | —<br>TLV2453CN     | TLV2452CP<br>—     |
| $-40^{\circ}\text{C}$ to $125^{\circ}\text{C}$ | TLV2452ID<br>TLV2453ID            | TLV2452IDGK<br>—   | xxTIABJ<br>—        | —<br>TLV2453IDGS   | —<br>xxTIABL        | —<br>TLV2453IN     | TLV2452IP<br>—     |
|                                                | TLV2452AID<br>TLV2453AID          | —<br>—             | —<br>—              | —<br>—             | —<br>—              | —<br>TLV2453AIN    | TLV2452AIP<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., TLV2452CDR).

<sup>‡</sup> xx represents the device date code.

TLV2454 and TLV2455 AVAILABLE OPTIONS

| T <sub>A</sub>                                 | PACKAGED DEVICES                  |                          |                            |
|------------------------------------------------|-----------------------------------|--------------------------|----------------------------|
|                                                | SMALL OUTLINE<br>(D) <sup>†</sup> | PLASTIC DIP<br>(N)       | TSSOP<br>(PW) <sup>†</sup> |
| 0°C to 70°C                                    | TLV2454CD<br>TLV2455CD            | TLV2454CN<br>TLV2455CN   | TLV2454CPW<br>TLV2455CPW   |
| $-40^{\circ}\text{C}$ to $125^{\circ}\text{C}$ | TLV2454ID<br>TLV2455ID            | TLV2454IN<br>TLV2455IN   | TLV2454IPW<br>TLV2455IPW   |
|                                                | TLV2454AID<br>TLV2455AID          | TLV2454AIN<br>TLV2455AIN | TLV2454AIPW<br>TLV2455AIPW |

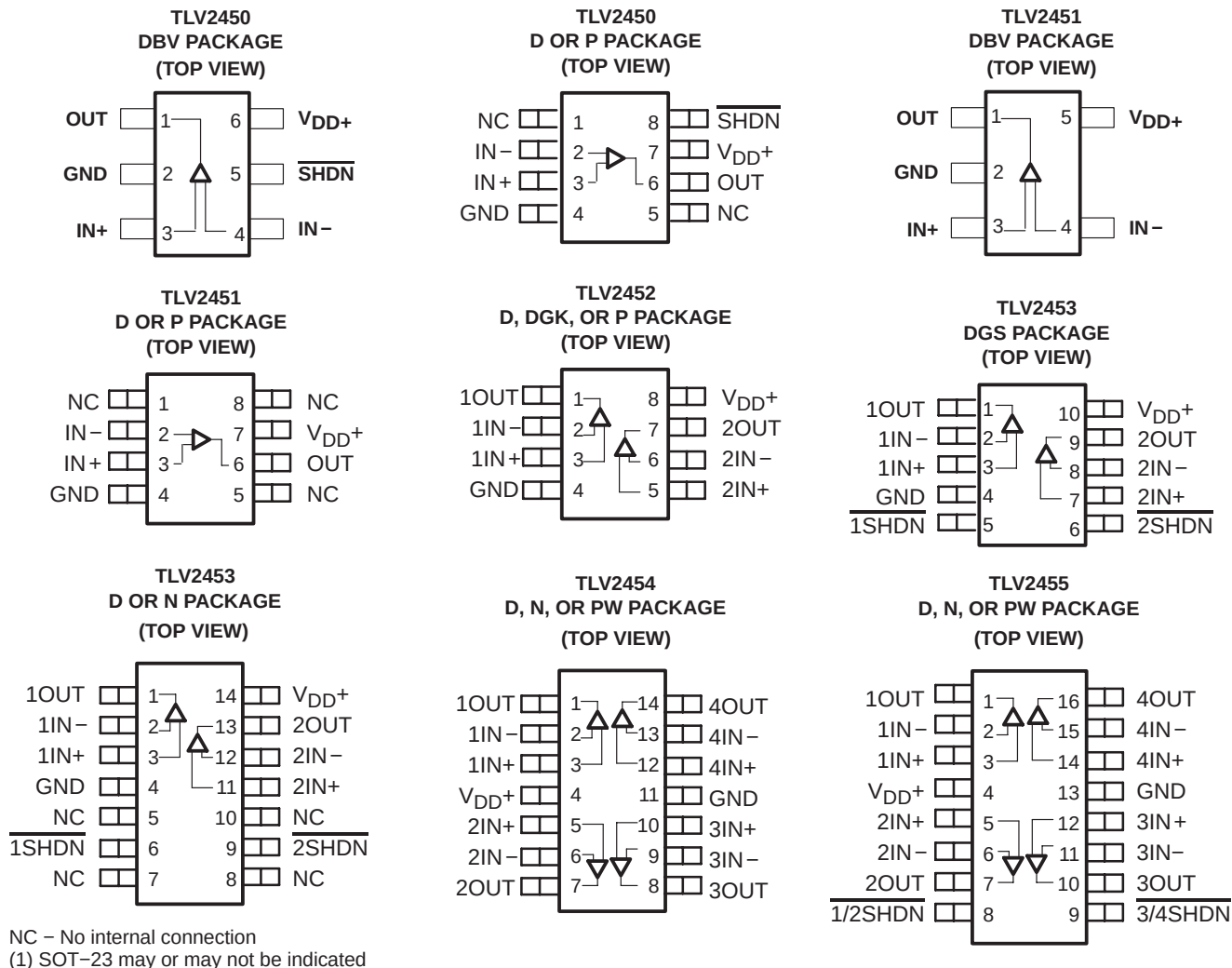
<sup>†</sup> This package is available taped and reeled. To order this packaging option, add an R suffix to the part number (e.g., TLV2454CDR).

**NOTE:** For the most current package and ordering information, see the Package Option Addendum located at the end of this data sheet, or refer to our web site at [www.ti.com](http://www.ti.com).

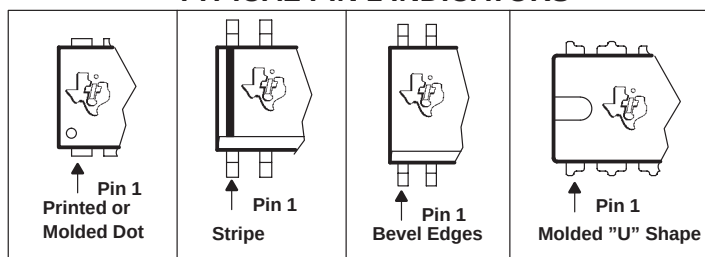
# TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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## TLV245x PACKAGE PINOUTS<sup>(1)</sup>



## TYPICAL PIN 1 INDICATORS



# TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA

## FAMILY OF 23- $\mu$ A 220-kHz 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)                        | 7 V                          |
| Differential input voltage, $V_{ID}$                         | $\pm V_{DD}$                 |
| 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:** 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 |
|------------|-------------------------|-------------------------|---------------------------------------------|
| D (8)      | 38.3                    | 176                     | 710 mW                                      |
| D (14)     | 26.9                    | 122.3                   | 1022 mW                                     |
| D (16)     | 25.7                    | 114.7                   | 1090 mW                                     |
| DBV (5)    | 55                      | 324.1                   | 385 mW                                      |
| DBV (6)    | 55                      | 294.3                   | 425 mW                                      |
| DGK (8)    | 54.2                    | 259.9                   | 481 mW                                      |
| DGS (10)   | 54.1                    | 257.7                   | 485 mW                                      |
| N (14, 16) | 32                      | 78                      | 1600 mW                                     |
| P (8)      | 41                      | 104                     | 1200 mW                                     |
| PW (14)    | 29.3                    | 173.6                   | 720 mW                                      |
| PW (16)    | 28.7                    | 161.4                   | 774 mW                                      |

#### recommended operating conditions

|                                            |               | MIN           | MAX      | UNIT |
|--------------------------------------------|---------------|---------------|----------|------|
| Supply voltage, $V_{DD}$                   | Single supply | 2.7           | 6        | V    |
|                                            | Split supply  | $\pm 1.35$    | $\pm 3$  |      |
| Common-mode input voltage range, $V_{ICR}$ |               | 0             | $V_{DD}$ | V    |
| Operating free-air temperature, $T_A$      | C-suffix      | 0             | 70       | °C   |
|                                            | I-suffix      | –40           | 125      |      |
| Shutdown on/off voltage level <sup>‡</sup> | $V_{IH}$      | 2             |          | V    |
|                                            | $V_{IL}$      | $V_{DD} = 5V$ | 0.8      |      |
|                                            |               | $V_{DD} = 3V$ | 0.5      | V    |

<sup>‡</sup> Relative to voltage on the GND terminal of the device.



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**electrical characteristics at specified free-air temperature,  $V_{DD} = 3$  V (unless otherwise noted)**

| PARAMETER             |                                                                           | TEST CONDITIONS                                                                                      |                                       | T <sub>A</sub> <sup>†</sup> | MIN             | TYP  | MAX  | UNIT  |
|-----------------------|---------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|---------------------------------------|-----------------------------|-----------------|------|------|-------|
| V <sub>IO</sub>       | Input offset voltage                                                      | V <sub>DD</sub> = ±1.5 V<br>V <sub>IC</sub> = 0,<br><br>V <sub>O</sub> = 0,<br>R <sub>S</sub> = 50 Ω |                                       | 25°C                        | 300             |      | 1500 | μV    |
|                       |                                                                           |                                                                                                      |                                       | Full range                  | 2000            |      |      |       |
|                       | TLV245xA                                                                  |                                                                                                      |                                       | 25°C                        | 300             |      | 1000 |       |
|                       |                                                                           |                                                                                                      |                                       | Full range                  | 1300            |      |      |       |
| α <sub>VIO</sub>      | Temperature coefficient of input offset voltage                           |                                                                                                      |                                       |                             | 0.3             |      |      | μV/°C |
| I <sub>IO</sub>       | Input offset current                                                      |                                                                                                      |                                       | 25°C                        | 0.3             |      | 4.5  | nA    |
|                       |                                                                           |                                                                                                      |                                       | Full range                  | 5.5             |      |      |       |
| I <sub>IB</sub>       | Input bias current                                                        |                                                                                                      |                                       | 25°C                        | 0.9             |      | 5    | nA    |
|                       |                                                                           |                                                                                                      |                                       | Full range                  | 7               |      |      |       |
| V <sub>OH</sub>       | High-level output voltage                                                 | V <sub>IC</sub> = 1.5 V,<br><br>I <sub>OH</sub> = −500 μA                                            |                                       | 25°C                        | 2.85            | 2.95 |      | V     |
|                       |                                                                           |                                                                                                      |                                       | Full range                  | 2.83            |      |      |       |
| V <sub>OL</sub>       | Low-level output voltage                                                  | V <sub>IC</sub> = 1.5 V,<br><br>I <sub>OL</sub> = 500 μA                                             |                                       | 25°C                        | 0.09            |      | 0.16 | V     |
|                       |                                                                           |                                                                                                      |                                       | Full range                  | 0.2             |      |      |       |
| I <sub>OS</sub>       | Short-circuit output current                                              | Sourcing                                                                                             |                                       | 25°C                        | 4               | 12   |      | mA    |
|                       |                                                                           |                                                                                                      |                                       | Full range                  | 3               |      |      |       |
|                       |                                                                           | Sinking                                                                                              |                                       | 25°C                        | 2               | 7    |      |       |
|                       |                                                                           |                                                                                                      |                                       | Full range                  | 1               |      |      |       |
| I <sub>O</sub>        | Output current                                                            | V <sub>O</sub> = 0.5 V from rail                                                                     |                                       | 25°C                        | ±4              |      | mA   |       |
| A <sub>VD</sub>       | Large-signal differential voltage amplification                           | V <sub>O(PP)</sub> = 1 V,<br><br>R <sub>L</sub> = 10 kΩ                                              |                                       | 25°C                        | 96              | 110  |      | dB    |
|                       |                                                                           |                                                                                                      |                                       | Full range                  | 91              |      |      |       |
| r <sub>i(d)</sub>     | Differential input resistance                                             |                                                                                                      |                                       | 25°C                        | 10 <sup>9</sup> |      | Ω    |       |
| C <sub>IC</sub>       | Common-mode input capacitance                                             | f = 10 kHz                                                                                           |                                       | 25°C                        | 4.5             |      | pF   |       |
| z <sub>O</sub>        | Closed-loop output impedance                                              | f = 10 kHz,<br><br>A <sub>V</sub> = 10                                                               |                                       | 25°C                        | 80              |      | Ω    |       |
| CMRR                  | Common-mode rejection ratio                                               | V <sub>IC</sub> = 0 to 3 V,<br>R <sub>S</sub> = 50 Ω                                                 |                                       | 25°C                        | 70              | 80   |      | dB    |
|                       |                                                                           |                                                                                                      | TLV245xC                              | Full range                  | 66              |      | dB   |       |
| k <sub>SVR</sub>      | Supply voltage rejection ratio (ΔV <sub>DD</sub> /ΔV <sub>IO</sub> )      | V <sub>DD</sub> = 2.7 V to 6 V,<br>No load                                                           | V <sub>IC</sub> = V <sub>DD</sub> /2, | 25°C                        | 76              | 89   |      | dB    |
|                       |                                                                           |                                                                                                      |                                       | Full range                  | 74              |      |      |       |
|                       |                                                                           | V <sub>DD</sub> = 3 V to 5 V,<br>No load                                                             | V <sub>IC</sub> = V <sub>DD</sub> /2, | 25°C                        | 88              | 106  |      |       |
|                       |                                                                           |                                                                                                      |                                       | Full range                  | 84              |      |      |       |
| I <sub>DD</sub>       | Supply current (per channel)                                              | V <sub>O</sub> = 1.5 V, No load                                                                      |                                       | 25°C                        | 23              |      | 35   | μA    |
|                       |                                                                           |                                                                                                      | TLV245xC                              | Full range                  | 40              |      |      |       |
|                       |                                                                           |                                                                                                      | TLV245xI                              | Full range                  | 45              |      |      |       |
| I <sub>DD(SHDN)</sub> | Supply current in shutdown mode (TLV2450, TLV2453, TLV2455) (per channel) | SHDN = −V <sub>DD</sub>                                                                              |                                       | 25°C                        | 12              |      | 65   | nA    |
|                       |                                                                           |                                                                                                      | TLV245xC                              | Full range                  | 70              |      |      |       |
|                       |                                                                           |                                                                                                      | TLV245xI                              | Full range                  | 80              |      |      |       |

$^\dagger$  Full range is 0°C to 70°C for C suffix and –40°C to 125°C for I suffix.



**TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA**  
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operating characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$  (unless otherwise noted)

| PARAMETER              |                                      | TEST CONDITIONS                                                                                           |                          | T <sub>A</sub> <sup>†</sup> | MIN  | TYP   | MAX | UNIT   |
|------------------------|--------------------------------------|-----------------------------------------------------------------------------------------------------------|--------------------------|-----------------------------|------|-------|-----|--------|
| SR                     | Slew rate at unity gain              | V <sub>O(PP)</sub> = 0.8 V,<br>R <sub>L</sub> = 10 kΩ                                                     |                          | 25°C                        | 0.05 | 0.11  |     | V/μs   |
|                        |                                      |                                                                                                           |                          | Full range                  | 0.02 |       |     |        |
| V <sub>n</sub>         | Equivalent input noise voltage       | f = 100 Hz                                                                                                |                          | 25°C                        |      | 49    |     | nV/√Hz |
|                        |                                      | f = 1 kHz                                                                                                 |                          | 25°C                        |      | 51    |     |        |
| I <sub>n</sub>         | Equivalent input noise current       | f = 1 kHz                                                                                                 |                          | 25°C                        |      | 3.5   |     | pA/√Hz |
| THD + N                | Total harmonic distortion plus noise | V <sub>O(PP)</sub> = 1.5 V,<br>R <sub>L</sub> = 10 kΩ,<br>f = 1 kHz                                       | A <sub>V</sub> = 1       | 25°C                        |      | 0.04% |     |        |
|                        |                                      |                                                                                                           | A <sub>V</sub> = 10      |                             |      | 0.3%  |     |        |
|                        |                                      |                                                                                                           | A <sub>V</sub> = 100     |                             |      | 1.5%  |     |        |
| t <sub>(on)</sub>      | Amplifier turnon time                | A <sub>V</sub> = 5, R <sub>L</sub> = OPEN,<br>Measured at 50% point                                       |                          | 25°C                        |      | 59    |     | μs     |
| t <sub>(off)</sub>     | Amplifier turnoff time               |                                                                                                           |                          | 25°C                        |      | 836   |     | ns     |
| Gain-bandwidth product |                                      | f = 10 kHz,                                                                                               | R <sub>L</sub> = 10 kΩ   | 25°C                        |      | 200   |     | kHz    |
| t <sub>s</sub>         | Settling time                        | V(STEP) <sub>PP</sub> = 2 V,<br>A <sub>V</sub> = -1,<br>C <sub>L</sub> = 10 pF,<br>R <sub>L</sub> = 10 kΩ | 0.1%                     | 25°C                        |      | 26    |     | μs     |
|                        |                                      |                                                                                                           | 0.01%                    |                             |      | 31    |     |        |
|                        |                                      | V(STEP) <sub>PP</sub> = 2 V,<br>A <sub>V</sub> = -1,<br>C <sub>L</sub> = 56 pF,<br>R <sub>L</sub> = 10 kΩ | 0.1%                     |                             |      | 26    |     |        |
|                        |                                      |                                                                                                           | 0.01%                    |                             |      | 31    |     |        |
| φ <sub>m</sub>         | Phase margin                         | R <sub>L</sub> = 10 kΩ,                                                                                   | C <sub>L</sub> = 1000 pF | 25°C                        |      | 56°   |     |        |
| Gain margin            |                                      | R <sub>L</sub> = 10 kΩ,                                                                                   | C <sub>L</sub> = 1000 pF | 25°C                        |      | 7     |     | dB     |

$^\dagger$  Full range is 0°C to 70°C for C suffix and -40°C to 125°C for I suffix.

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

| PARAMETER             |                                                                              | TEST CONDITIONS                                      |                                                                                                      | T <sub>A</sub> <sup>†</sup> | MIN             | TYP  | MAX  | UNIT |       |
|-----------------------|------------------------------------------------------------------------------|------------------------------------------------------|------------------------------------------------------------------------------------------------------|-----------------------------|-----------------|------|------|------|-------|
| V <sub>IO</sub>       | Input offset voltage                                                         | TLV245x                                              | V <sub>DD</sub> = ±2.5 V<br>V <sub>IC</sub> = 0,<br><br>V <sub>O</sub> = 0,<br>R <sub>S</sub> = 50 Ω | 25°C                        | 300             |      | 1500 | μV   |       |
|                       |                                                                              |                                                      |                                                                                                      | Full range                  | 2000            |      |      |      |       |
|                       |                                                                              |                                                      |                                                                                                      | 25°C                        | 300             |      | 1000 |      |       |
|                       |                                                                              |                                                      |                                                                                                      | Full range                  | 1300            |      |      |      |       |
| α <sub>VIO</sub>      | Temperature coefficient of input offset voltage                              |                                                      |                                                                                                      |                             |                 | 0.3  |      |      | μV/°C |
| I <sub>IO</sub>       | Input offset current                                                         |                                                      |                                                                                                      |                             | 25°C            | 0.3  |      | 4.5  | nA    |
|                       |                                                                              |                                                      |                                                                                                      |                             | Full range      | 5.5  |      |      |       |
| I <sub>IB</sub>       | Input bias current                                                           |                                                      |                                                                                                      |                             | 25°C            | 0.5  |      | 5    | nA    |
|                       |                                                                              |                                                      |                                                                                                      | Full range                  | 7               |      |      |      |       |
| V <sub>OH</sub>       | High-level output voltage                                                    | V <sub>IC</sub> = 2.5 V,                             | I <sub>OH</sub> = −500 μA                                                                            | 25°C                        | 4.87            | 4.97 |      | V    |       |
|                       |                                                                              |                                                      |                                                                                                      | Full range                  | 4.85            |      |      |      |       |
| V <sub>OL</sub>       | Low-level output voltage                                                     | V <sub>IC</sub> = 2.5 V,                             | I <sub>OL</sub> = 500 μA                                                                             | 25°C                        | 0.07            |      | 0.15 | V    |       |
|                       |                                                                              |                                                      |                                                                                                      | Full range                  | 0.16            |      |      |      |       |
| I <sub>OS</sub>       | Short-circuit output current                                                 | Sourcing                                             |                                                                                                      | 25°C                        | 20              | 32   |      | mA   |       |
|                       |                                                                              |                                                      |                                                                                                      | Full range                  | 18              |      |      |      |       |
|                       |                                                                              | Sinking                                              |                                                                                                      | 25°C                        | 12              | 18   |      |      |       |
|                       |                                                                              |                                                      |                                                                                                      | Full range                  | 10              |      |      |      |       |
| I <sub>O</sub>        | Output current                                                               | V <sub>O</sub> = 0.5 V from rail                     |                                                                                                      | 25°C                        | ±10             |      | mA   |      |       |
| A <sub>VD</sub>       | Large-signal differential voltage amplification                              | V <sub>O(PP)</sub> = 3 V,                            | R <sub>L</sub> = 10 kΩ                                                                               | 25°C                        | 96              | 103  |      | dB   |       |
|                       |                                                                              |                                                      |                                                                                                      | Full range                  | 91              |      |      |      |       |
| r <sub>i(d)</sub>     | Differential input resistance                                                |                                                      |                                                                                                      | 25°C                        | 10 <sup>9</sup> |      | Ω    |      |       |
| C <sub>IC</sub>       | Common-mode input capacitance                                                | f = 10 kHz                                           |                                                                                                      | 25°C                        | 4.5             |      | pF   |      |       |
| z <sub>O</sub>        | Closed-loop output impedance                                                 | f = 10 kHz,                                          | A <sub>V</sub> = 10                                                                                  | 25°C                        | 45              |      | Ω    |      |       |
| CMRR                  | Common-mode rejection ratio                                                  | V <sub>IC</sub> = 0 to 5 V,<br>R <sub>S</sub> = 50 Ω |                                                                                                      | 25°C                        | 70              | 80   |      | dB   |       |
|                       |                                                                              |                                                      | TLV245xC                                                                                             | Full range                  | 68              |      |      |      |       |
| k <sub>SVR</sub>      | Supply voltage rejection ratio<br>(ΔV <sub>DD</sub> /ΔV <sub>IO</sub> )      | V <sub>DD</sub> = 2.7 V to 6 V,<br>No load           | V <sub>IC</sub> = V <sub>DD</sub> /2,                                                                | 25°C                        | 76              | 89   |      | dB   |       |
|                       |                                                                              |                                                      |                                                                                                      | Full range                  | 74              |      |      |      |       |
|                       |                                                                              | V <sub>DD</sub> = 3 V to 5 V,<br>No load             | V <sub>IC</sub> = V <sub>DD</sub> /2,                                                                | 25°C                        | 88              | 106  |      |      |       |
|                       |                                                                              |                                                      |                                                                                                      | Full range                  | 84              |      |      |      |       |
| I <sub>DD</sub>       | Supply current (per channel)                                                 | V <sub>O</sub> = 2.5 V, No load                      |                                                                                                      | 25°C                        | 23              |      | 42   | μA   |       |
|                       |                                                                              |                                                      | TLV245xC                                                                                             | Full range                  | 44              |      |      |      |       |
|                       |                                                                              |                                                      | TLV245xI                                                                                             | Full range                  | 46              |      |      |      |       |
| I <sub>DD(SHDN)</sub> | Supply current in shutdown mode<br>(TLV2450, TLV2453, TLV2455) (per channel) | $\overline{\text{SHDN}}$ = −V <sub>DD</sub>          |                                                                                                      | 25°C                        | 16              |      | 70   | nA   |       |
|                       |                                                                              |                                                      | TLV245xC                                                                                             | Full range                  | 70              |      |      |      |       |
|                       |                                                                              |                                                      | TLV245xI                                                                                             | Full range                  | 80              |      |      |      |       |

$^\dagger$  Full range is 0°C to 70°C for C suffix and –40°C to 125°C for I suffix.



**TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA**  
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operating characteristics at specified free-air temperature,  $V_{DD} = 5$  V (unless otherwise noted)

| PARAMETER              |                                      | TEST CONDITIONS                                                                         | $T_A^\dagger$           | MIN  | TYP   | MAX | UNIT                   |
|------------------------|--------------------------------------|-----------------------------------------------------------------------------------------|-------------------------|------|-------|-----|------------------------|
| SR                     | Slew rate at unity gain              | $V_{O(PP)} = 2$ V,<br>$R_L = 10$ k $\Omega$                                             | $C_L = 150$ pF,<br>25°C | 0.05 | 0.11  |     | V/ $\mu$ s             |
|                        |                                      |                                                                                         | Full range              | 0.02 |       |     |                        |
| $V_n$                  | Equivalent input noise voltage       | $f = 100$ Hz                                                                            | 25°C                    |      | 49    |     | nV/ $\sqrt{\text{Hz}}$ |
|                        |                                      | $f = 1$ kHz                                                                             | 25°C                    |      | 52    |     |                        |
| $I_n$                  | Equivalent input noise current       | $f = 1$ kHz                                                                             | 25°C                    |      | 3.5   |     | pA/ $\sqrt{\text{Hz}}$ |
| THD + N                | Total harmonic distortion plus noise | $V_{O(PP)} = 3$ V,<br>$R_L = 10$ k $\Omega$ ,<br>$f = 1$ kHz                            | $A_V = 1$               |      | 0.02% |     |                        |
|                        |                                      |                                                                                         | $A_V = 10$              |      | 0.18% |     |                        |
|                        |                                      |                                                                                         | $A_V = 100$             |      | 0.9%  |     |                        |
| $t_{(on)}$             | Amplifier turnon time                | $A_V = 5$ ,<br>$R_L = \text{OPEN}$ ,<br>Measured at 50% point                           | 25°C                    |      | 59    |     | $\mu$ s                |
| $t_{(off)}$            | Amplifier turnoff time               |                                                                                         | 25°C                    |      | 836   |     | ns                     |
| Gain-bandwidth product |                                      | $f = 10$ kHz, $R_L = 10$ k $\Omega$                                                     | 25°C                    |      | 220   |     | kHz                    |
| $t_s$                  | Settling time                        | $V(\text{STEP})_{PP} = 2$ V,<br>$A_V = -1$ ,<br>$C_L = 10$ pF,<br>$R_L = 10$ k $\Omega$ | 0.1%                    |      | 24    |     | $\mu$ s                |
|                        |                                      |                                                                                         | 0.01%                   |      | 30    |     |                        |
|                        |                                      | $V(\text{STEP})_{PP} = 2$ V,<br>$A_V = -1$ ,<br>$C_L = 56$ pF,<br>$R_L = 10$ k $\Omega$ | 0.1%                    |      | 25    |     |                        |
|                        |                                      |                                                                                         | 0.01%                   |      | 30    |     |                        |
| $\phi_m$               | Phase margin                         | $R_L = 10$ k $\Omega$ , $C_L = 1000$ pF                                                 | 25°C                    |      | 56°   |     |                        |
| Gain margin            |                                      | $R_L = 10$ k $\Omega$ , $C_L = 1000$ pF                                                 | 25°C                    |      | 7     |     | dB                     |

$^\dagger$  Full range is 0°C to 70°C for C suffix and –40°C to 125°C for I suffix.

**TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA**  
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**TYPICAL CHARACTERISTICS**

**Table of Graphs**

|             |                                      |                                                         | <b>FIGURE</b> |
|-------------|--------------------------------------|---------------------------------------------------------|---------------|
| $V_{IO}$    | Input offset voltage                 | vs Common-mode input voltage                            | 1, 2          |
| $I_{IO}$    | Input offset current                 | vs Common-mode input voltage<br>vs Free-air temperature | 3, 4<br>7, 8  |
| $I_{IB}$    | Input bias current                   | vs Common-mode input voltage<br>vs Free-air temperature | 5, 6<br>7, 8  |
| $A_{VD}$    | Differential voltage amplification   | vs Frequency                                            | 9, 10         |
|             | Phase                                | vs Frequency                                            | 9, 10         |
| $V_{OL}$    | Low-level output voltage             | vs Low-level output current                             | 11, 13        |
| $V_{OH}$    | High-level output voltage            | vs High-level output current                            | 12, 14        |
| $Z_o$       | Output impedance                     | vs Frequency                                            | 15, 16        |
| CMRR        | Common-mode rejection ratio          | vs Frequency                                            | 17            |
| PSRR        | Power supply rejection ratio         | vs Frequency                                            | 18            |
| $I_{DD}$    | Supply current                       | vs Supply voltage                                       | 19            |
| $I_{DD}$    | Supply current                       | vs Free-air temperature                                 | 20            |
| $V_n$       | Equivalent input noise voltage       | vs Frequency                                            | 21            |
| THD + N     | Total harmonic distortion plus noise | vs Frequency                                            | 22, 23        |
| $\phi_m$    | Phase margin                         | vs Load capacitance                                     | 24            |
|             | Gain-bandwidth product               | vs Supply voltage                                       | 25            |
| SR          | Slew rate                            | vs Supply voltage<br>vs Free-air temperature            | 26<br>27      |
| $V_{O(PP)}$ | Maximum peak-to-peak output voltage  | vs Frequency                                            | 28            |
|             | Crosstalk                            | vs Frequency                                            | 29, 30        |
|             | Small-signal follower pulse response | vs Time                                                 | 31, 33        |
|             | Large-signal follower pulse response | vs Time                                                 | 32, 34        |
|             | Shutdown on supply current           | vs Time                                                 | 35            |
|             | Shutdown off supply current          | vs Time                                                 | 36            |
|             | Shutdown supply current              | vs Free-air temperature                                 | 37            |
|             | Shutdown supply current              | vs Time                                                 | 38 – 41       |
|             | Shutdown pulse                       | vs Time                                                 | 38 – 41       |
|             | Shutdown off pulse response          | vs Time                                                 | 42, 43        |
|             | Shutdown on pulse response           | vs Time                                                 | 44, 45        |
|             | Shutdown reverse isolation           | vs Frequency                                            | 46            |
|             | Shutdown forward isolation           | vs Frequency                                            | 47            |



# TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA

## FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT

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#### TYPICAL CHARACTERISTICS

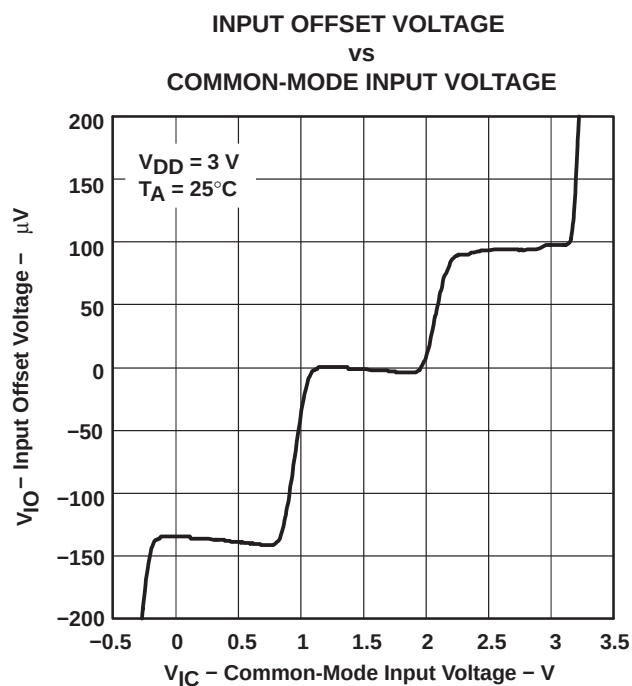


Figure 1

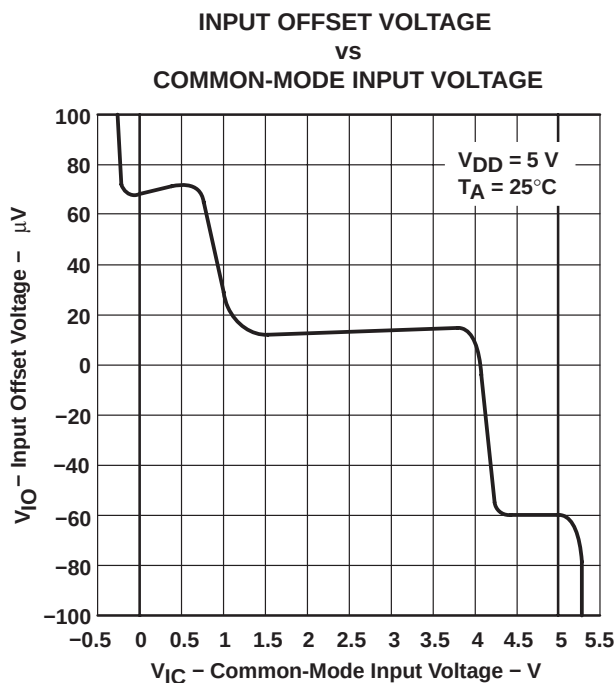


Figure 2

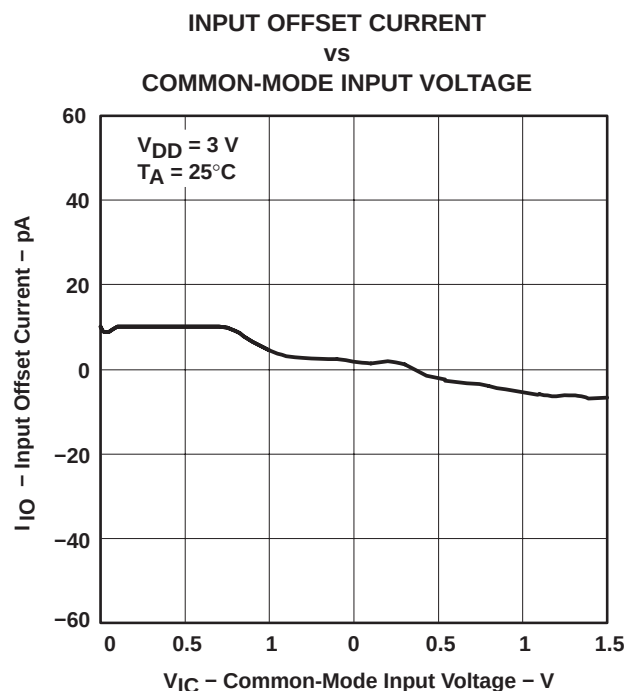


Figure 3

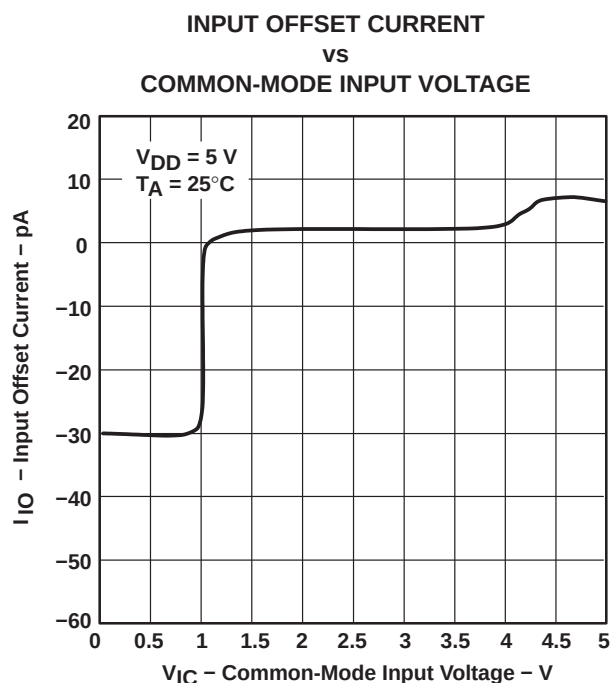


Figure 4

TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA  
FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT  
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TYPICAL CHARACTERISTICS

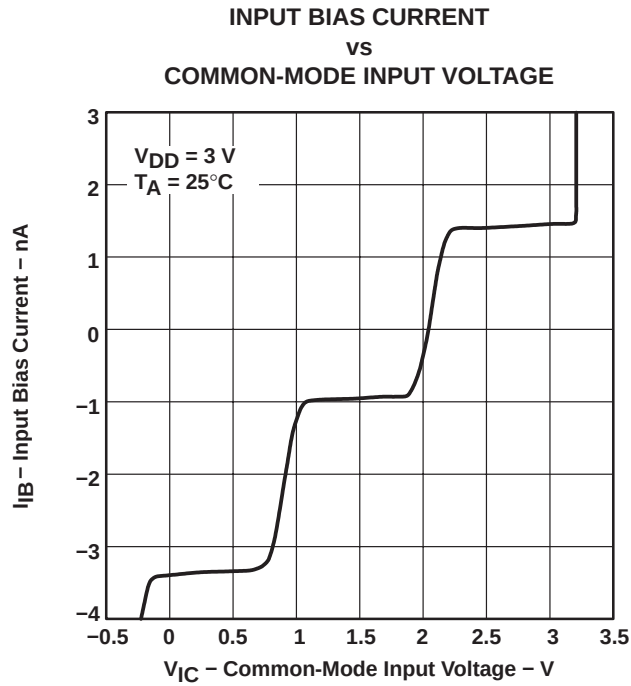


Figure 5

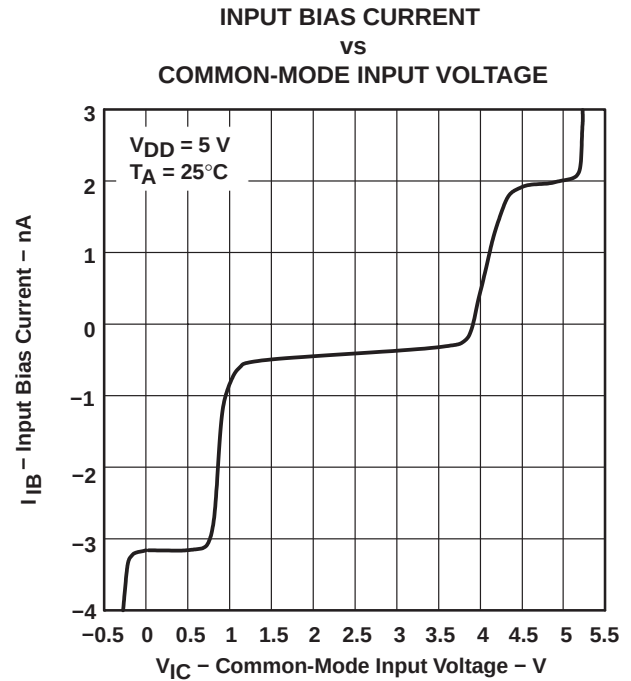


Figure 6

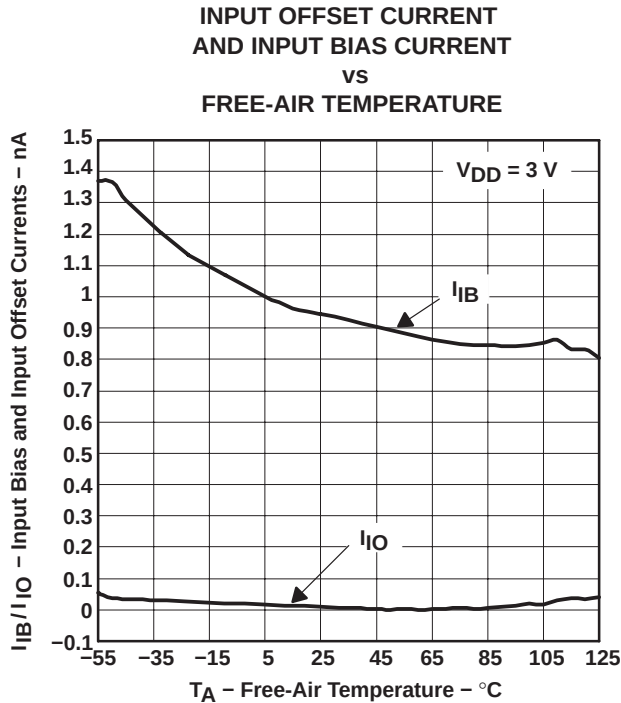


Figure 7

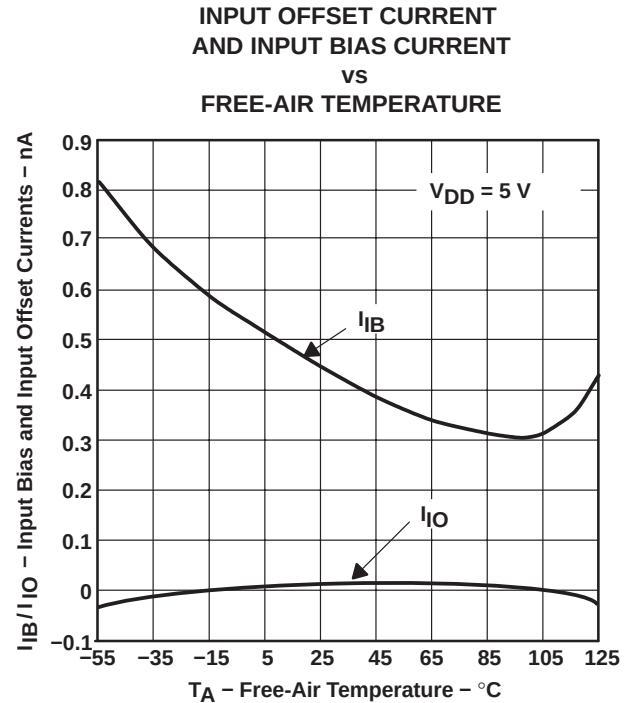


Figure 8

# TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA

## FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT

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#### TYPICAL CHARACTERISTICS

##### DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE VS FREQUENCY

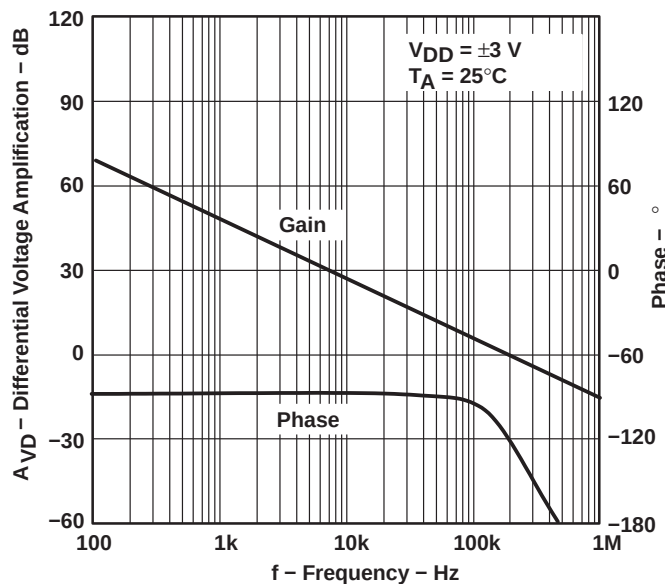


Figure 9

##### DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE VS FREQUENCY

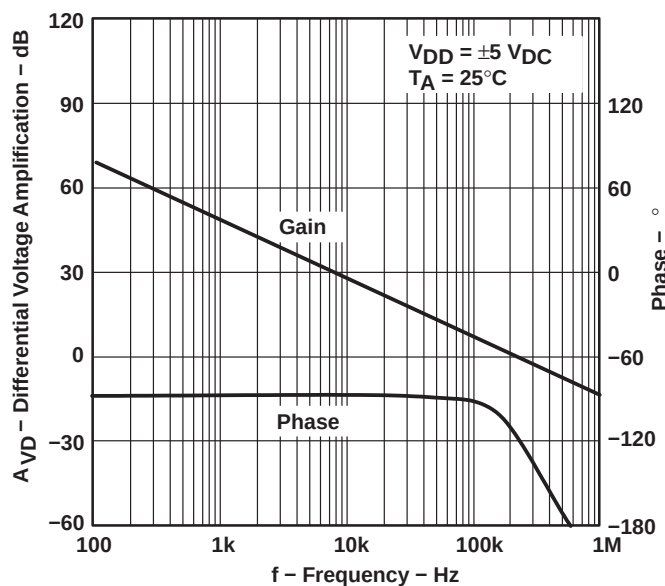


Figure 10

**TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA**  
**FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT**  
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**TYPICAL CHARACTERISTICS**

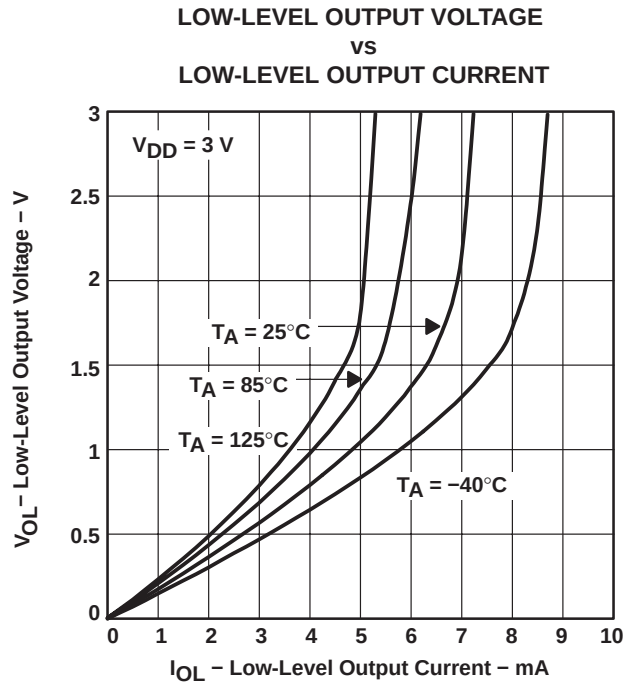


Figure 11

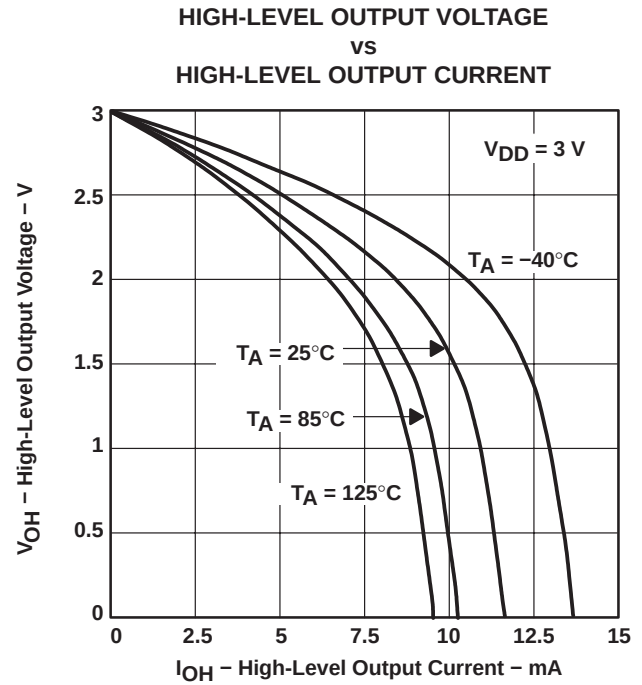


Figure 12

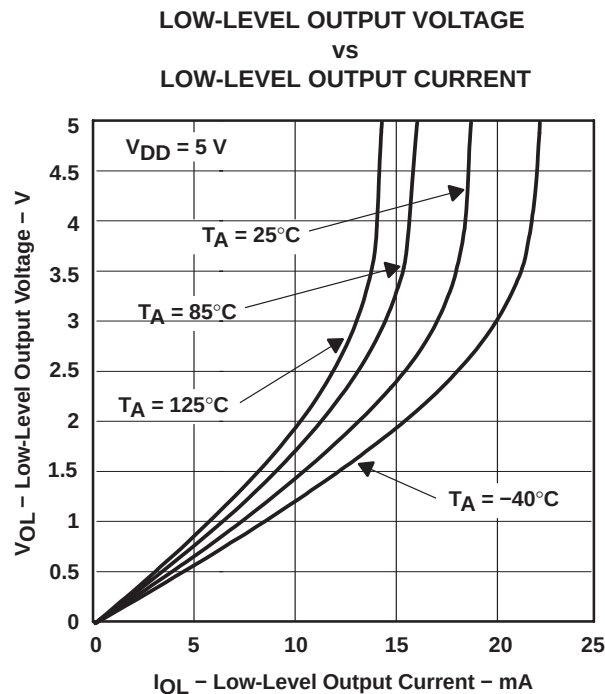


Figure 13

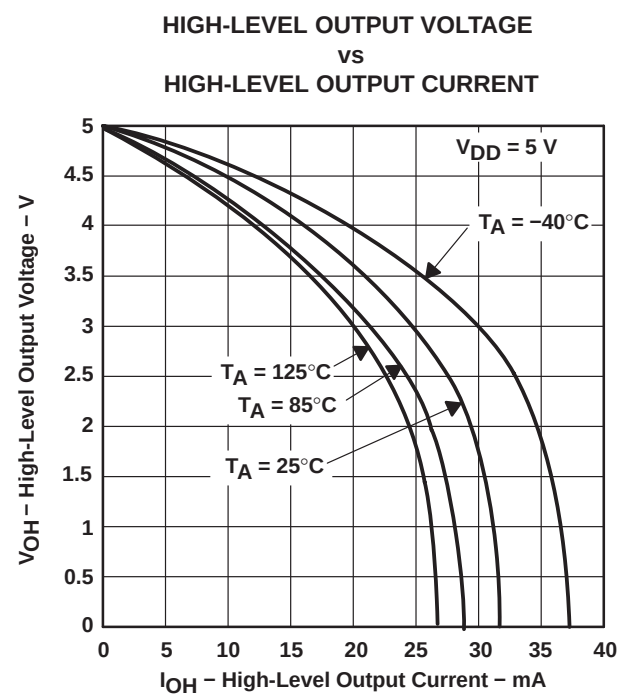


Figure 14

# TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA

## FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT

### OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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#### TYPICAL CHARACTERISTICS

