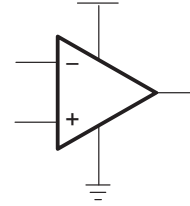


TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA FAMILY OF 23- μ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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- Supply Current . . . 23 μ A/Channel
- Gain-Bandwidth Product . . . 220 kHz
- Output Drive Capability . . . ± 10 mA
- Input Offset Voltage . . . 20 μ 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 μ 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†

| DEVICE | V_{DD} (V) | BW (MHz) | SLEW RATE (V/ μ s) | I_{DD} (per channel) (μ 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 |

† All specifications measured at 5 V.



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TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA FAMILY OF 23- μ 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°C to 125°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 _A | PACKAGED DEVICES | | | |
|--|--------------------------------|----------------------------|--------------|--------------------------|
| | SMALL OUTLINE (D) [†] | SOT-23 | | PLASTIC DIP (P) |
| | | (DBV) | SYMBOL | |
| 0°C to 70°C | TLV2450CD TLV2451CD | TLV2450CDBV TLV2451CDBV | VAQC VARC | TLV2450CP TLV2451CP |
| -40°C to 125°C | TLV2450ID TLV2451ID | TLV2450IDBV TLV2451IDBV | VAQI VARI | TLV2450IP TLV2451IP |
| | TLV2450AID TLV2451AID | — — | — — | TLV2450AIP TLV2451AIP |

[†] 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 _A | PACKAGED DEVICES | | | | | | |
|--|--------------------------------|--------------------|---------------------|--------------------|---------------------|-----------------|-----------------|
| | SMALL OUTLINE (D) [†] | MSOP | | | | PLASTIC DIP (N) | PLASTIC DIP (P) |
| | | (DGK) [†] | SYMBOL [‡] | (DGS) [†] | SYMBOL [‡] | | |
| 0°C to 70°C | TLV2452CD TLV2453CD | TLV2452CDGK — | xxTIABI — | — TLV2453CDGS | — xxTIABK | — TLV2453CN | TLV2452CP — |
| -40°C to 125°C | TLV2452ID TLV2453ID | TLV2452IDGK — | xxTIABJ — | — TLV2453IDGS | — xxTIABL | — TLV2453IN | TLV2452IP — |
| | TLV2452AID TLV2453AID | — — | — — | — — | — — | — TLV2453AIN | TLV2452AIP — |

[†] This package is available taped and reeled. To order this packaging option, add an R suffix to the part number (e.g., TLV2452CDR).

[‡] xx represents the device date code.

TLV2454 and TLV2455 AVAILABLE OPTIONS

| T _A | PACKAGED DEVICES | | |
|--|--------------------------------|--------------------------|----------------------------|
| | SMALL OUTLINE (D) [†] | PLASTIC DIP (N) | TSSOP (PW) [†] |
| 0°C to 70°C | TLV2454CD TLV2455CD | TLV2454CN TLV2455CN | TLV2454CPW TLV2455CPW |
| -40°C to 125°C | TLV2454ID TLV2455ID | TLV2454IN TLV2455IN | TLV2454IPW TLV2455IPW |
| | TLV2454AID TLV2455AID | TLV2454AIN TLV2455AIN | TLV2454AIPW TLV2455AIPW |