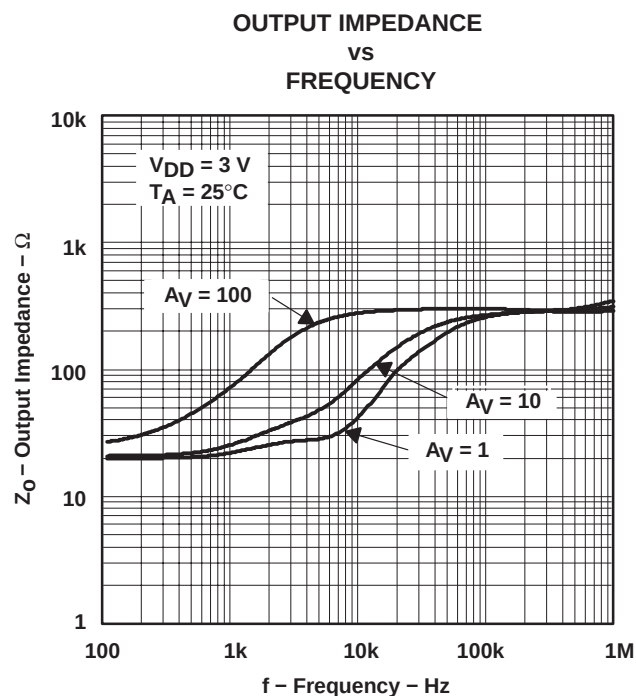


Figure 15

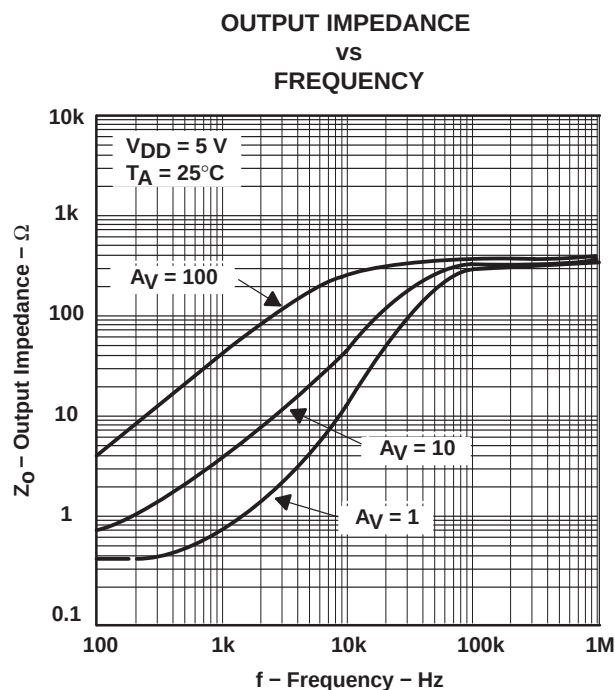


Figure 16

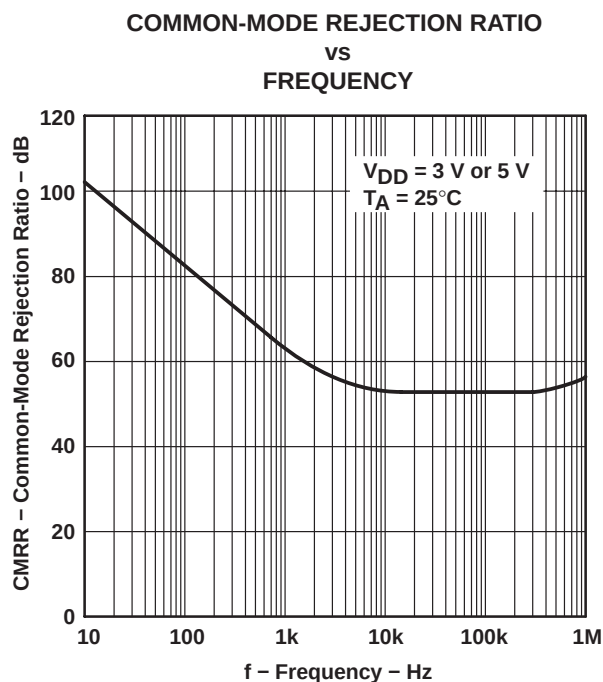


Figure 17

TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA  
FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT  
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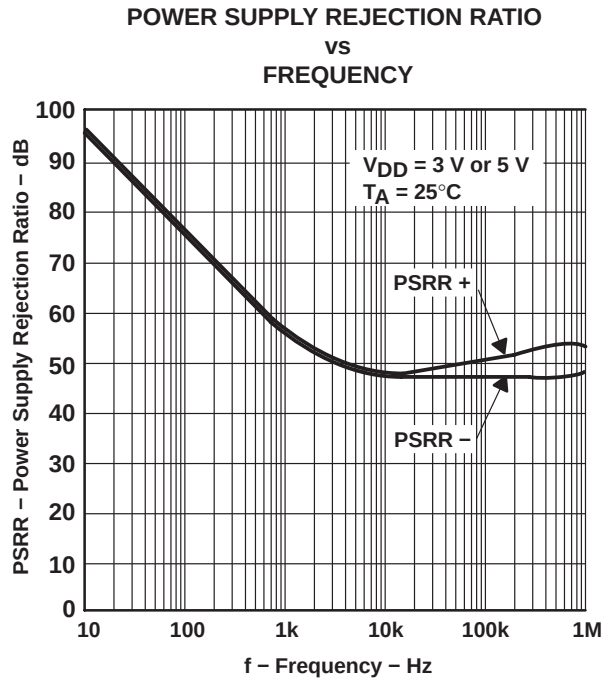


Figure 18

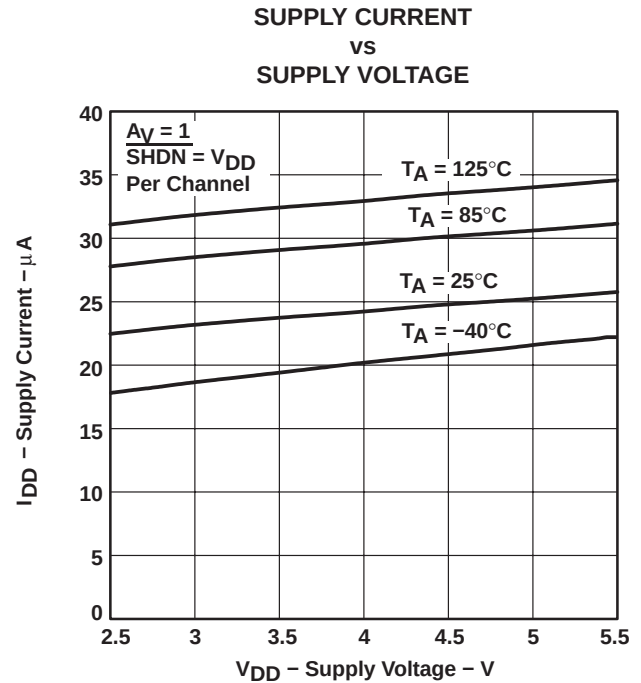


Figure 19

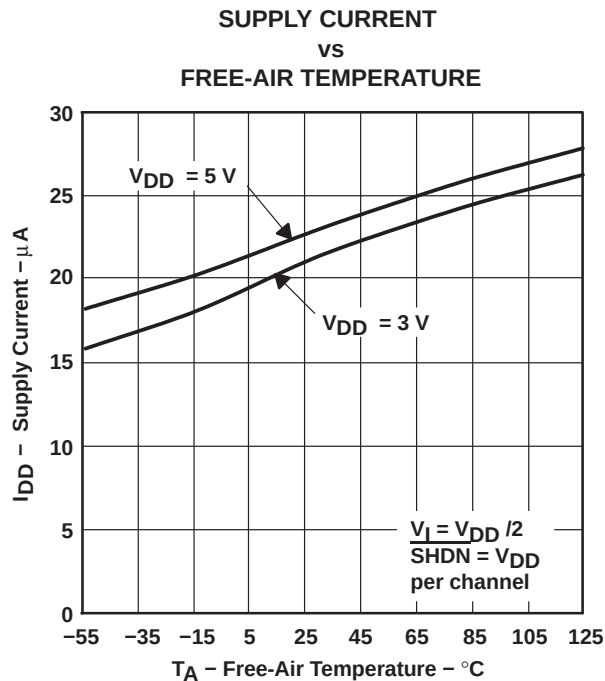


Figure 20

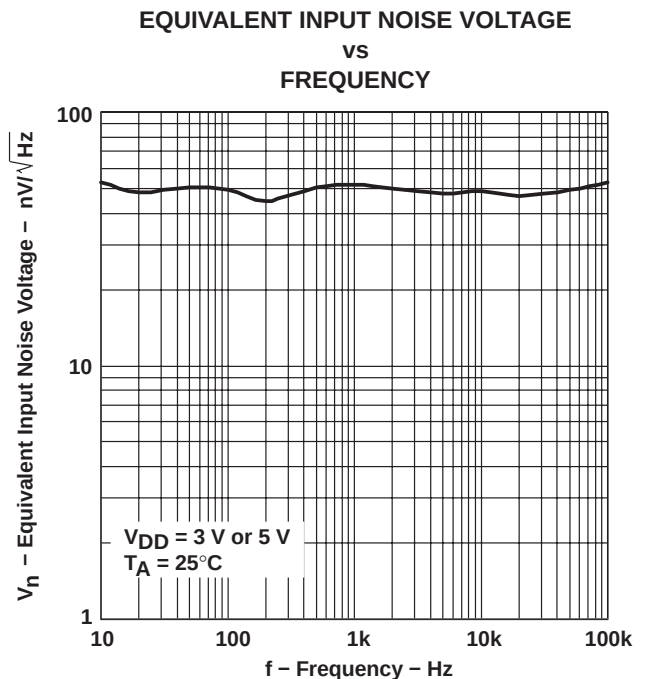


Figure 21

# TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA

## FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT

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#### TYPICAL CHARACTERISTICS

**TOTAL HARMONIC DISTORTION PLUS NOISE  
VS  
FREQUENCY**

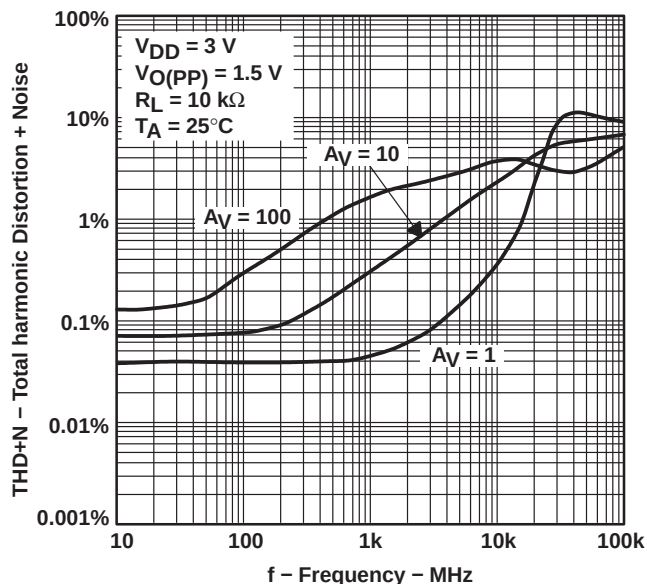


Figure 22

**TOTAL HARMONIC DISTORTION PLUS NOISE  
VS  
FREQUENCY**

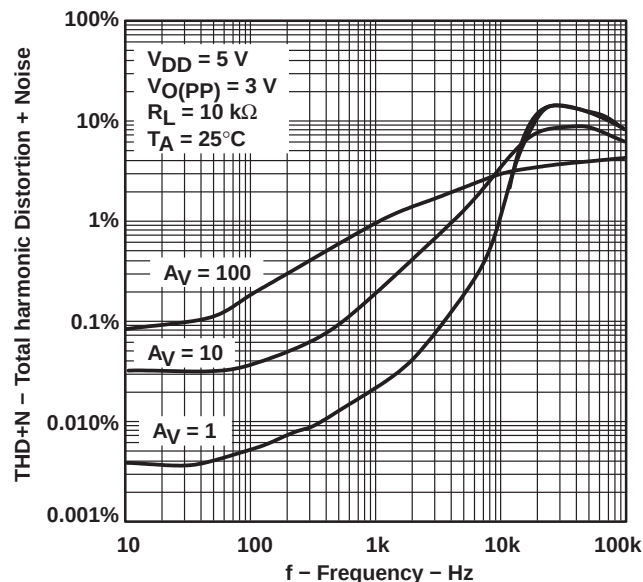


Figure 23

**PHASE MARGIN  
VS  
LOAD CAPACITANCE**

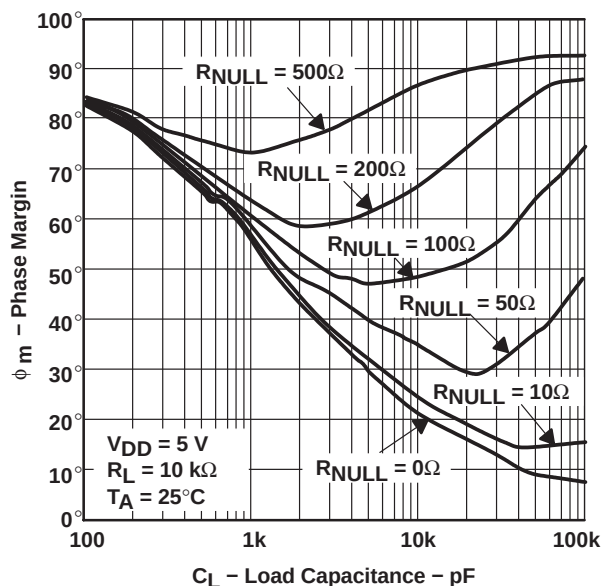


Figure 24

**GAIN-BANDWIDTH PRODUCT  
VS  
SUPPLY VOLTAGE**

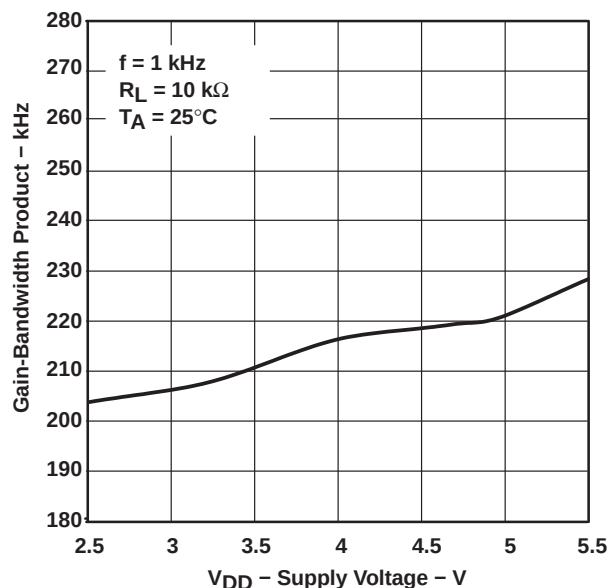


Figure 25

TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA  
FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT  
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TYPICAL CHARACTERISTICS

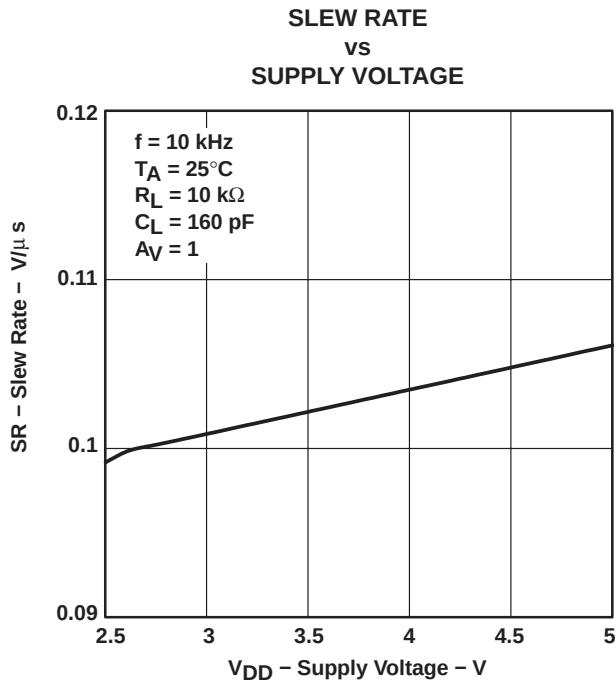


Figure 26

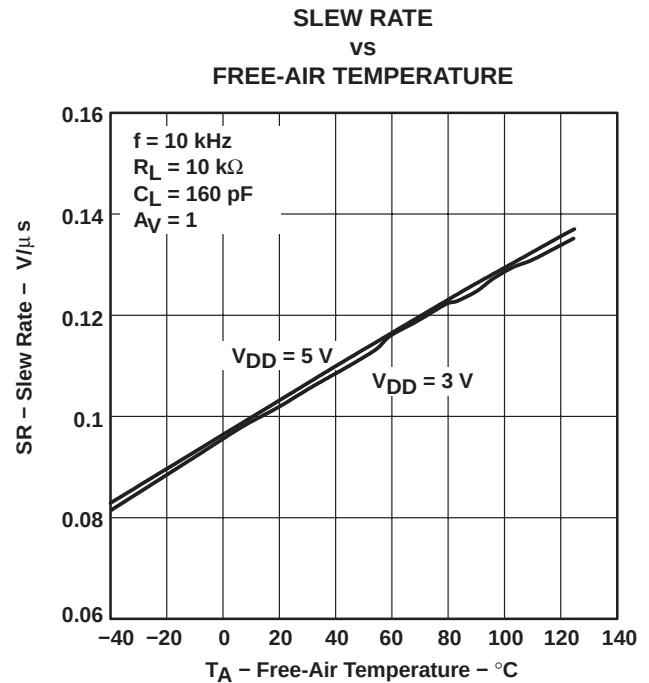


Figure 27

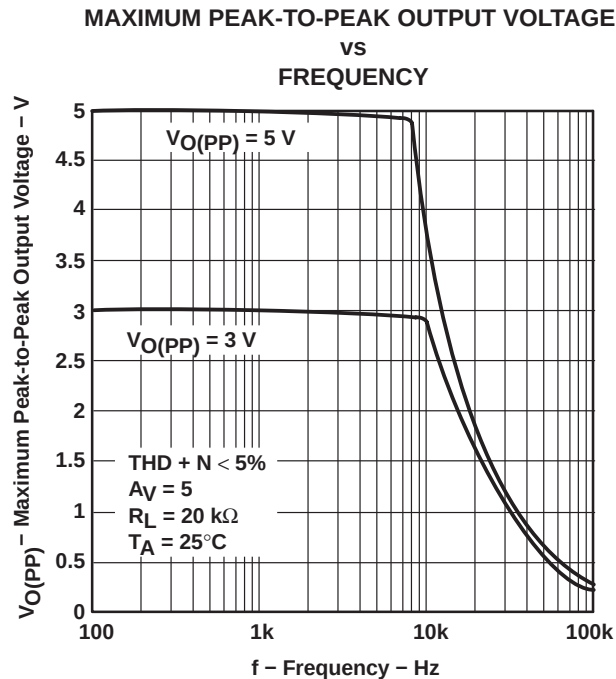


Figure 28

# TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA

## FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT

### OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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#### TYPICAL CHARACTERISTICS

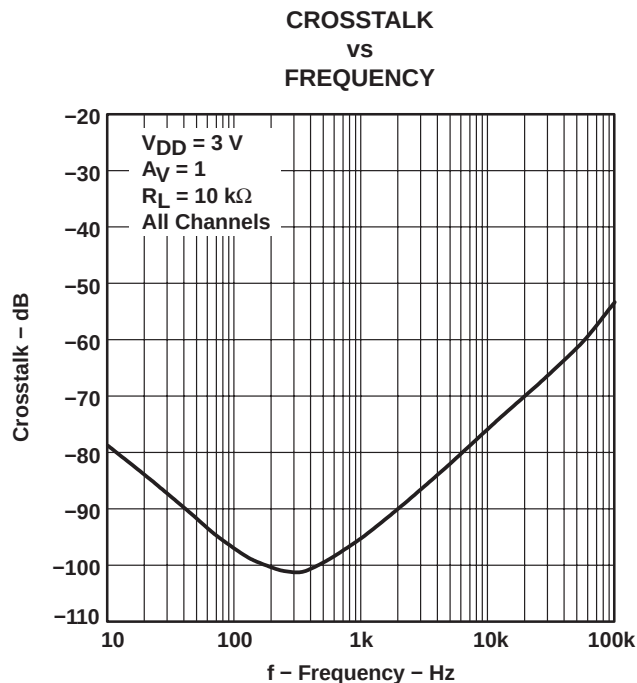


Figure 29

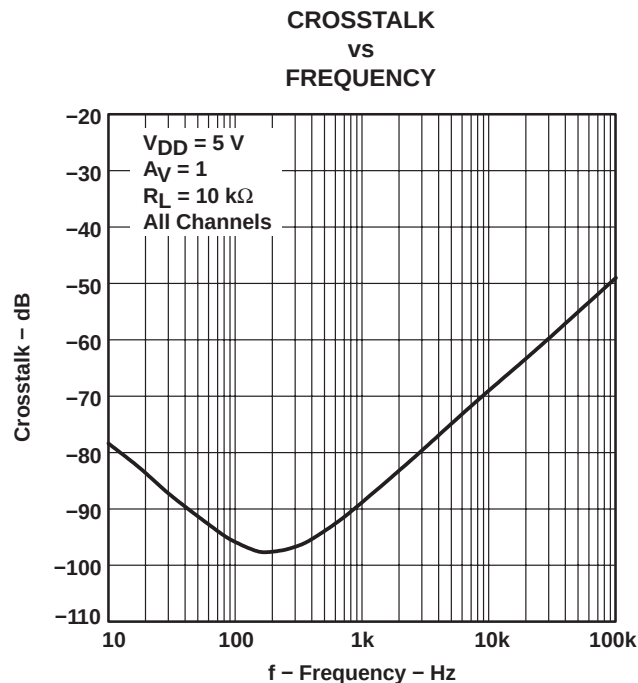


Figure 30

#### SMALL-SIGNAL FOLLOWER PULSE RESPONSE

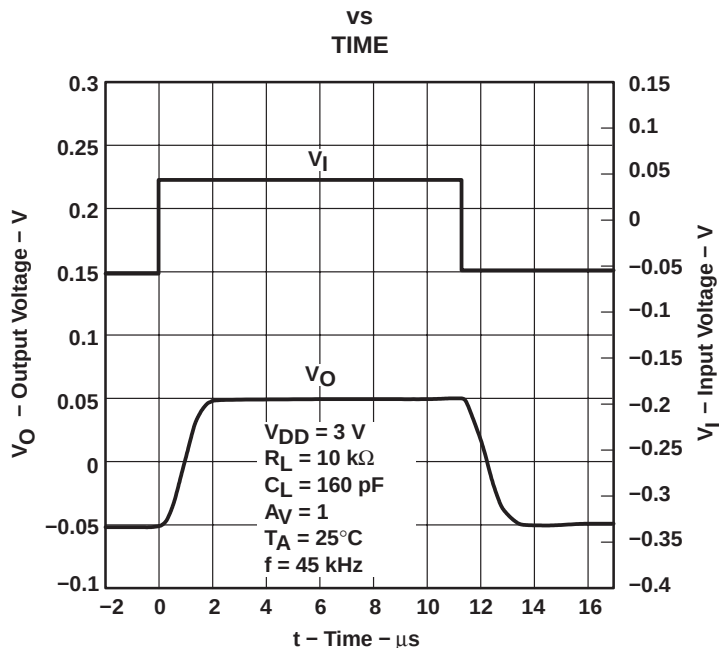


Figure 31

**TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA**  
**FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT**  
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**TYPICAL CHARACTERISTICS**

**LARGE-SIGNAL FOLLOWER PULSE RESPONSE**

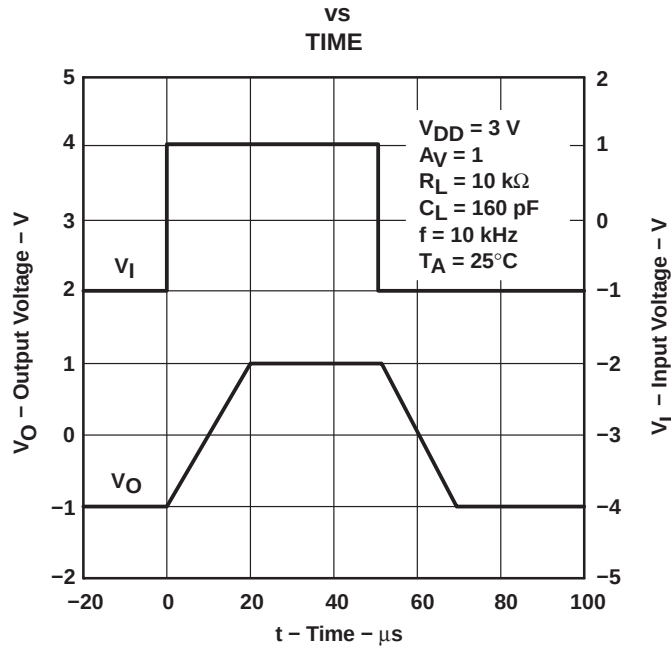


**Figure 32**

**SMALL-SIGNAL FOLLOWER PULSE RESPONSE**

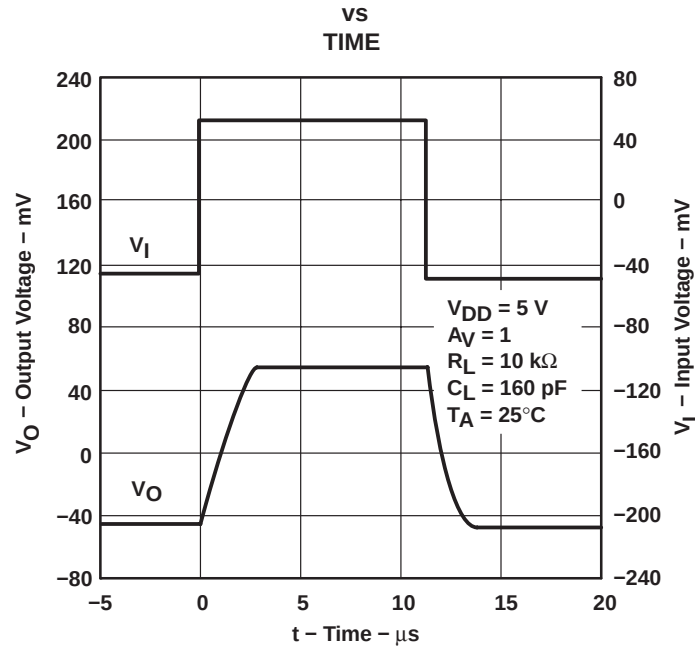


**Figure 33**

# TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA

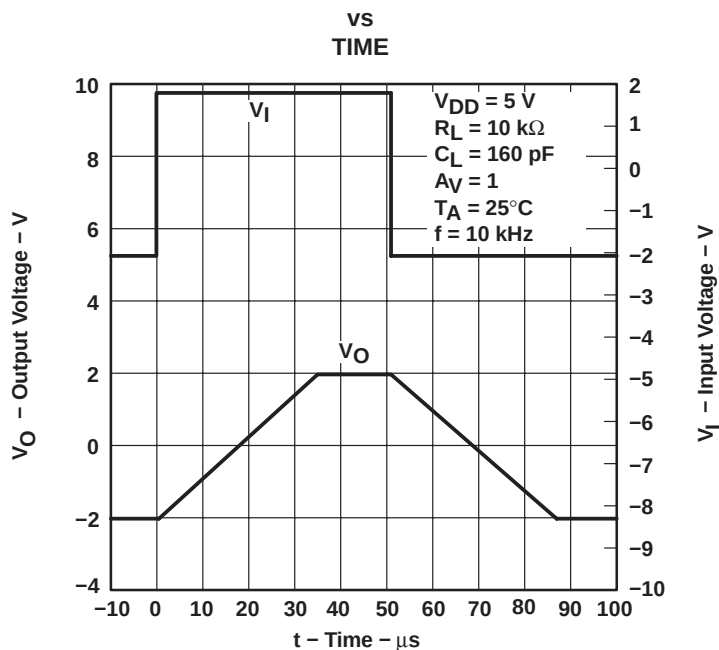
## FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT

### OPERATIONAL AMPLIFIERS WITH SHUTDOWN

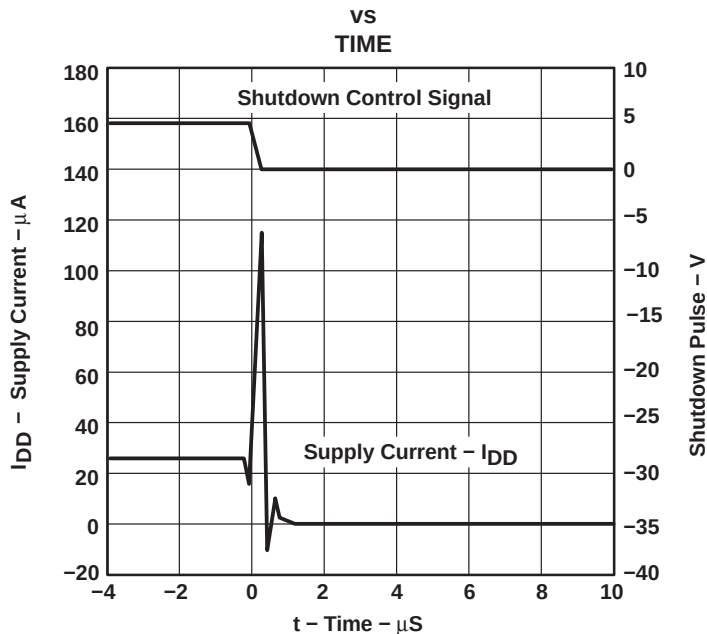
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#### TYPICAL CHARACTERISTICS

##### LARGE-SIGNAL FOLLOWER PULSE RESPONSE



##### SHUTDOWN ON SUPPLY CURRENT



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OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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TYPICAL CHARACTERISTICS

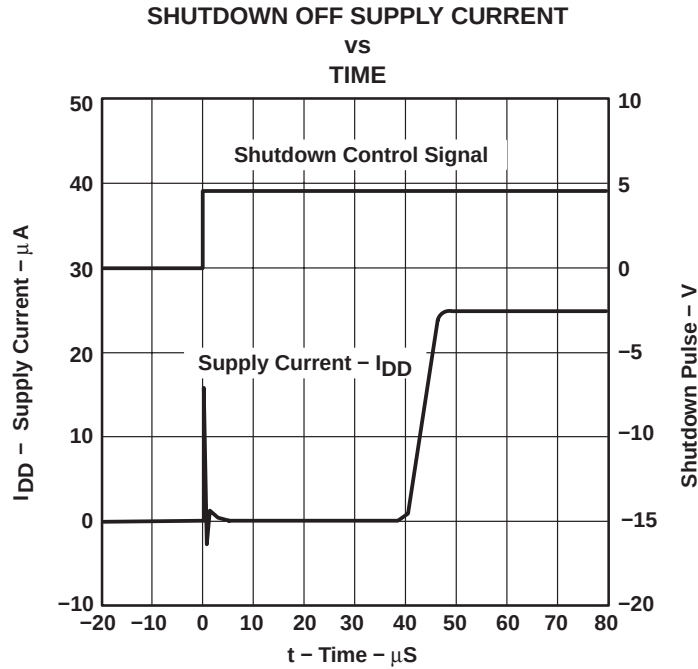


Figure 36

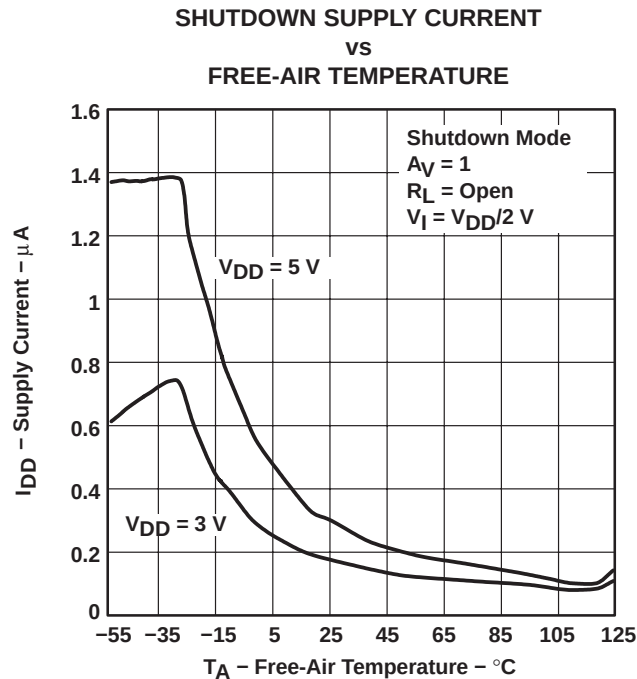


Figure 37



# TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA

## FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT

### OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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#### TYPICAL CHARACTERISTICS

##### SHUTDOWN SUPPLY CURRENT AND SHUTDOWN PULSE vs TIME

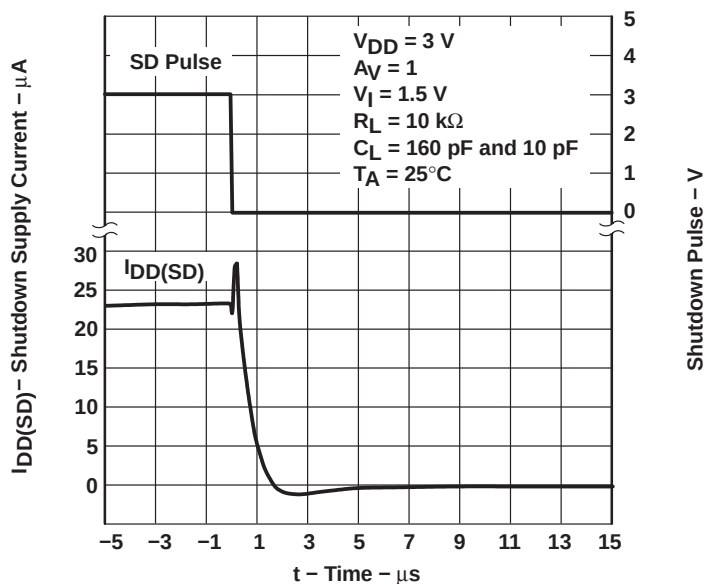


Figure 38

##### SHUTDOWN SUPPLY CURRENT AND SHUTDOWN PULSE vs TIME

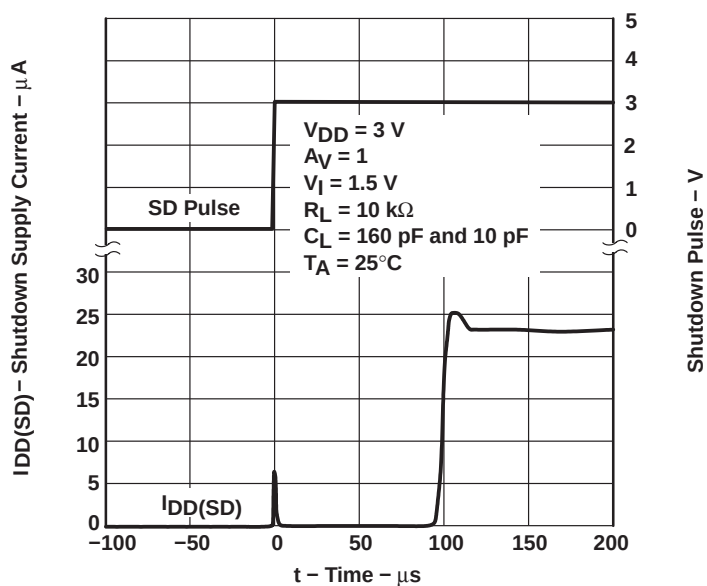


Figure 39

TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA  
FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT  
OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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TYPICAL CHARACTERISTICS

SHUTDOWN SUPPLY CURRENT AND SHUTDOWN PULSE  
vs  
TIME

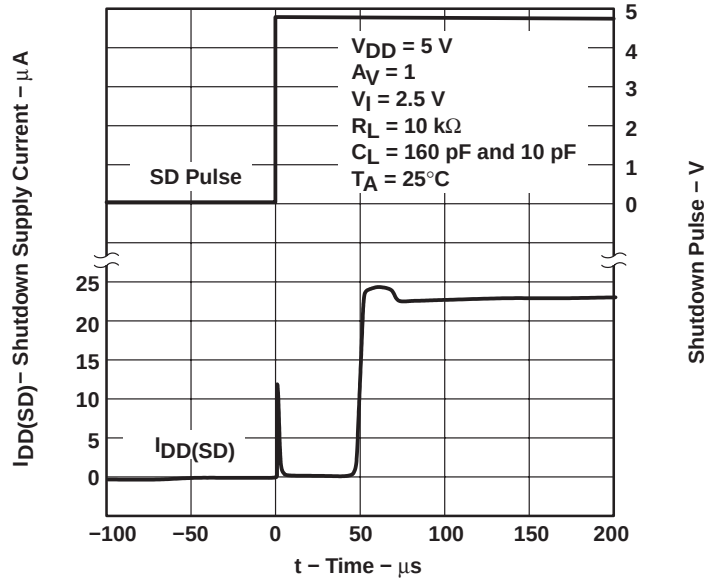


Figure 40

SHUTDOWN SUPPLY CURRENT AND SHUTDOWN PULSE  
vs  
TIME

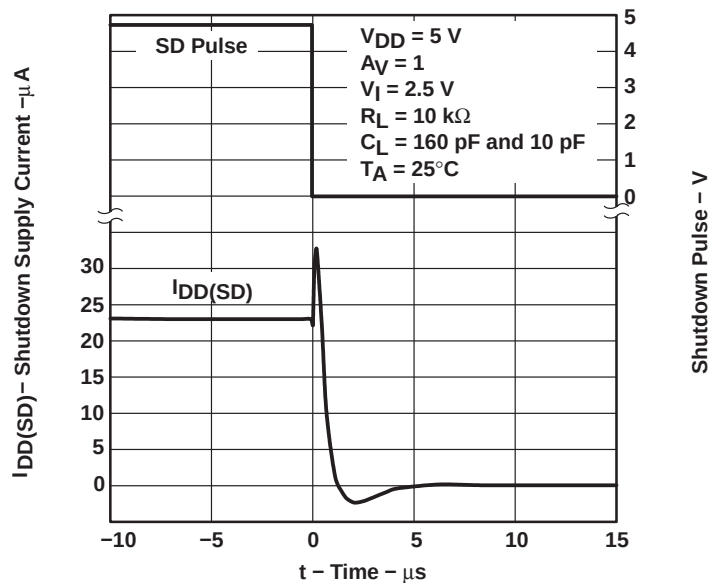


Figure 41



# TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA

## FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT

### OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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#### TYPICAL CHARACTERISTICS

SHUTDOWN OFF PULSE RESPONSE

VS  
TIME

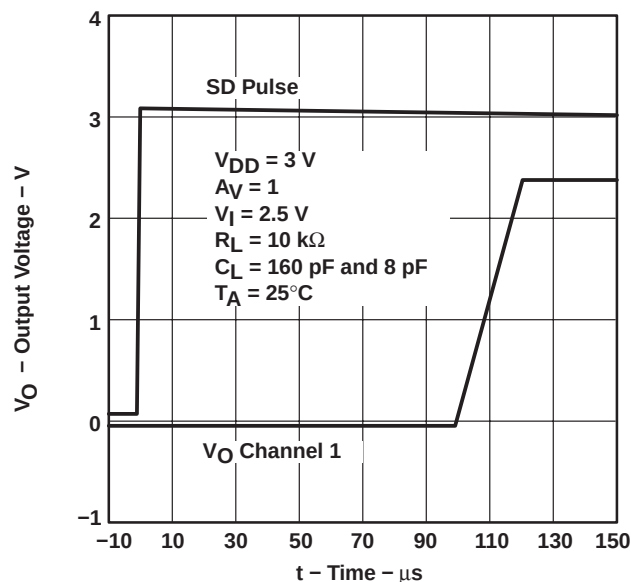


Figure 42

SHUTDOWN OFF PULSE RESPONSE

VS  
TIME

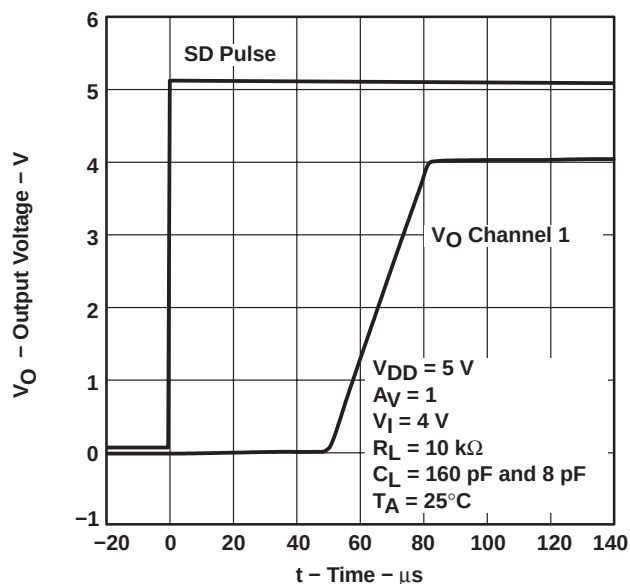


Figure 43

SHUTDOWN ON PULSE RESPONSE

VS  
TIME

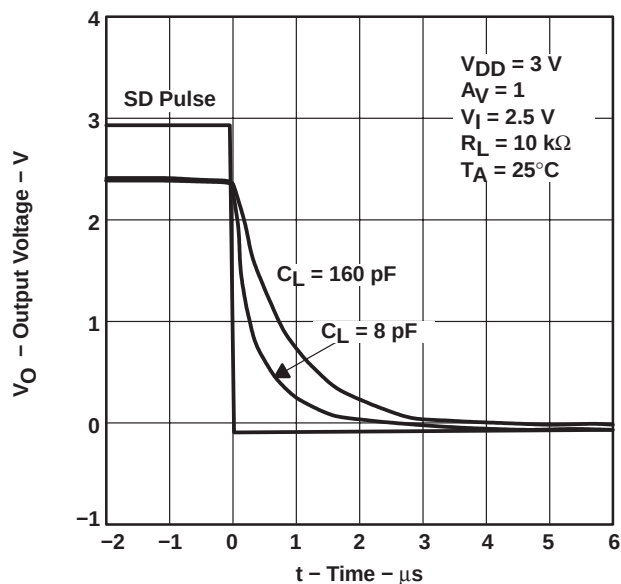


Figure 44

SHUTDOWN ON PULSE RESPONSE

VS  
TIME

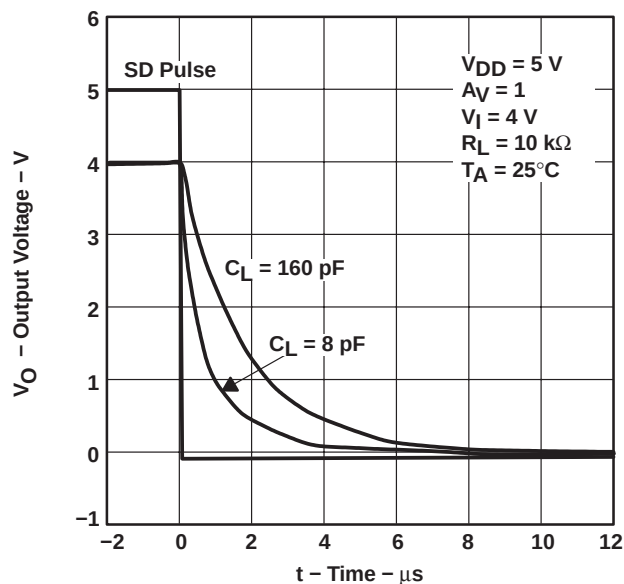


Figure 45

# TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA

## FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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### TYPICAL CHARACTERISTICS

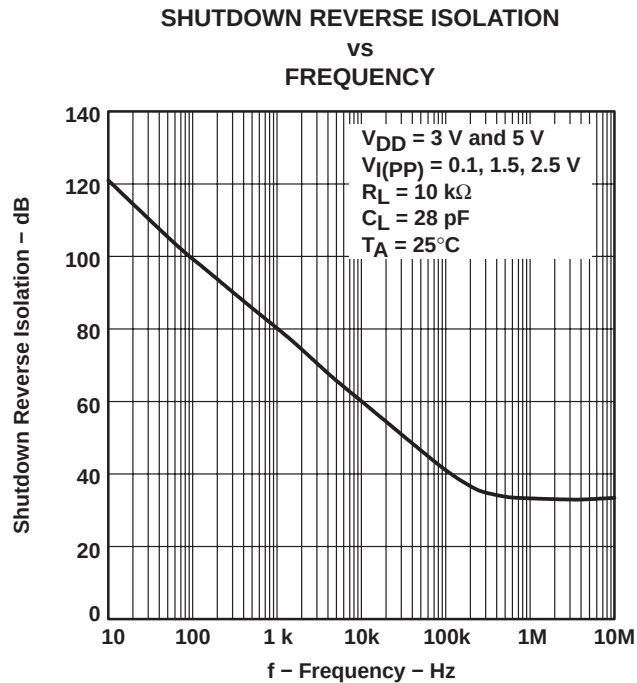


Figure 46

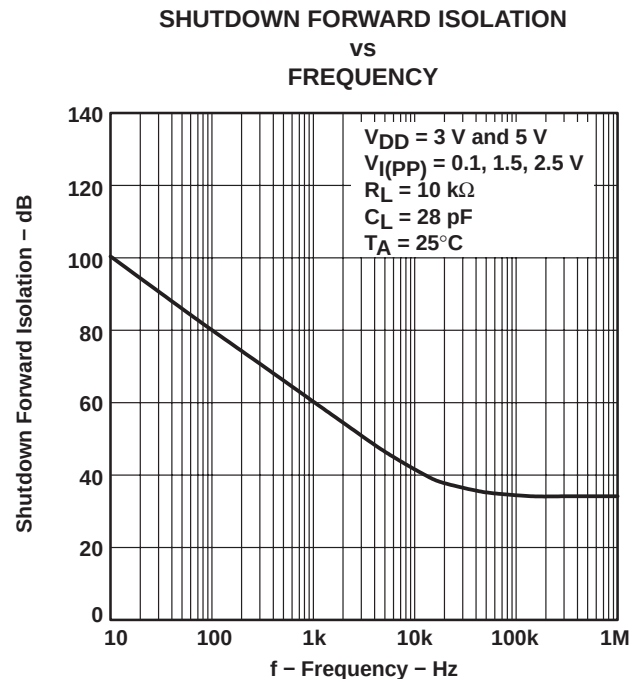


Figure 47

### PARAMETER MEASUREMENT INFORMATION

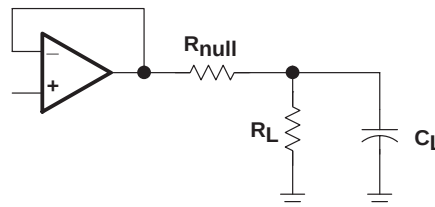


Figure 48

# TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA

## FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT

### OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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## APPLICATION INFORMATION

### shutdown function

Three members of the TLV245x family (TLV2450/3/5) have a shutdown terminal for conserving battery life in portable applications. When the shutdown terminal is pulled to the voltage level on the GND terminal of the device, the supply current is reduced to 16 nA/channel, the amplifier is disabled, and the outputs are placed in a high impedance mode. To enable the amplifier, the shutdown terminal must be pulled high. The shutdown terminal should never be left floating. The shutdown terminal threshold is always referenced to the GND terminal of the device. Therefore, when operating the device with split supply voltages (e.g.  $\pm 2.5$  V), the shutdown terminal needs to be pulled to  $V_{DD-}$  (not system ground) to disable the operational amplifier.

The amplifier's output with a shutdown pulse is shown in Figures 42, 43, 44, and 45. The amplifier is powered with a single 5-V supply and configured as a noninverting configuration with a gain of 5. The amplifier turnon and turnoff times are measured from the 50% point of the shutdown pulse to the 50% point of the output waveform. The times for the single, dual, and quad are listed in the data tables.

Figures 46 and 47 show the amplifier's forward and reverse isolation in shutdown. The operational amplifier is powered by  $\pm 1.35$ -V supplies and configured as a voltage follower ( $A_V = 1$ ). The isolation performance is plotted across frequency using 0.1- $V_{PP}$ , 1.5- $V_{PP}$ , and 2.5- $V_{PP}$  input signals. During normal operation, the amplifier would not be able to handle a 2.5- $V_{PP}$  input signal with a supply voltage of  $\pm 1.35$  V since it exceeds the common-mode input voltage range ( $V_{ICR}$ ). However, this curve illustrates that the amplifier remains in shutdown even under a worst case scenario.

### 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 49. A minimum value of 20  $\Omega$  should work well for most applications.

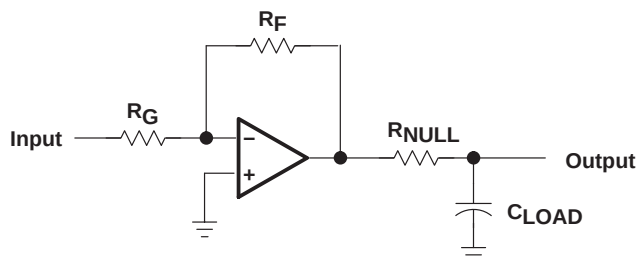


Figure 49. Driving a Capacitive Load

## APPLICATION INFORMATION

### 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:

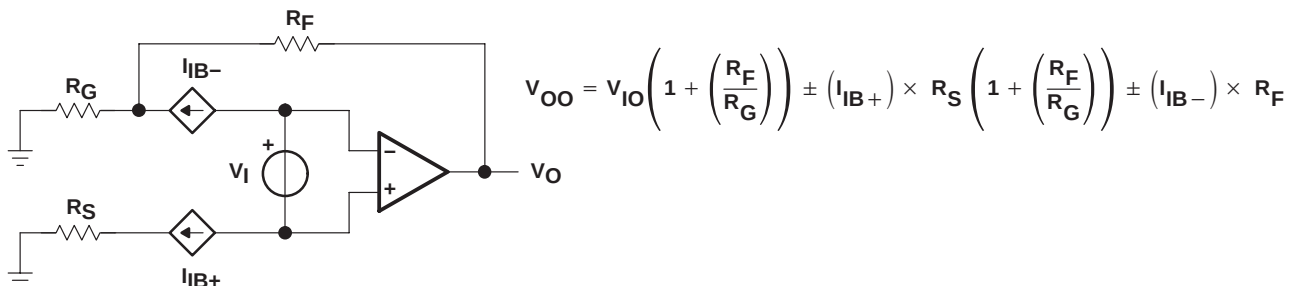


Figure 50. Output Offset Voltage Model

### 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 51).

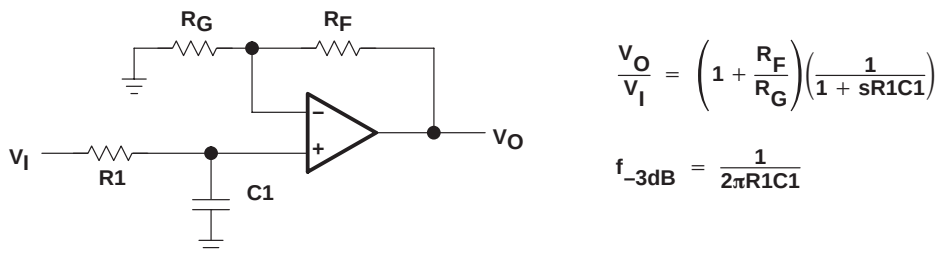


Figure 51. Single-Pole Low-Pass Filter

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.