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

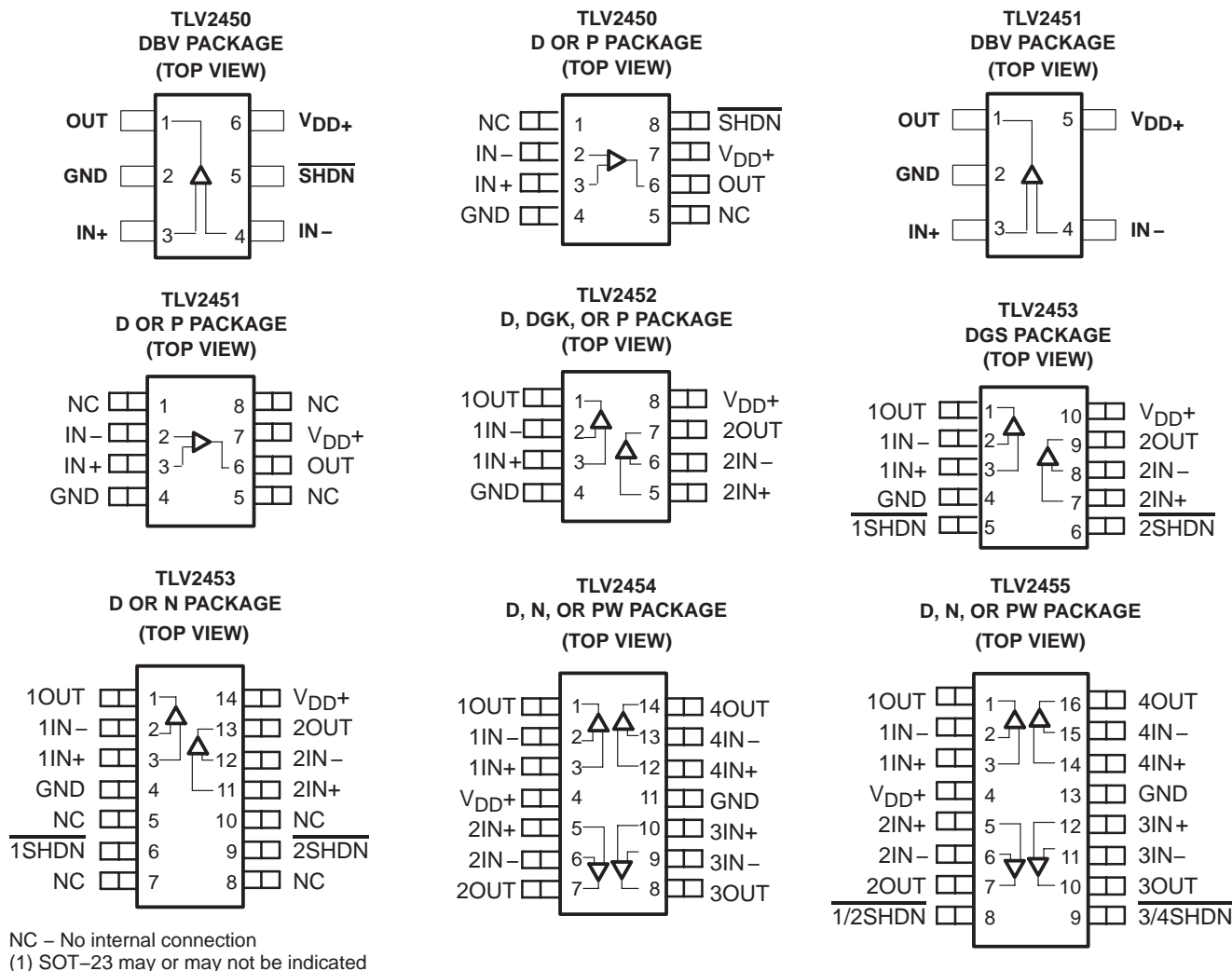
NOTE: For the most current package and ordering information, see the Package Option Addendum located at the end of this data sheet, or refer to our web site at www.ti.com.



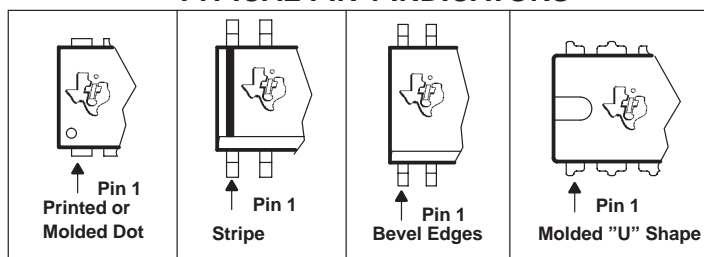
TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA FAMILY OF 23- μ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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TLV245x PACKAGE PINOUTS(1)



TYPICAL PIN 1 INDICATORS



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

| | |
|--|------------------------------|
| 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 |

[†] 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 | θ_{JC} (°C/W) | θ_{JA} (°C/W) | $T_A \leq 25^\circ\text{C}$ 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 | ± 1.35 | ± 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 [‡] | V_{IH} | 2 | | V |
| | V_{IL} | $V_{DD} = 5V$ | 0.8 | |
| | | $V_{DD} = 3V$ | 0.5 | V |

[‡] Relative to voltage on the GND terminal of the device.