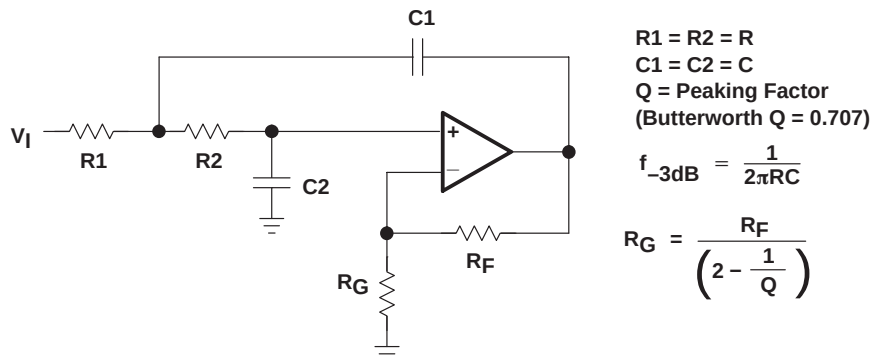


Figure 52. 2-Pole Low-Pass Sallen-Key Filter

# TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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## APPLICATION INFORMATION

### general power dissipation considerations

For a given  $\theta_{JA}$ , the maximum power dissipation is shown in Figure 53 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 TLV245x IC (watts)

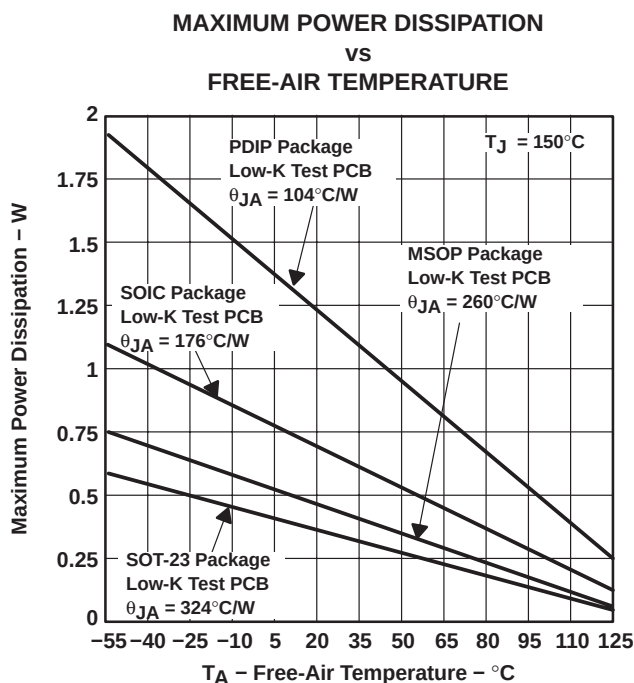
$T_{MAX}$  = Absolute maximum junction temperature (150°C)

$T_A$  = 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 53. Maximum Power Dissipation vs Free-Air Temperature**

**TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA**  
**FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT**  
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**APPLICATION INFORMATION**

**macromodel information**

Macromodel information provided was derived using Microsim *Parts*™, the model generation software used with Microsim *PSpice*™. The Boyle macromodel (see Note 1) and subcircuit in Figure 54 are generated using the TLV245x typical electrical and operating characteristics at  $T_A = 25^\circ\text{C}$ . Using this information, output simulations of the following key parameters can be generated to a tolerance of 20% (in most cases):

- 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

NOTE 1: G. R. Boyle, B. M. Cohn, D. O. Pederson, and J. E. Solomon, "Macromodeling of Integrated Circuit Operational Amplifiers," *IEEE Journal of Solid-State Circuits*, SC-9, 353 (1974).

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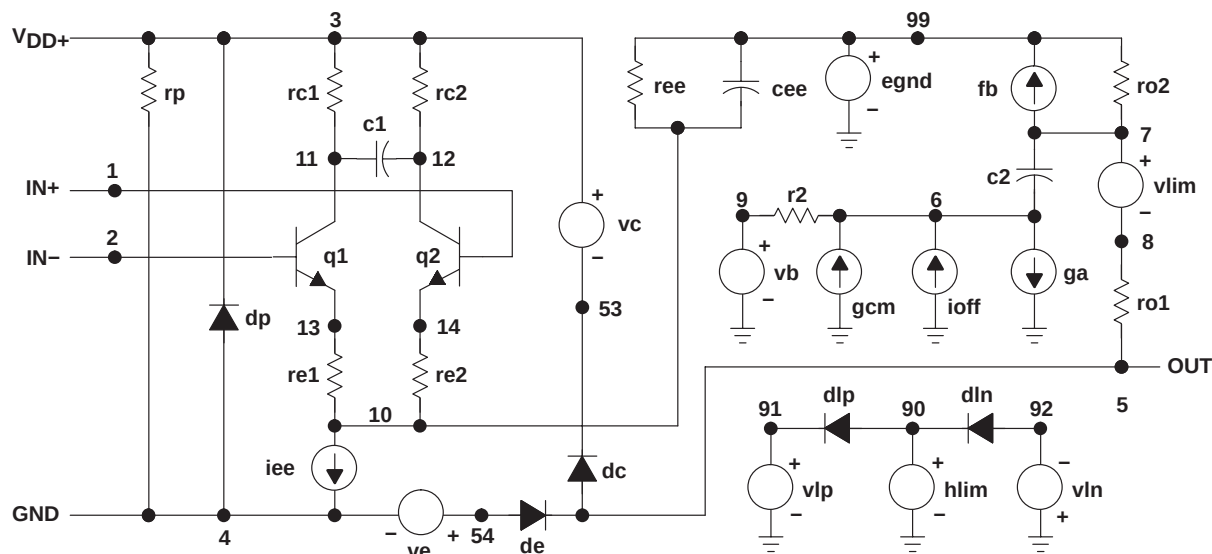
# TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA

## FAMILY OF 23- $\mu$ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT

### OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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#### APPLICATION INFORMATION



\* AMP\_TLV2450-X operational amplifier "macromodel" subcircuit  
 \* created using Parts release 8.0 on 10/12/98 at 11:06  
 \* Parts is a MicroSim product.

\* connections:  
 \* noninverting input  
 \* inverting input  
 \* positive power supply  
 \* negative power supply  
 \* output  
 \*.subckt AMP\_TLV2450-X 1 2 3 4 5

|                                  |    |    |                             |
|----------------------------------|----|----|-----------------------------|
| C1                               | 11 | 12 | 354.48E-15                  |
| C2                               | 6  | 7  | 7.5000E-12                  |
| CEE                              | 10 | 99 | 42.237E-15                  |
| DC                               | 5  | 53 | dy                          |
| DE                               | 54 | 5  | dy                          |
| DLP                              | 90 | 91 | dx                          |
| DLN                              | 92 | 90 | dx                          |
| DP                               | 4  | 3  | dx                          |
| EGND                             | 99 | 0  | poly(2) (3,0) (4,0) 0 .5 .5 |
| FB                               | 7  | 99 | poly(5) vb vc ve vlp vln 0  |
| + 207.31E6 -1E3 1E3 210E6 -210E6 |    |    |                             |
| GA                               | 6  | 0  | 11 12 15.254E-6             |
| GCM                              | 0  | 6  | 10 99 48.237E-12            |

|                                           |    |    |              |
|-------------------------------------------|----|----|--------------|
| IEE                                       | 10 | 4  | dc 938.61E-9 |
| HLIM                                      | 90 | 0  | vlim 1K      |
| Q1                                        | 11 | 2  | 13 qx1       |
| Q2                                        | 12 | 1  | 14 qx2       |
| R2                                        | 6  | 9  | 100.00E3     |
| RC1                                       | 3  | 11 | 65.557E3     |
| RC2                                       | 3  | 12 | 65.557E3     |
| RE1                                       | 13 | 10 | 10.367E3     |
| RE2                                       | 14 | 10 | 10.367E3     |
| REE                                       | 10 | 99 | 213.08E6     |
| RO1                                       | 8  | 5  | 10           |
| RO2                                       | 7  | 99 | 10           |
| RP                                        | 3  | 4  | 147.06       |
| VB                                        | 9  | 0  | dc 0         |
| VC                                        | 3  | 53 | dc .82       |
| VE                                        | 54 | 4  | dc .82       |
| VLIM                                      | 7  | 8  | dc 0         |
| VLP                                       | 91 | 0  | dc 38        |
| VLN                                       | 0  | 92 | dc 38        |
| .model dx D(Is=800.00E-18)                |    |    |              |
| .model dy D(Is=800.00E-18 Rs=1m Cjo=10p)  |    |    |              |
| .model qx1 NPN(Is=800.00E-18 Bf=843.08)   |    |    |              |
| .model qx2 NPN(Is=800.0000E-18 Bf=843.08) |    |    |              |
| .ends                                     |    |    |              |

Figure 54. Boyle Macromodel and Subcircuit

**PACKAGING INFORMATION**

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| TLV2450AIDR      | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | 2450AI                  | <a href="#">Samples</a> |
| TLV2450AIP       | ACTIVE        | PDIP         | P                  | 8    | 50             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | N / A for Pkg Type   | -40 to 125   | TLV2450AI               | <a href="#">Samples</a> |
| TLV2450CD        | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | 2450C                   | <a href="#">Samples</a> |
| TLV2450CDBVR     | ACTIVE        | SOT-23       | DBV                | 6    | 3000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | VAQC                    | <a href="#">Samples</a> |
| TLV2450CDBVRG4   | ACTIVE        | SOT-23       | DBV                | 6    | 3000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | VAQC                    | <a href="#">Samples</a> |
| TLV2450CDBVT     | ACTIVE        | SOT-23       | DBV                | 6    | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | VAQC                    | <a href="#">Samples</a> |
| TLV2450CP        | ACTIVE        | PDIP         | P                  | 8    | 50             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | N / A for Pkg Type   | 0 to 70      | TLV2450C                | <a href="#">Samples</a> |
| TLV2450ID        | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | 2450I                   | <a href="#">Samples</a> |
| TLV2450IDBVR     | ACTIVE        | SOT-23       | DBV                | 6    | 3000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | VAQI                    | <a href="#">Samples</a> |
| TLV2450IDBVT     | ACTIVE        | SOT-23       | DBV                | 6    | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | VAQI                    | <a href="#">Samples</a> |
| TLV2451AID       | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | 2451AI                  | <a href="#">Samples</a> |
| TLV2451AIDR      | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | 2451AI                  | <a href="#">Samples</a> |
| TLV2451AIP       | ACTIVE        | PDIP         | P                  | 8    | 50             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | N / A for Pkg Type   | -40 to 125   | TLV2451AI               | <a href="#">Samples</a> |
| TLV2451CD        | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | 2451C                   | <a href="#">Samples</a> |
| TLV2451CDBVR     | ACTIVE        | SOT-23       | DBV                | 5    | 3000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | VARC                    | <a href="#">Samples</a> |
| TLV2451CDBVRG4   | ACTIVE        | SOT-23       | DBV                | 5    | 3000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | VARC                    | <a href="#">Samples</a> |
| TLV2451CDBVT     | ACTIVE        | SOT-23       | DBV                | 5    | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | VARC                    | <a href="#">Samples</a> |

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish<br>(6)    | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|----------------------------|----------------------|--------------|-------------------------|-------------------------|
| TLV2451CDG4      | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU                  | Level-1-260C-UNLIM   | 0 to 70      | 2451C                   | <a href="#">Samples</a> |
| TLV2451CDR       | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU                  | Level-1-260C-UNLIM   | 0 to 70      | 2451C                   | <a href="#">Samples</a> |
| TLV2451CP        | ACTIVE        | PDIP         | P                  | 8    | 50             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU                  | N / A for Pkg Type   | 0 to 70      | TLV2451C                | <a href="#">Samples</a> |
| TLV2451ID        | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU                  | Level-1-260C-UNLIM   | -40 to 125   | 2451I                   | <a href="#">Samples</a> |
| TLV2451IDBVR     | ACTIVE        | SOT-23       | DBV                | 5    | 3000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU                  | Level-1-260C-UNLIM   | -40 to 125   | VARI                    | <a href="#">Samples</a> |
| TLV2451IDBVT     | ACTIVE        | SOT-23       | DBV                | 5    | 250            | Green (RoHS<br>& no Sb/Br) | CU NIPDAU                  | Level-1-260C-UNLIM   | -40 to 125   | VARI                    | <a href="#">Samples</a> |
| TLV2451IDR       | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU                  | Level-1-260C-UNLIM   | -40 to 125   | 2451I                   | <a href="#">Samples</a> |
| TLV2451IP        | ACTIVE        | PDIP         | P                  | 8    | 50             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU                  | N / A for Pkg Type   | -40 to 125   | TLV2451I                | <a href="#">Samples</a> |
| TLV2452AID       | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU                  | Level-1-260C-UNLIM   | -40 to 125   | 2452AI                  | <a href="#">Samples</a> |
| TLV2452AIDR      | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU                  | Level-1-260C-UNLIM   | -40 to 125   | 2452AI                  | <a href="#">Samples</a> |
| TLV2452AIP       | ACTIVE        | PDIP         | P                  | 8    | 50             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU                  | N / A for Pkg Type   | -40 to 125   | TLV2452AI               | <a href="#">Samples</a> |
| TLV2452CD        | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU                  | Level-1-260C-UNLIM   | 0 to 70      | 2452C                   | <a href="#">Samples</a> |
| TLV2452CDGK      | ACTIVE        | VSSOP        | DGK                | 8    | 80             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU  <br>CU NIPDAUAG | Level-1-260C-UNLIM   | 0 to 70      | ABI                     | <a href="#">Samples</a> |
| TLV2452CDGKR     | ACTIVE        | VSSOP        | DGK                | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU  <br>CU NIPDAUAG | Level-1-260C-UNLIM   | 0 to 70      | ABI                     | <a href="#">Samples</a> |
| TLV2452CDR       | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU                  | Level-1-260C-UNLIM   | 0 to 70      | 2452C                   | <a href="#">Samples</a> |
| TLV2452ID        | ACTIVE        | SOIC         | D                  | 8    | 75             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU                  | Level-1-260C-UNLIM   | -40 to 125   | 2452I                   | <a href="#">Samples</a> |
| TLV2452IDGK      | ACTIVE        | VSSOP        | DGK                | 8    | 80             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU  <br>CU NIPDAUAG | Level-1-260C-UNLIM   | -40 to 125   | ABJ                     | <a href="#">Samples</a> |
| TLV2452IDGKR     | ACTIVE        | VSSOP        | DGK                | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU  <br>CU NIPDAUAG | Level-1-260C-UNLIM   | -40 to 125   | ABJ                     | <a href="#">Samples</a> |

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| TLV2452IDGKRG4   | ACTIVE        | VSSOP        | DGK                | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAUAG             | Level-1-260C-UNLIM   | -40 to 125   | ABJ                     | <a href="#">Samples</a> |
| TLV2452IDR       | ACTIVE        | SOIC         | D                  | 8    | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | 2452I                   | <a href="#">Samples</a> |
| TLV2452IP        | ACTIVE        | PDIP         | P                  | 8    | 50             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | N / A for Pkg Type   | -40 to 125   | TLV2452IP               | <a href="#">Samples</a> |
| TLV2453CD        | ACTIVE        | SOIC         | D                  | 14   | 50             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | TLV2453C                | <a href="#">Samples</a> |
| TLV2453CDGSR     | ACTIVE        | VSSOP        | DGS                | 10   | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | ABK                     | <a href="#">Samples</a> |
| TLV2453CDR       | ACTIVE        | SOIC         | D                  | 14   | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | TLV2453C                | <a href="#">Samples</a> |
| TLV2453IDGS      | ACTIVE        | VSSOP        | DGS                | 10   | 80             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | ABL                     | <a href="#">Samples</a> |
| TLV2453IDGSG4    | ACTIVE        | VSSOP        | DGS                | 10   | 80             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | ABL                     | <a href="#">Samples</a> |
| TLV2453IDGSR     | ACTIVE        | VSSOP        | DGS                | 10   | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | ABL                     | <a href="#">Samples</a> |
| TLV2453IN        | ACTIVE        | PDIP         | N                  | 14   | 25             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | N / A for Pkg Type   | -40 to 125   | TLV2453IN               | <a href="#">Samples</a> |
| TLV2454AID       | ACTIVE        | SOIC         | D                  | 14   | 50             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | 2454AI                  | <a href="#">Samples</a> |
| TLV2454AIDR      | ACTIVE        | SOIC         | D                  | 14   | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | 2454AI                  | <a href="#">Samples</a> |
| TLV2454AIN       | ACTIVE        | PDIP         | N                  | 14   | 25             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | N / A for Pkg Type   | -40 to 125   | TLV2454AI               | <a href="#">Samples</a> |
| TLV2454AIPW      | ACTIVE        | TSSOP        | PW                 | 14   | 90             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   |              | TY2454A                 | <a href="#">Samples</a> |
| TLV2454AIPWR     | ACTIVE        | TSSOP        | PW                 | 14   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | TY2454A                 | <a href="#">Samples</a> |
| TLV2454CD        | ACTIVE        | SOIC         | D                  | 14   | 50             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | 2454C                   | <a href="#">Samples</a> |
| TLV2454CN        | ACTIVE        | PDIP         | N                  | 14   | 25             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | N / A for Pkg Type   | 0 to 70      | TLV2454C                | <a href="#">Samples</a> |
| TLV2454CPW       | ACTIVE        | TSSOP        | PW                 | 14   | 90             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | TV2454                  | <a href="#">Samples</a> |

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)            | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|----------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| TLV2454CPWR      | ACTIVE        | TSSOP        | PW                 | 14   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | TV2454                  | <a href="#">Samples</a> |
| TLV2454CPWRG4    | ACTIVE        | TSSOP        | PW                 | 14   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | TV2454                  | <a href="#">Samples</a> |
| TLV2454ID        | ACTIVE        | SOIC         | D                  | 14   | 50             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | 2454I                   | <a href="#">Samples</a> |
| TLV2454IDR       | ACTIVE        | SOIC         | D                  | 14   | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | 2454I                   | <a href="#">Samples</a> |
| TLV2454IDRG4     | ACTIVE        | SOIC         | D                  | 14   | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | 2454I                   | <a href="#">Samples</a> |
| TLV2454IN        | ACTIVE        | PDIP         | N                  | 14   | 25             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | N / A for Pkg Type   | -40 to 125   | TLV2454I                | <a href="#">Samples</a> |
| TLV2454IPW       | ACTIVE        | TSSOP        | PW                 | 14   | 90             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | TY2454                  | <a href="#">Samples</a> |
| TLV2454IPWR      | ACTIVE        | TSSOP        | PW                 | 14   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | TY2454                  | <a href="#">Samples</a> |
| TLV2455AID       | ACTIVE        | SOIC         | D                  | 16   | 40             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | TLV2455AI               | <a href="#">Samples</a> |
| TLV2455AIDR      | ACTIVE        | SOIC         | D                  | 16   | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | TLV2455AI               | <a href="#">Samples</a> |
| TLV2455AIN       | ACTIVE        | PDIP         | N                  | 16   | 25             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | N / A for Pkg Type   | -40 to 125   | TLV2455AI               | <a href="#">Samples</a> |
| TLV2455AIPW      | ACTIVE        | TSSOP        | PW                 | 16   | 90             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | TY2455A                 | <a href="#">Samples</a> |
| TLV2455AIPWR     | ACTIVE        | TSSOP        | PW                 | 16   | 2000           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | TY2455A                 | <a href="#">Samples</a> |
| TLV2455CD        | ACTIVE        | SOIC         | D                  | 16   | 40             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | 0 to 70      | TLV2455C                | <a href="#">Samples</a> |
| TLV2455ID        | ACTIVE        | SOIC         | D                  | 16   | 40             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | TLV2455I                | <a href="#">Samples</a> |
| TLV2455IDR       | ACTIVE        | SOIC         | D                  | 16   | 2500           | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | TLV2455I                | <a href="#">Samples</a> |
| TLV2455IPW       | ACTIVE        | TSSOP        | PW                 | 16   | 90             | Green (RoHS<br>& no Sb/Br) | CU NIPDAU               | Level-1-260C-UNLIM   | -40 to 125   | TY2455                  | <a href="#">Samples</a> |

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

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

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

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

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

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

<sup>(2)</sup> **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of  $\leq 1000$ ppm threshold. Antimony trioxide based flame retardants must also meet the  $\leq 1000$ ppm threshold requirement.

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

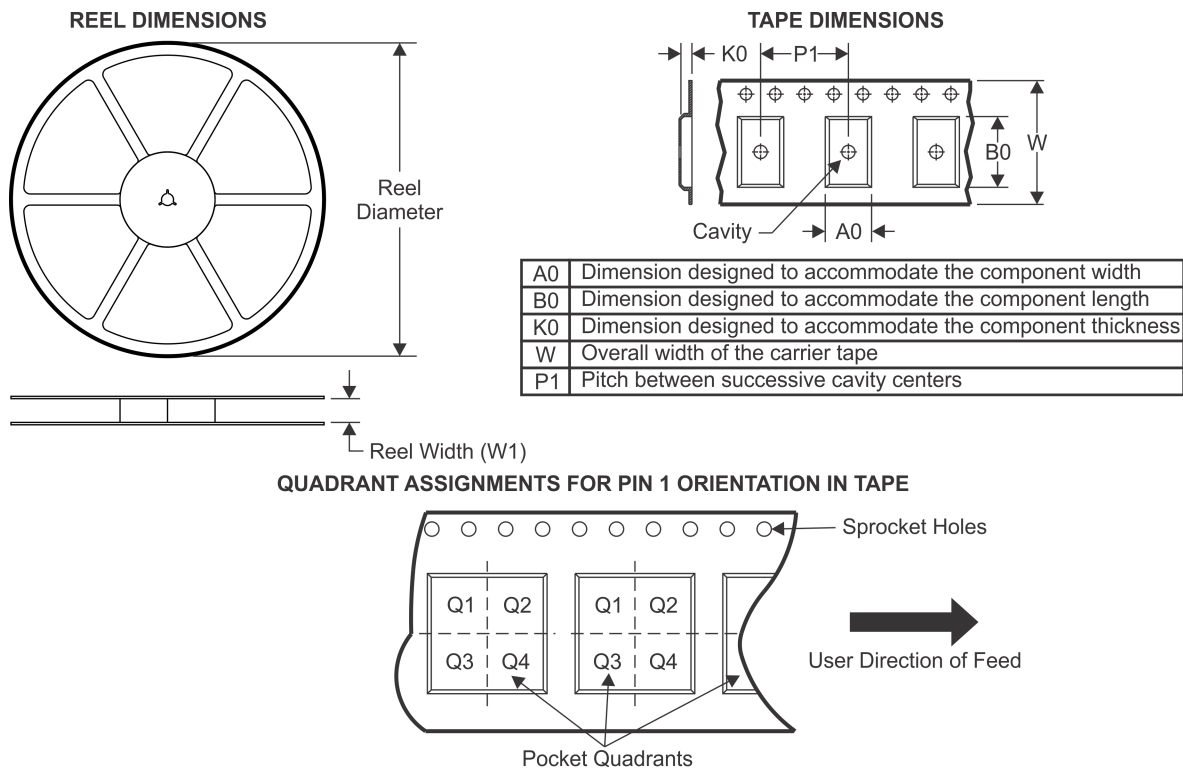
<sup>(4)</sup> There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

<sup>(5)</sup> 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.

<sup>(6)</sup> 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.

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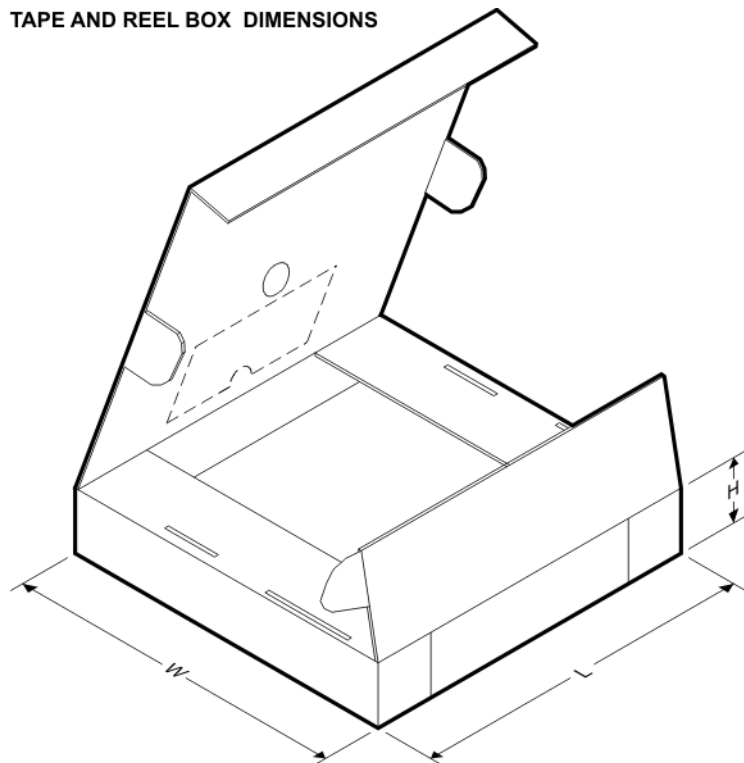
**TAPE AND REEL INFORMATION**


\*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 |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TLV2450AIDR  | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| TLV2450CDBVR | SOT-23       | DBV             | 6    | 3000 | 180.0              | 9.0                | 3.15    | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| TLV2450CDBVT | SOT-23       | DBV             | 6    | 250  | 180.0              | 9.0                | 3.15    | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| TLV2450IDBVR | SOT-23       | DBV             | 6    | 3000 | 180.0              | 9.0                | 3.15    | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| TLV2450IDBVT | SOT-23       | DBV             | 6    | 250  | 180.0              | 9.0                | 3.15    | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| TLV2451AIDR  | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| TLV2451CDBVR | SOT-23       | DBV             | 5    | 3000 | 180.0              | 9.0                | 3.15    | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| TLV2451CDBVT | SOT-23       | DBV             | 5    | 250  | 180.0              | 9.0                | 3.15    | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| TLV2451CDR   | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| TLV2451IDBVR | SOT-23       | DBV             | 5    | 3000 | 180.0              | 9.0                | 3.15    | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| TLV2451IDBVT | SOT-23       | DBV             | 5    | 250  | 180.0              | 9.0                | 3.15    | 3.2     | 1.4     | 4.0     | 8.0    | Q3            |
| TLV2451IDR   | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| TLV2452AIDR  | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| TLV2452CDGKR | VSSOP        | DGK             | 8    | 2500 | 330.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| TLV2452CDGKR | VSSOP        | DGK             | 8    | 2500 | 330.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| TLV2452CDR   | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| TLV2452IDGKR | VSSOP        | DGK             | 8    | 2500 | 330.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| TLV2452IDGKR | VSSOP        | DGK             | 8    | 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 |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TLV2452IDR   | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| TLV2453CDGSR | VSSOP        | DGS             | 10   | 2500 | 330.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| TLV2453CDR   | SOIC         | D               | 14   | 2500 | 330.0              | 16.4               | 6.5     | 9.0     | 2.1     | 8.0     | 16.0   | Q1            |
| TLV2453IDGSR | VSSOP        | DGS             | 10   | 2500 | 330.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| TLV2454AIDR  | SOIC         | D               | 14   | 2500 | 330.0              | 16.4               | 6.5     | 9.0     | 2.1     | 8.0     | 16.0   | Q1            |
| TLV2454AIPWR | TSSOP        | PW              | 14   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| TLV2454CPWR  | TSSOP        | PW              | 14   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| TLV2454IDR   | SOIC         | D               | 14   | 2500 | 330.0              | 16.4               | 6.5     | 9.0     | 2.1     | 8.0     | 16.0   | Q1            |
| TLV2454IPWR  | TSSOP        | PW              | 14   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| TLV2455AIDR  | SOIC         | D               | 16   | 2500 | 330.0              | 16.4               | 6.5     | 10.3    | 2.1     | 8.0     | 16.0   | Q1            |
| TLV2455AIPWR | TSSOP        | PW              | 16   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| TLV2455IDR   | SOIC         | D               | 16   | 2500 | 330.0              | 16.4               | 6.5     | 10.3    | 2.1     | 8.0     | 16.0   | Q1            |

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device       | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TLV2450AIDR  | SOIC         | D               | 8    | 2500 | 340.5       | 338.1      | 20.6        |
| TLV2450CDBVR | SOT-23       | DBV             | 6    | 3000 | 182.0       | 182.0      | 20.0        |
| TLV2450CDBVT | SOT-23       | DBV             | 6    | 250  | 182.0       | 182.0      | 20.0        |
| TLV2450IDBVR | SOT-23       | DBV             | 6    | 3000 | 182.0       | 182.0      | 20.0        |
| TLV2450IDBVT | SOT-23       | DBV             | 6    | 250  | 182.0       | 182.0      | 20.0        |

| Device       | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TLV2451AIDR  | SOIC         | D               | 8    | 2500 | 340.5       | 338.1      | 20.6        |
| TLV2451CDBVR | SOT-23       | DBV             | 5    | 3000 | 182.0       | 182.0      | 20.0        |
| TLV2451CDBVT | SOT-23       | DBV             | 5    | 250  | 182.0       | 182.0      | 20.0        |
| TLV2451CDR   | SOIC         | D               | 8    | 2500 | 340.5       | 338.1      | 20.6        |
| TLV2451IDBVR | SOT-23       | DBV             | 5    | 3000 | 182.0       | 182.0      | 20.0        |
| TLV2451IDBVT | SOT-23       | DBV             | 5    | 250  | 182.0       | 182.0      | 20.0        |
| TLV2451IDR   | SOIC         | D               | 8    | 2500 | 340.5       | 338.1      | 20.6        |
| TLV2452AIDR  | SOIC         | D               | 8    | 2500 | 340.5       | 338.1      | 20.6        |
| TLV2452CDGKR | VSSOP        | DGK             | 8    | 2500 | 364.0       | 364.0      | 27.0        |
| TLV2452CDGKR | VSSOP        | DGK             | 8    | 2500 | 358.0       | 335.0      | 35.0        |
| TLV2452CDR   | SOIC         | D               | 8    | 2500 | 340.5       | 338.1      | 20.6        |
| TLV2452IDGKR | VSSOP        | DGK             | 8    | 2500 | 358.0       | 335.0      | 35.0        |
| TLV2452IDGKR | VSSOP        | DGK             | 8    | 2500 | 364.0       | 364.0      | 27.0        |
| TLV2452IDR   | SOIC         | D               | 8    | 2500 | 340.5       | 338.1      | 20.6        |
| TLV2453CDGSR | VSSOP        | DGS             | 10   | 2500 | 358.0       | 335.0      | 35.0        |
| TLV2453CDR   | SOIC         | D               | 14   | 2500 | 350.0       | 350.0      | 43.0        |
| TLV2453IDGSR | VSSOP        | DGS             | 10   | 2500 | 358.0       | 335.0      | 35.0        |
| TLV2454AIDR  | SOIC         | D               | 14   | 2500 | 350.0       | 350.0      | 43.0        |
| TLV2454AIPWR | TSSOP        | PW              | 14   | 2000 | 367.0       | 367.0      | 35.0        |
| TLV2454CPWR  | TSSOP        | PW              | 14   | 2000 | 367.0       | 367.0      | 35.0        |
| TLV2454IDR   | SOIC         | D               | 14   | 2500 | 350.0       | 350.0      | 43.0        |
| TLV2454IPWR  | TSSOP        | PW              | 14   | 2000 | 367.0       | 367.0      | 35.0        |
| TLV2455AIDR  | SOIC         | D               | 16   | 2500 | 350.0       | 350.0      | 43.0        |
| TLV2455AIPWR | TSSOP        | PW              | 16   | 2000 | 367.0       | 367.0      | 35.0        |
| TLV2455IDR   | SOIC         | D               | 16   | 2500 | 350.0       | 350.0      | 43.0        |

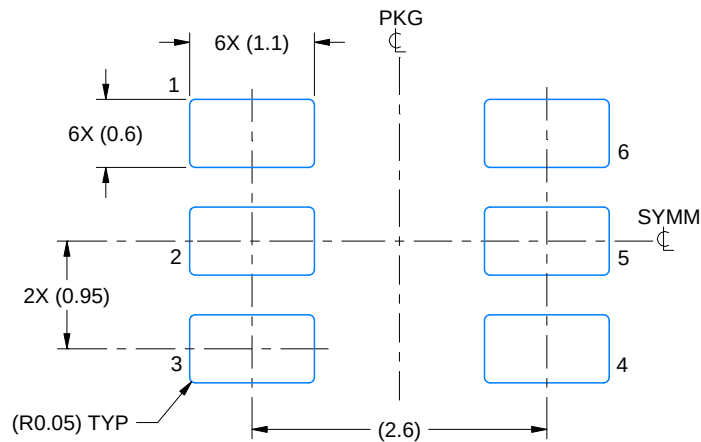


# EXAMPLE BOARD LAYOUT

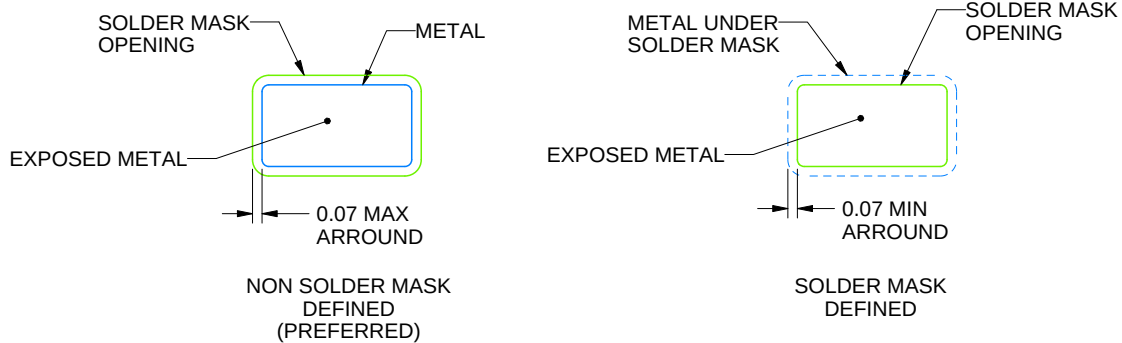
DBV0006A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:15X



SOLDER MASK DETAILS

4214840/B 03/2018

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

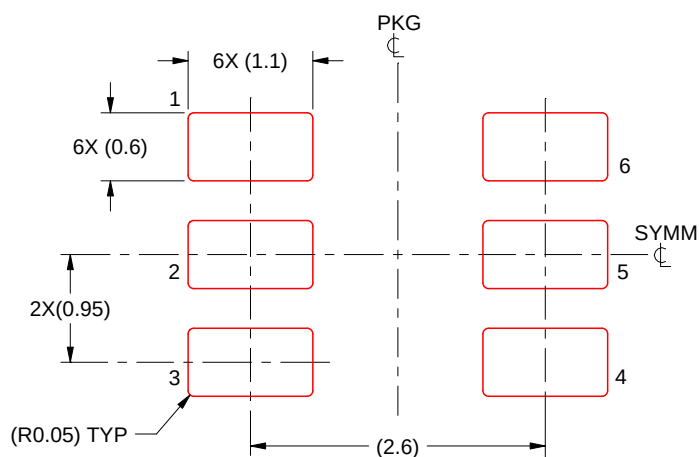
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

DBV0006A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:15X

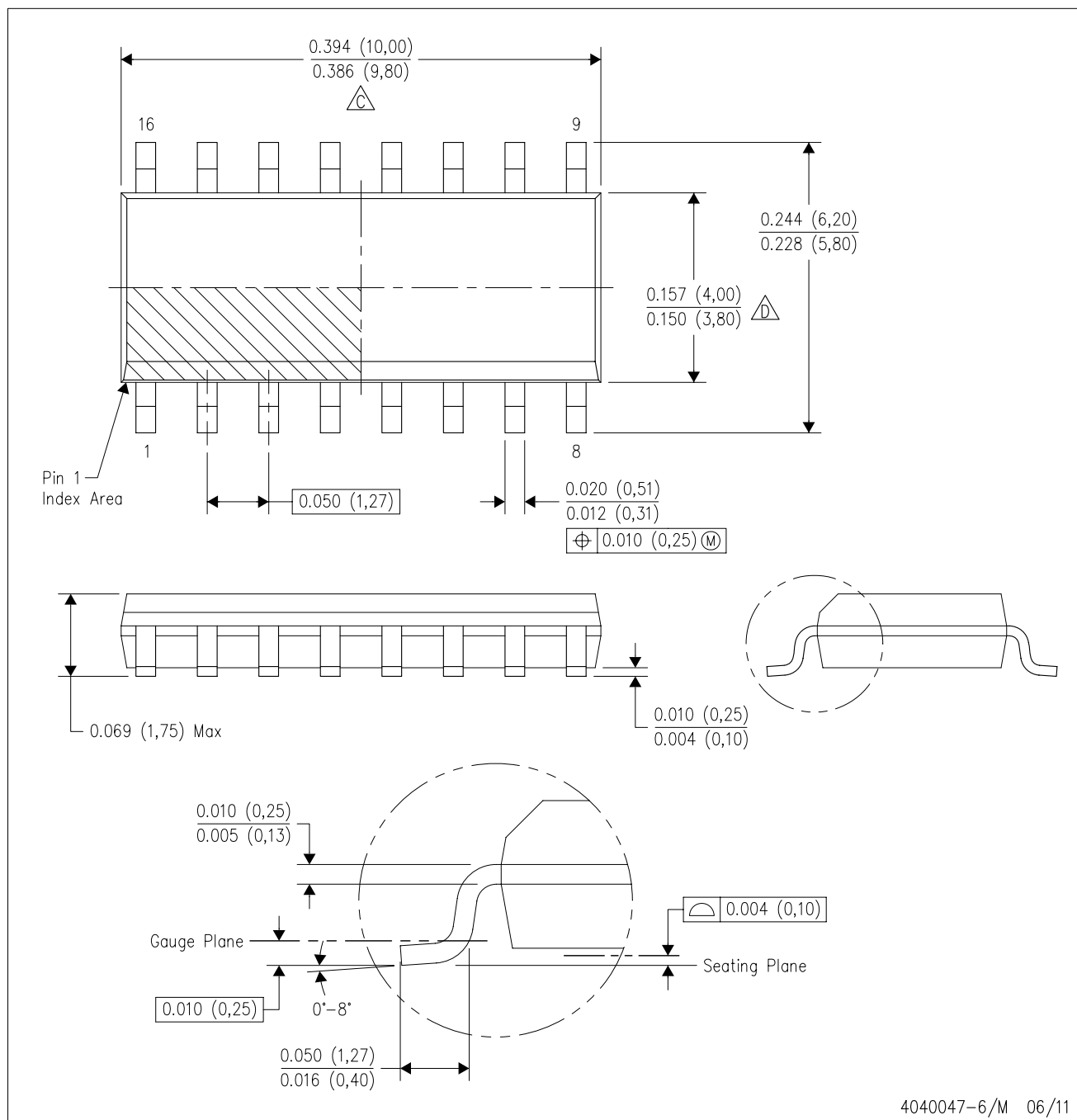
4214840/B 03/2018

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

D (R-PDSO-G16)

PLASTIC SMALL OUTLINE

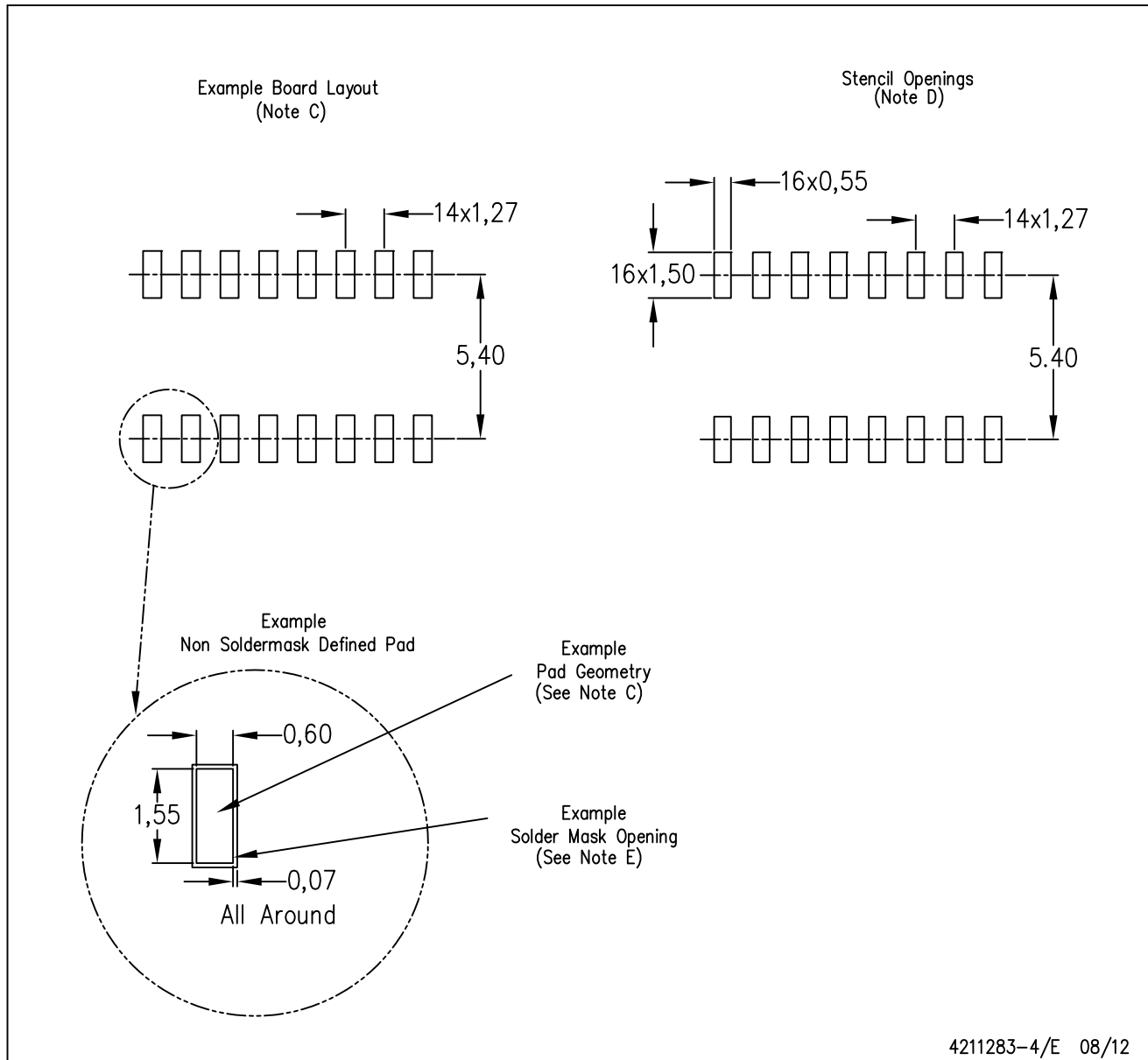


NOTES:

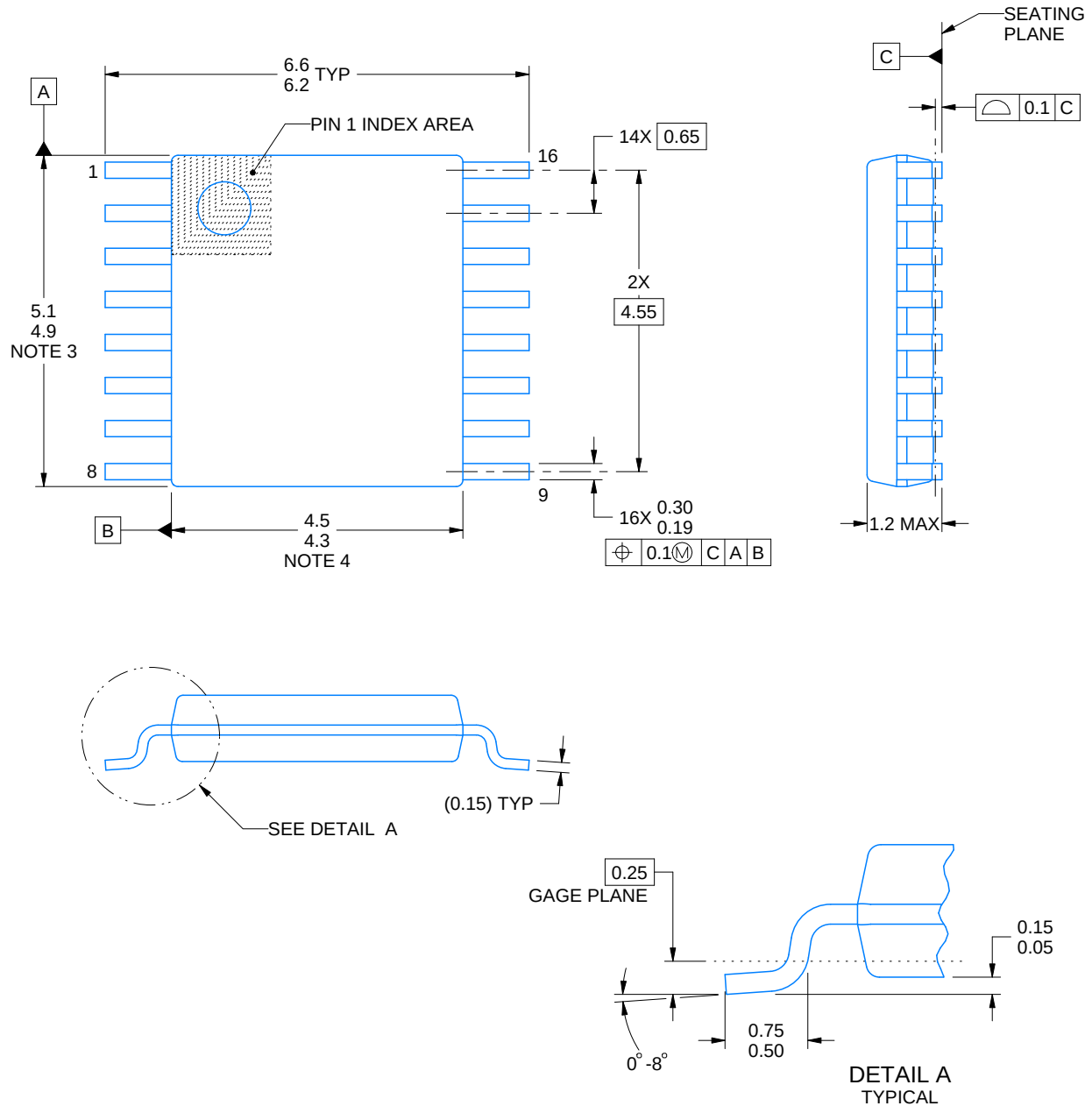
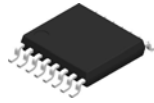
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
- D. Body width does not include interlead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

D (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.



4220204/A 02/2017

## NOTES:

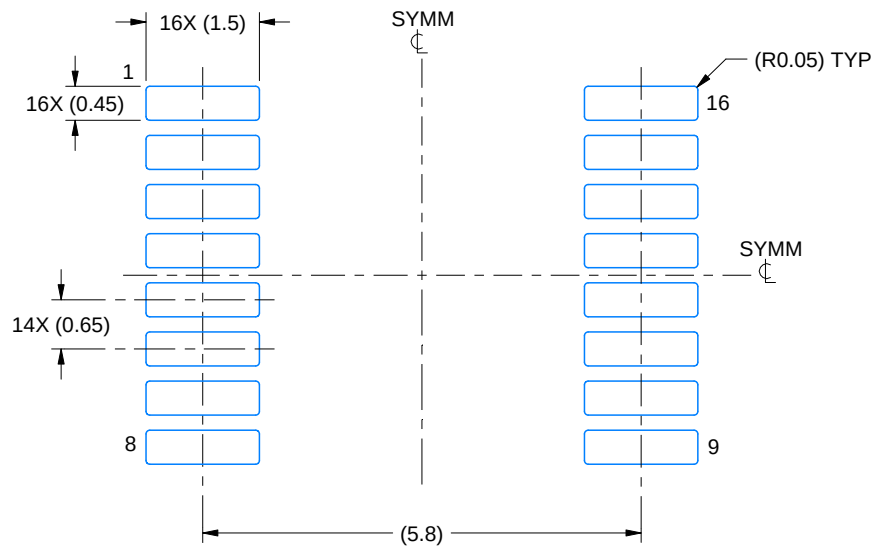
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.