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

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

| PARAMETER | | TEST CONDITIONS | | T_A † | MIN | TYP | MAX | UNIT |
|----------------|---|---|--|------------|------------|---------|------|------------|
| V_{IO} | Input offset voltage | TLV245x | $V_{DD} = \pm 1.5$ V $V_{IC} = 0$, $V_O = 0$, $R_S = 50$ Ω | 25°C | 300 | 1500 | | μ V |
| | | | | Full range | | 2000 | | |
| | | TLV245xA | | 25°C | 300 | 1000 | | |
| | | | | Full range | | 1300 | | |
| α_{VIO} | Temperature coefficient of input offset voltage | | | | | 0.3 | | μ V/°C |
| I_{IO} | Input offset current | | | 25°C | | 0.3 | 4.5 | nA |
| | | | | Full range | | | 5.5 | |
| I_{IB} | Input bias current | | | 25°C | | 0.9 | 5 | nA |
| | | | | Full range | | | 7 | |
| V_{OH} | High-level output voltage | $V_{IC} = 1.5$ V, | $I_{OH} = -500$ μ A | 25°C | 2.85 | 2.95 | | V |
| | | | | Full range | 2.83 | | | |
| V_{OL} | Low-level output voltage | $V_{IC} = 1.5$ V, | $I_{OL} = 500$ μ A | 25°C | | 0.09 | 0.16 | V |
| | | | | Full range | | | 0.2 | |
| I_{OS} | Short-circuit output current | Sourcing | | 25°C | 4 | 12 | | mA |
| | | | | Full range | 3 | | | |
| | | Sinking | | 25°C | 2 | 7 | | |
| | | | | Full range | 1 | | | |
| I_O | Output current | $V_O = 0.5$ V from rail | | 25°C | | ± 4 | | mA |
| A_{VD} | Large-signal differential voltage amplification | $V_{O(PP)} = 1$ V, | $R_L = 10$ k Ω | 25°C | 96 | 110 | | dB |
| | | | | Full range | 91 | | | |
| $r_{i(d)}$ | Differential input resistance | | | 25°C | | 10^9 | | Ω |
| C_{IC} | Common-mode input capacitance | $f = 10$ kHz | | 25°C | | 4.5 | | pF |
| z_o | Closed-loop output impedance | $f = 10$ kHz, | $A_V = 10$ | 25°C | | 80 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC} = 0$ to 3 V, $R_S = 50$ Ω | TLV245xC | 25°C | 70 | 80 | | dB |
| | | | | Full range | 66 | | | |
| k_{SVR} | Supply voltage rejection ratio ($\Delta V_{DD} / \Delta V_{IO}$) | $V_{DD} = 2.7$ V to 6 V, No load | $V_{IC} = V_{DD}/2$, | 25°C | 76 | 89 | | dB |
| | | | | Full range | 74 | | | |
| | | $V_{DD} = 3$ V to 5 V, No load | | 25°C | 88 | 106 | | |
| | | | | Full range | 84 | | | |
| I_{DD} | Supply current (per channel) | $V_O = 1.5$ V, No load | TLV245xC | 25°C | | 23 | 35 | μ A |
| | | | | Full range | | | 40 | |
| | | | | TLV245xl | Full range | | | |
| $I_{DD(SHDN)}$ | Supply current in shutdown mode (TLV2450, TLV2453, TLV2455) (per channel) | $\overline{SHDN} = -V_{DD}$ | TLV245xC | 25°C | | 12 | 65 | nA |
| | | | | Full range | | | 70 | |
| | | | | TLV245xl | Full range | | | |

† Full range is 0°C to 70°C for C suffix and –40°C to 125°C for l suffix.