# EXAMPLE BOARD LAYOUT

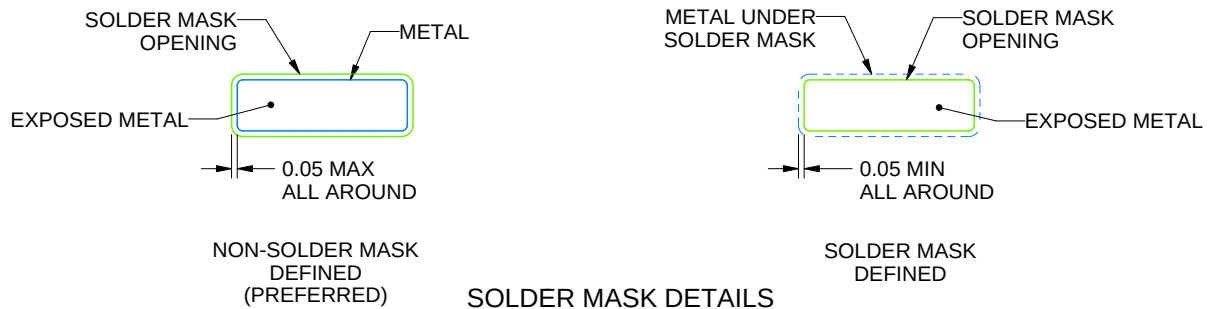
PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 10X



4220204/A 02/2017

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

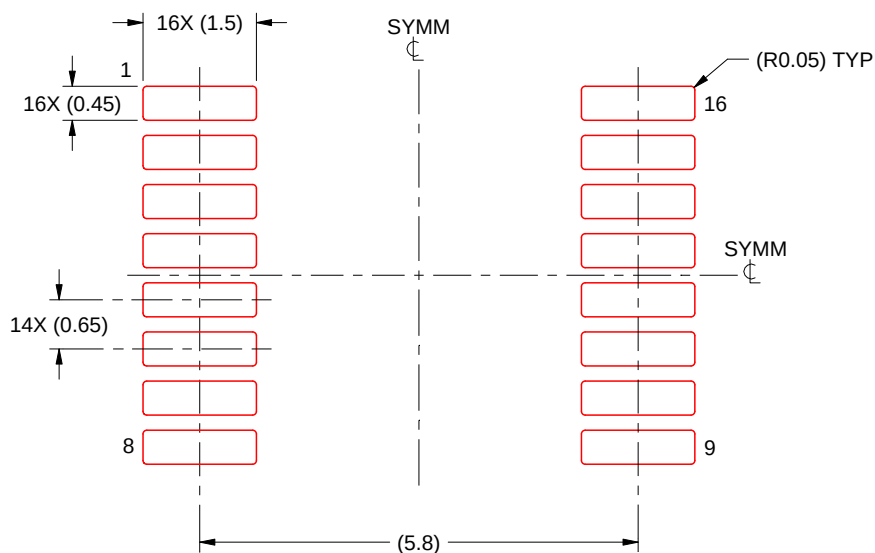
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

PW0016A

TSSOP - 1.2 mm max height

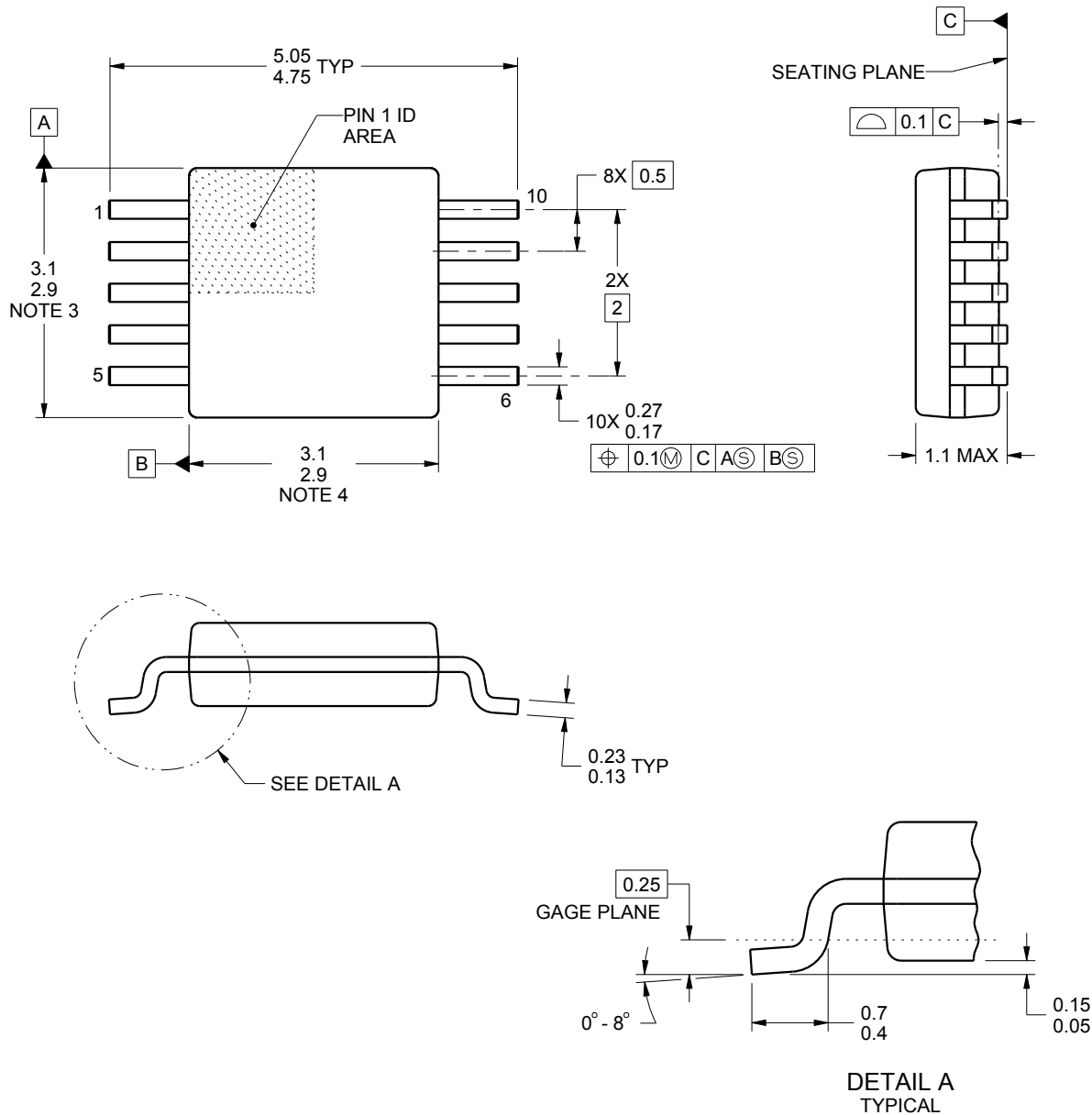
SMALL OUTLINE PACKAGE



4220204/A 02/2017

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.



4221984/A 05/2015

## NOTES:

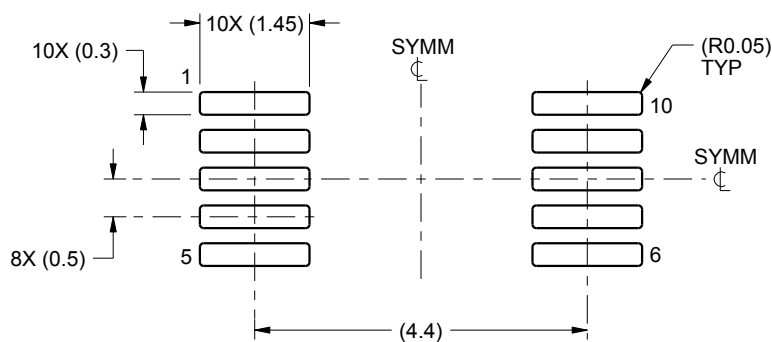
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-187, variation BA.

# EXAMPLE BOARD LAYOUT

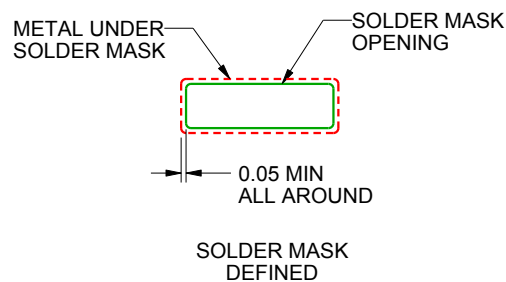
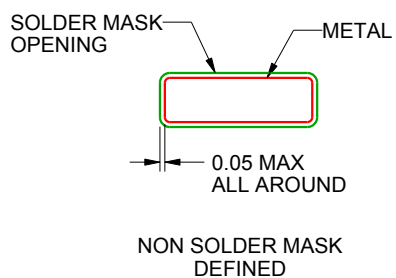
DGS0010A

VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
SCALE:10X



SOLDER MASK DETAILS  
NOT TO SCALE

4221984/A 05/2015

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

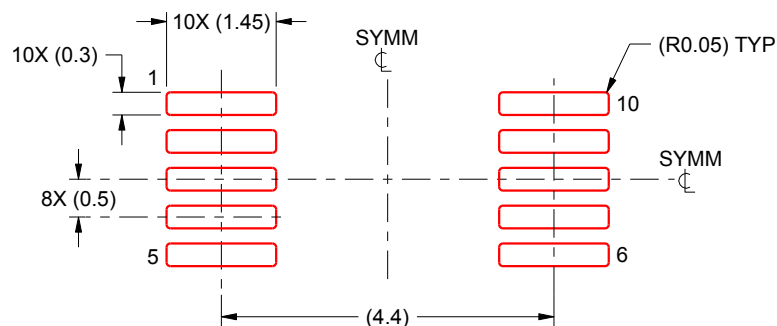
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

DGS0010A

VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:10X

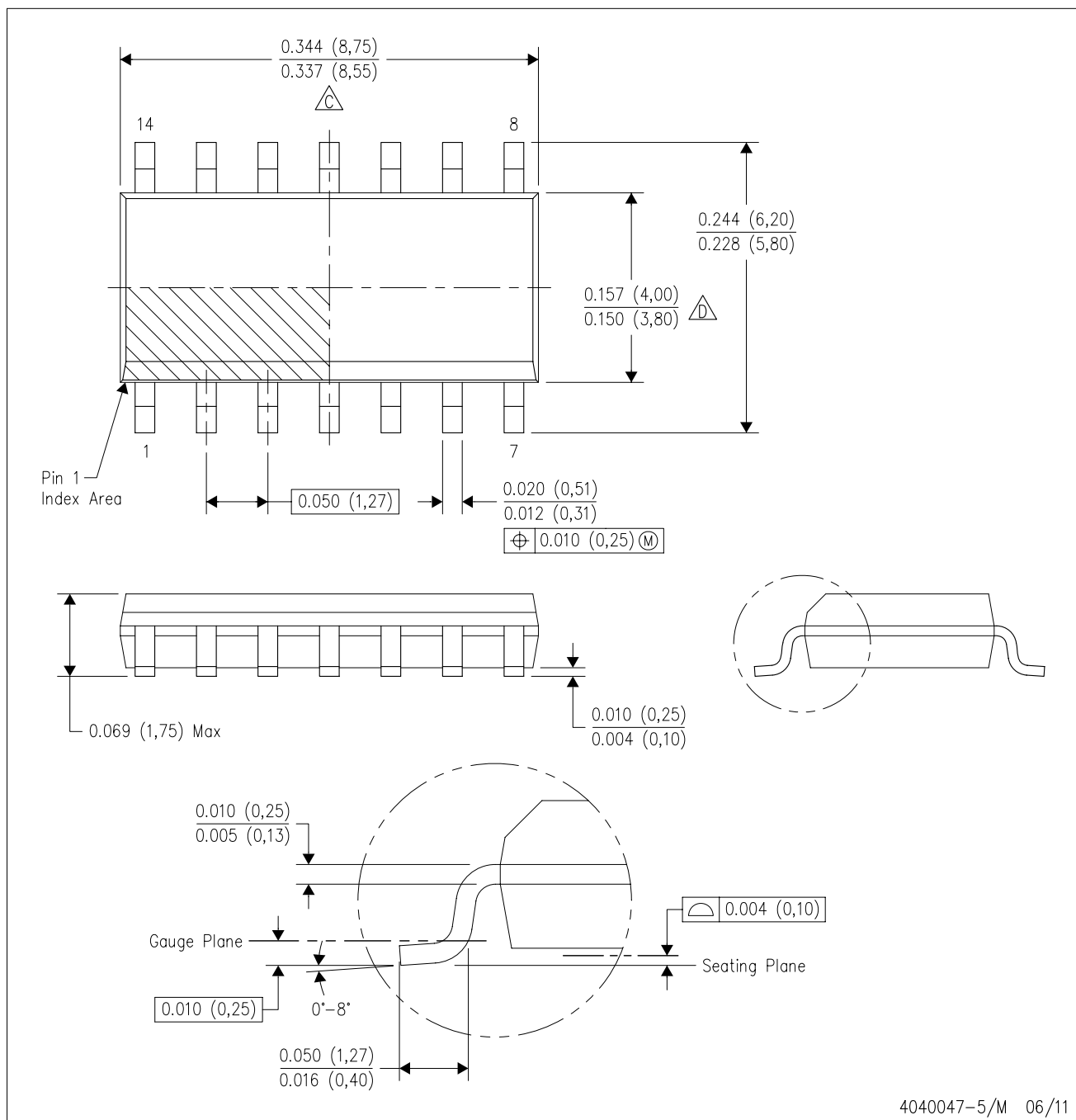
4221984/A 05/2015

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

D (R-PDSO-G14)

PLASTIC SMALL OUTLINE

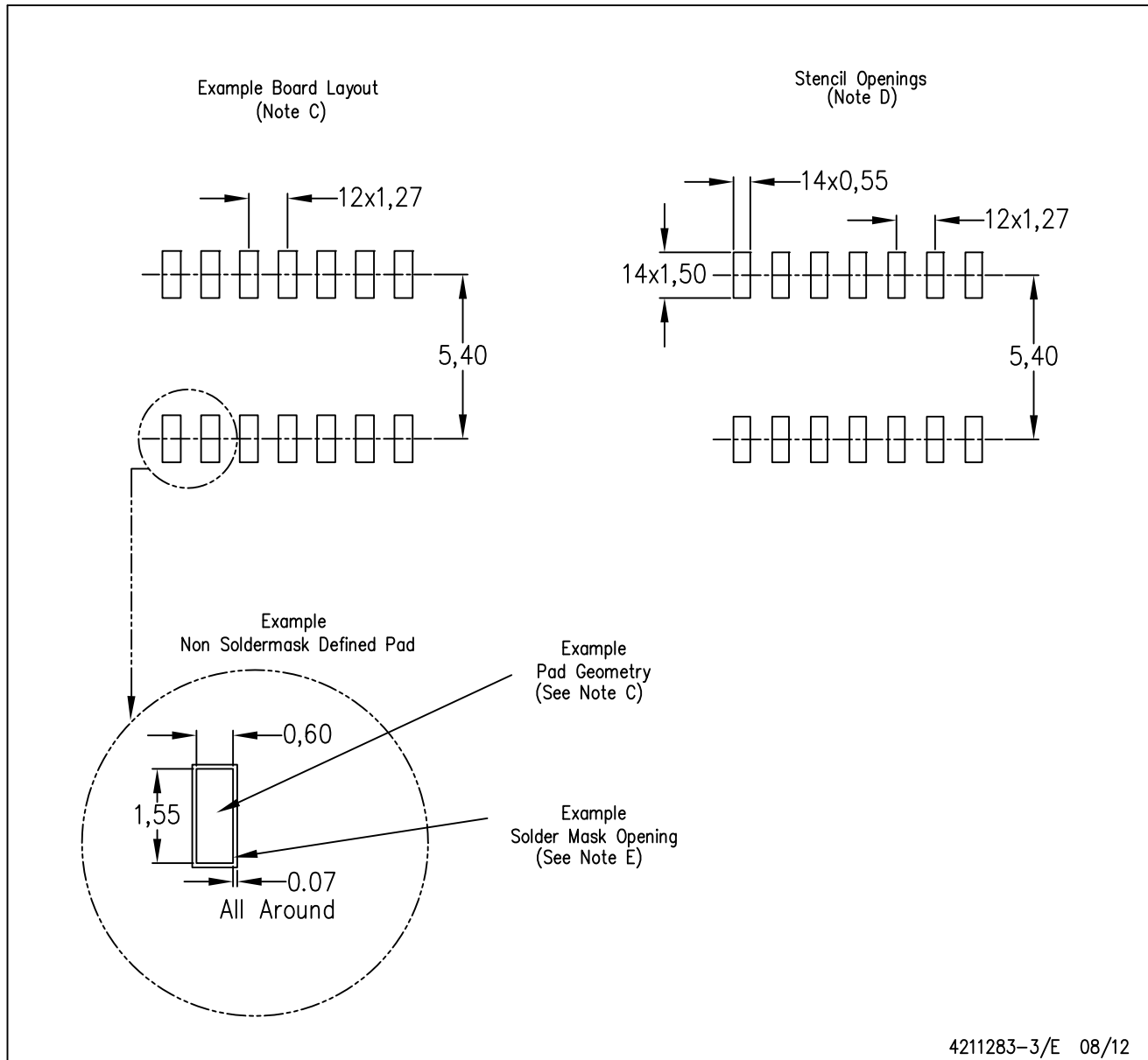


NOTES:

- 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 AB.

D (R-PDSO-G14)

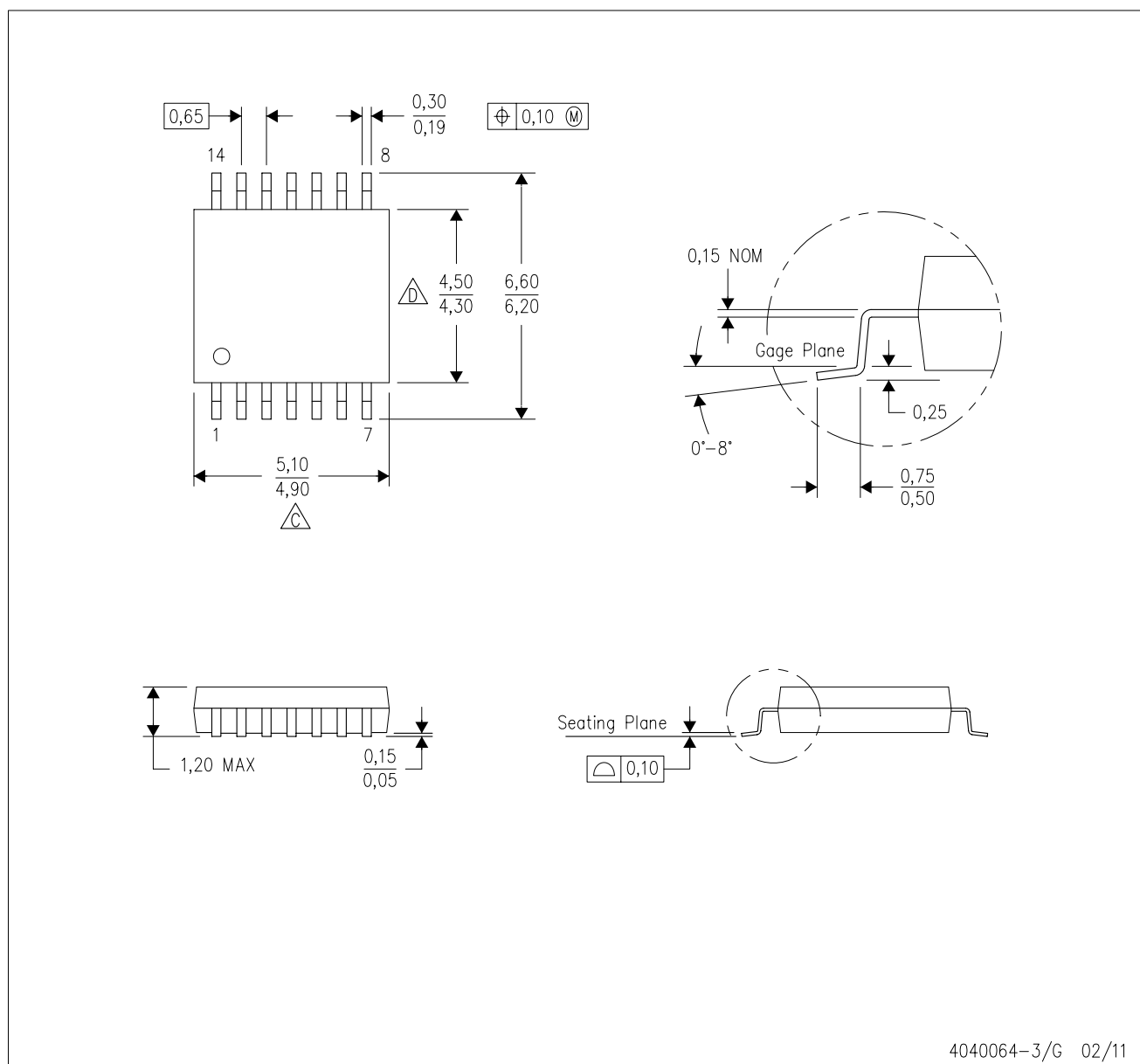
PLASTIC SMALL OUTLINE

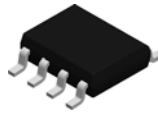


- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate designs.
  - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers 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.

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



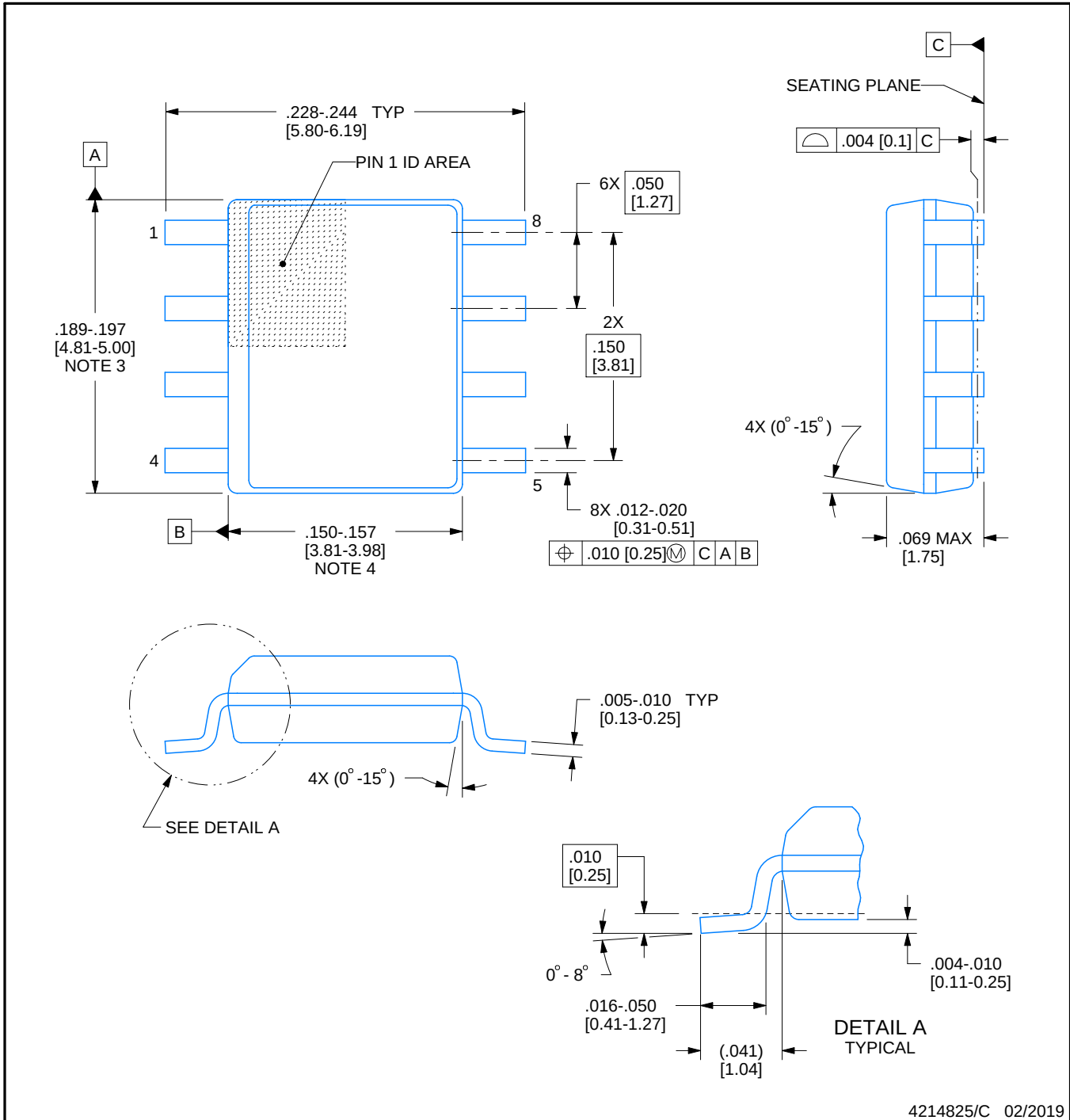


**D0008A**

# PACKAGE OUTLINE

**SOIC - 1.75 mm max height**

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

## NOTES:

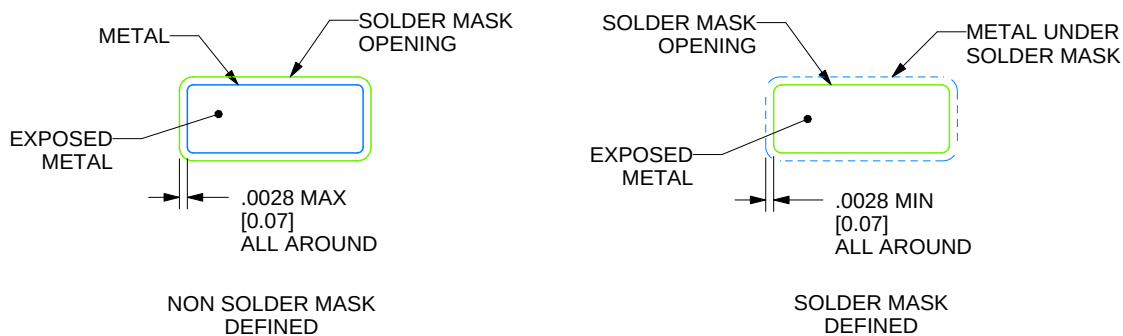
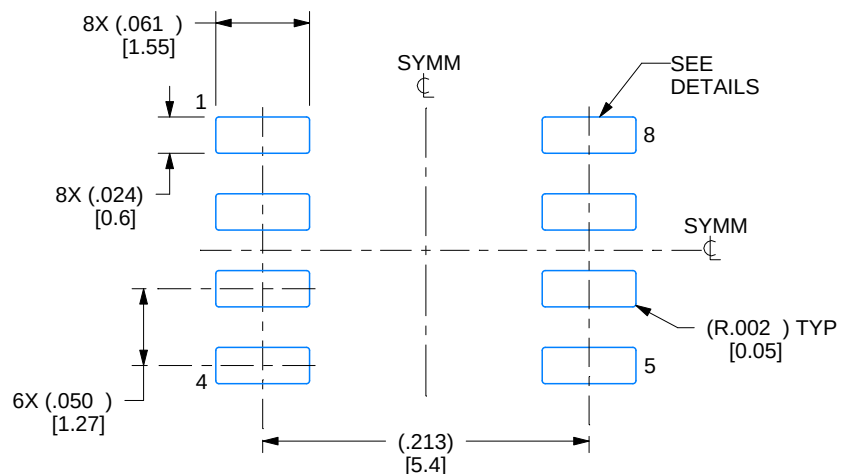
1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.

# EXAMPLE BOARD LAYOUT

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

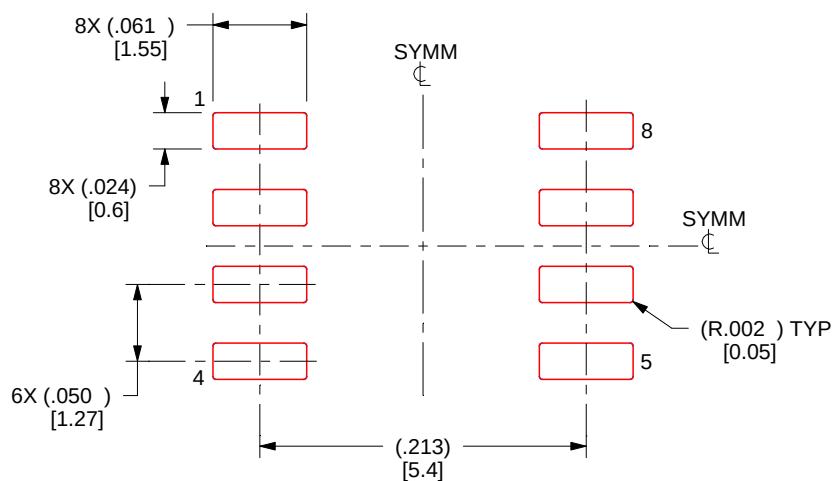
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE  
BASED ON .005 INCH [0.125 MM] THICK STENCIL  
SCALE:8X

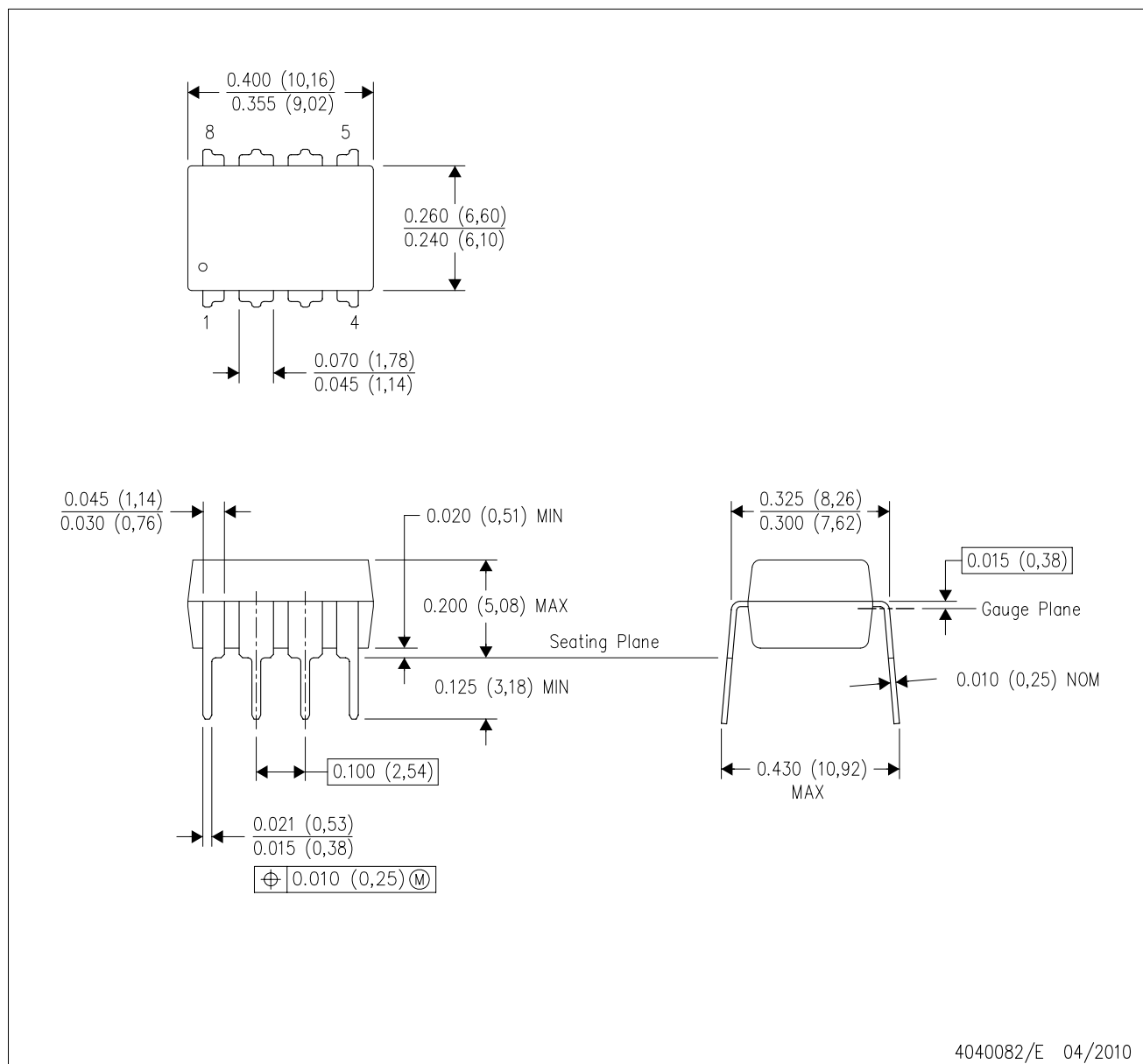
4214825/C 02/2019

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE

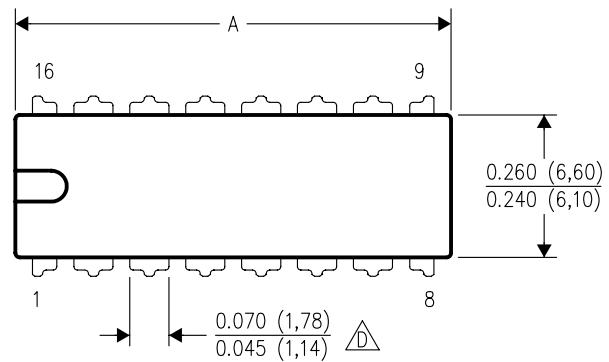


- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Falls within JEDEC MS-001 variation BA.

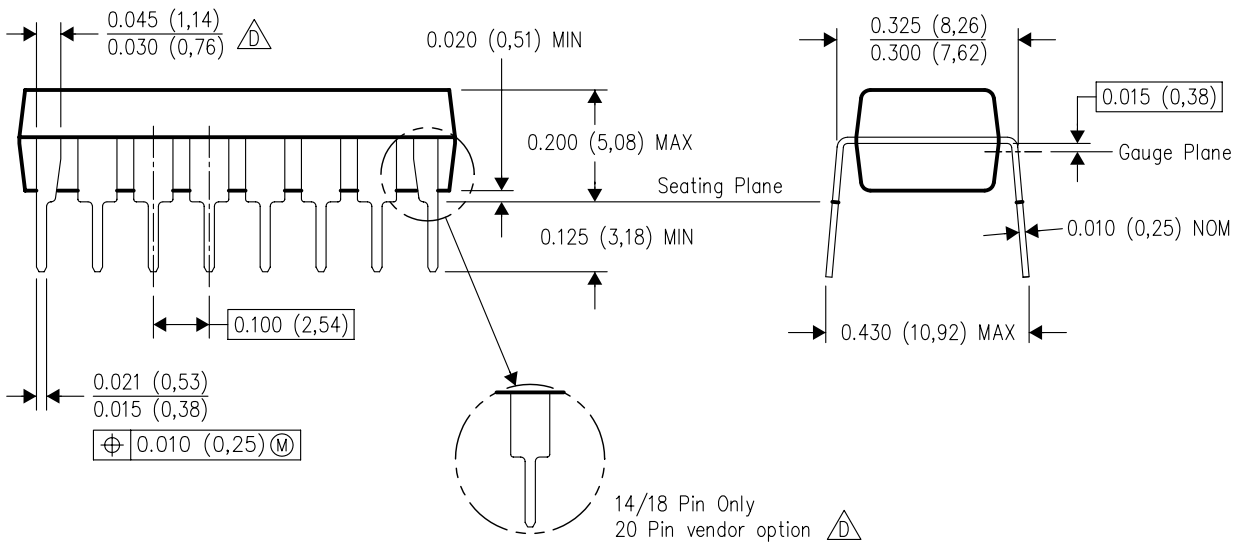
## N (R-PDIP-T\*\*)

16 PINS SHOWN

## PLASTIC DUAL-IN-LINE PACKAGE



| PINS **             | 14               | 16               | 18               | 20               |
|---------------------|------------------|------------------|------------------|------------------|
| DIM                 |                  |                  |                  |                  |
| A MAX               | 0.775<br>(19,69) | 0.775<br>(19,69) | 0.920<br>(23,37) | 1.060<br>(26,92) |
| A MIN               | 0.745<br>(18,92) | 0.745<br>(18,92) | 0.850<br>(21,59) | 0.940<br>(23,88) |
| MS-001<br>VARIATION | AA               | BB               | AC               | AD               |



14/18 Pin Only  
20 Pin vendor option

4040049/E 12/2002

- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
  - The 20 pin end lead shoulder width is a vendor option, either half or full width.

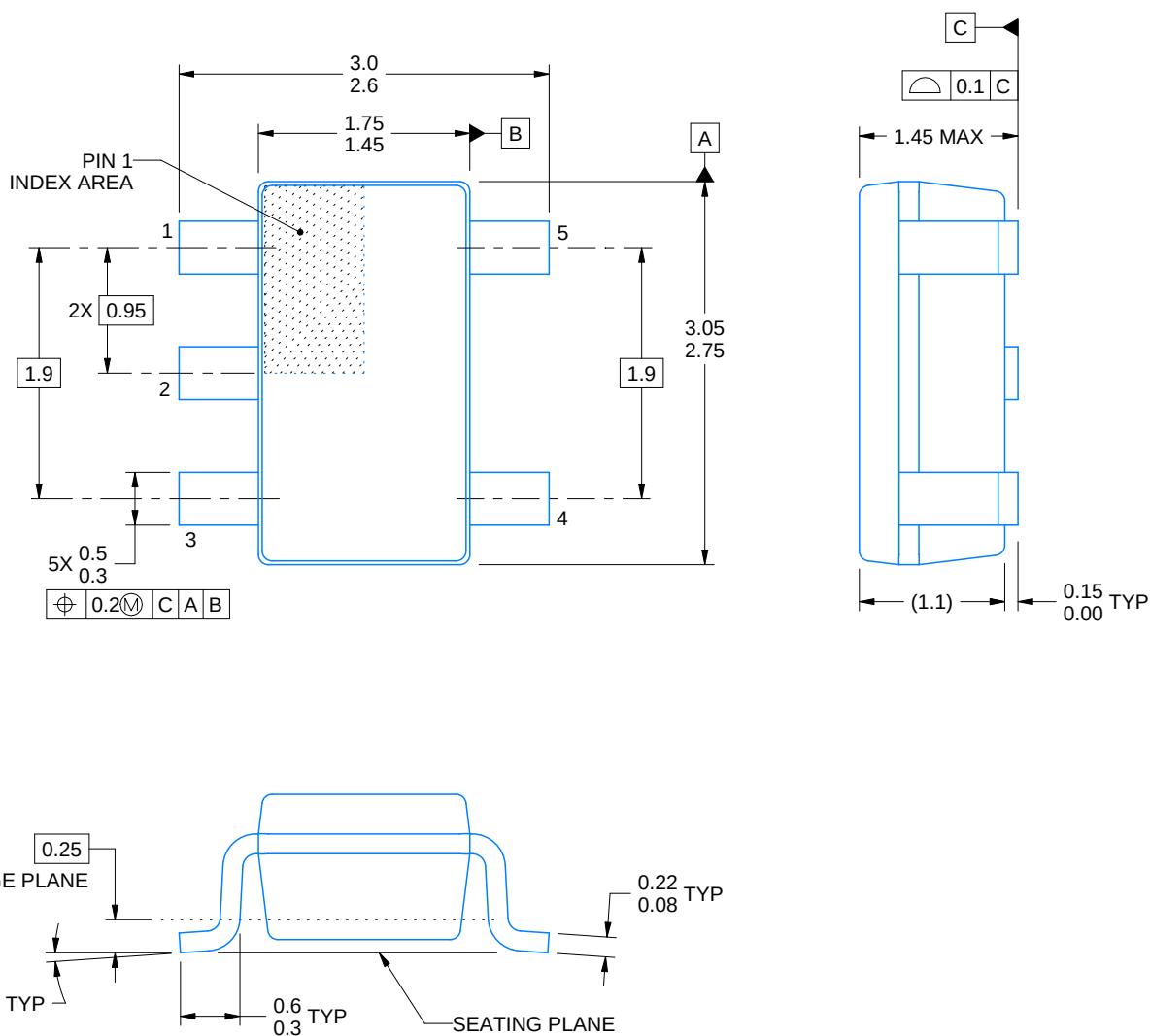


DBV0005A

# PACKAGE OUTLINE

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



4214839/D 11/2018

## NOTES:

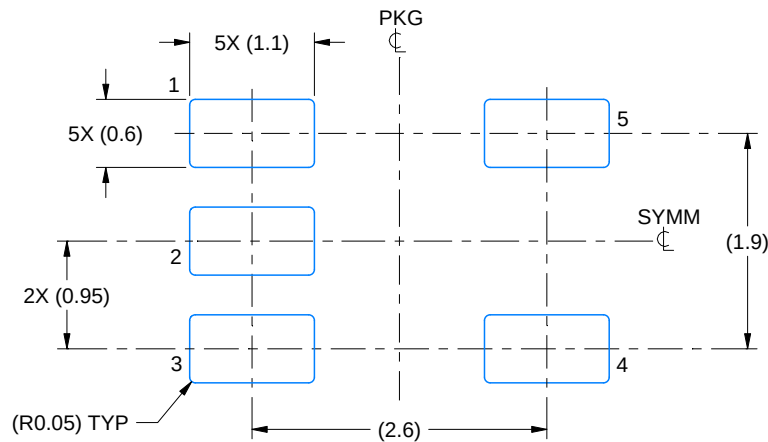
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC MO-178.
4. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.

# EXAMPLE BOARD LAYOUT

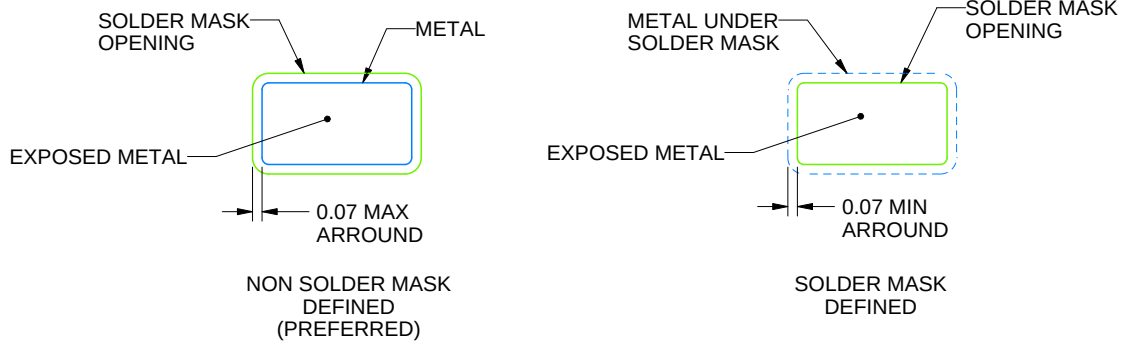
DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:15X



SOLDER MASK DETAILS

4214839/D 11/2018

NOTES: (continued)

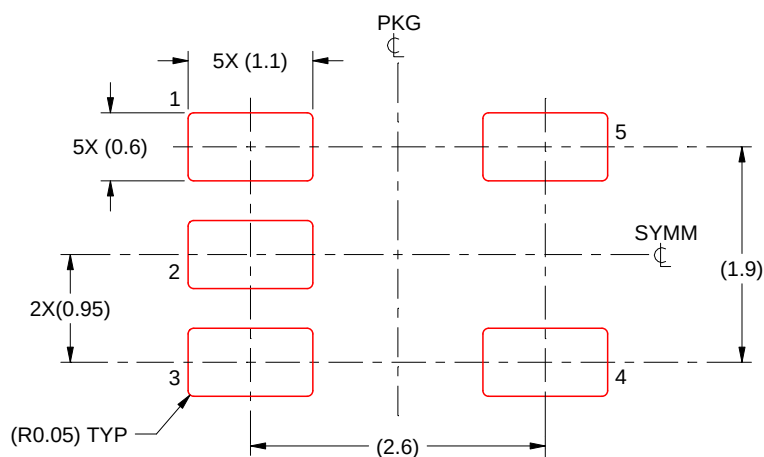
5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:15X

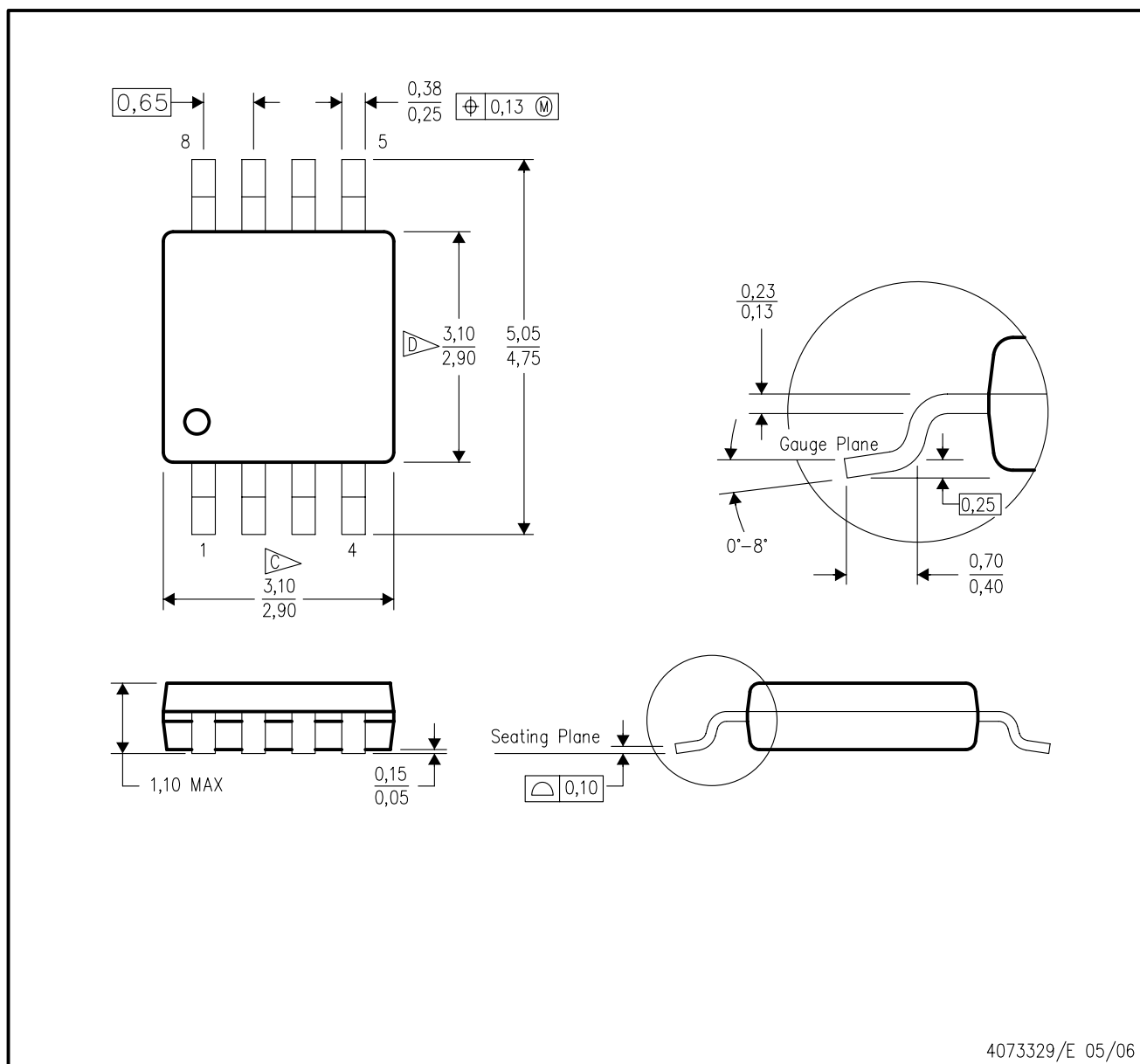
4214839/D 11/2018

NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.

DGK (S-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE

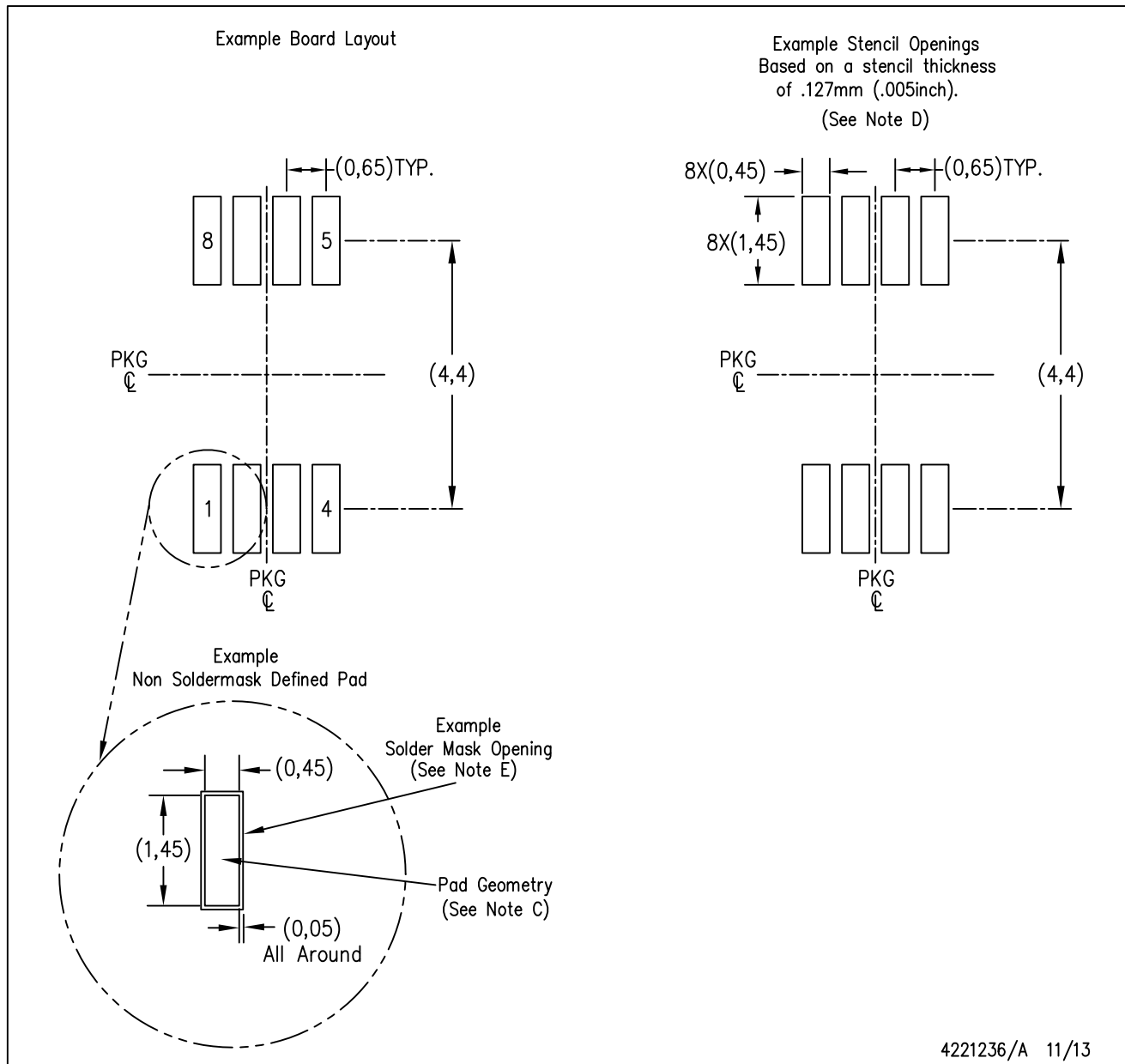


## NOTES:

- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per end.
- D. Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
- E. Falls within JEDEC MO-187 variation AA, except interlead flash.

DGK (S-PDSO-G8)

PLASTIC SMALL OUTLINE PACKAGE



- 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.

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