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

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

| PARAMETER | | TEST CONDITIONS | | T_A † | MIN | TYP | MAX | UNIT |
|-------------|--------------------------------------|---|---------------------------|------------|------|-------------|---------|------------------------|
| SR | Slew rate at unity gain | $V_{O(PP)} = 0.8\text{ V}$, $R_L = 10\text{ k}\Omega$ | $C_L = 150\text{ pF}$ | 25°C | 0.05 | 0.11 | | V/ μ 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 | | 51 | | |
| I_n | Equivalent input noise current | f = 1 kHz | | 25°C | | 3.5 | | pA/ $\sqrt{\text{Hz}}$ |
| THD + N | Total harmonic distortion plus noise | $V_{O(PP)} = 1.5\text{ V}$, $R_L = 10\text{ k}\Omega$, f = 1 kHz | | 25°C | | $A_V = 1$ | 0.04% | |
| | | | | | | $A_V = 10$ | 0.3% | |
| | | | | | | $A_V = 100$ | 1.5% | |
| $t_{(on)}$ | Amplifier turnon time | $A_V = 5$, $R_L = \text{OPEN}$, | | 25°C | | 59 | | μ s |
| $t_{(off)}$ | Amplifier turnoff time | Measured at 50% point | | 25°C | | 836 | | ns |
| | Gain-bandwidth product | f = 10 kHz, | $R_L = 10\text{ k}\Omega$ | 25°C | | 200 | | kHz |
| t_s | Settling time | $V_{(\text{STEP})PP} = 2\text{ V}$, $A_V = -1$, $C_L = 10\text{ pF}$, $R_L = 10\text{ k}\Omega$ | 0.1% | 25°C | | 26 | μ s | |
| | | | 0.01% | | | 31 | | |
| | | $V_{(\text{STEP})PP} = 2\text{ V}$, $A_V = -1$, $C_L = 56\text{ pF}$, $R_L = 10\text{ k}\Omega$ | 0.1% | | | 26 | | |
| | | | 0.01% | | | 31 | | |
| ϕ_m | Phase margin | $R_L = 10\text{ k}\Omega$, | $C_L = 1000\text{ pF}$ | 25°C | | 56° | | |
| | Gain margin | $R_L = 10\text{ k}\Omega$, | $C_L = 1000\text{ pF}$ | 25°C | | 7 | | dB |

† 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
FAMILY OF 23- μ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT
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electrical characteristics at specified free-air temperature, $V_{DD} = 5$ V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | T_A † | MIN | TYP | MAX | UNIT | |
|----------------|---|-----------------|--|------------|------|----------|------|------------|----|
| V_{IO} | Input offset voltage | | | 25°C | | 300 | 1500 | μ V | |
| | | | | Full range | | | 2000 | | |
| | | | | 25°C | | 300 | 1000 | | |
| | | | | Full range | | | 1300 | | |
| α_{VIO} | Temperature coefficient of input offset voltage | | $V_{DD} = \pm 2.5$ V $V_{IC} = 0$, $V_O = 0$, $R_S = 50$ Ω | | | 0.3 | | μ V/°C | |
| I_{IO} | Input offset current | | | 25°C | | 0.3 | 4.5 | nA | |
| | | | | Full range | | | 5.5 | | |
| I_{IB} | Input bias current | | | 25°C | | 0.5 | 5 | nA | |
| | | | | Full range | | | 7 | | |
| V_{OH} | High-level output voltage | | $V_{IC} = 2.5$ V, $I_{OH} = -500$ μ A | 25°C | 4.87 | 4.97 | | V | |
| | | | | Full range | 4.85 | | | | |
| V_{OL} | Low-level output voltage | | $V_{IC} = 2.5$ V, $I_{OL} = 500$ μ A | 25°C | | 0.07 | 0.15 | V | |
| | | | | Full range | | | 0.16 | | |
| I_{OS} | Short-circuit output current | | | Sourcing | | 25°C | 20 | 32 | mA |
| | | | | Full range | | 18 | | | |
| | | | | Sinking | | 25°C | 12 | 18 | |
| | | | | Full range | | 10 | | | |
| I_O | Output current | | $V_O = 0.5$ V from rail | 25°C | | ± 10 | | mA | |
| A_{VD} | Large-signal differential voltage amplification | | $V_{O(PP)} = 3$ V, $R_L = 10$ k Ω | 25°C | 96 | 103 | | dB | |
| | | | | Full range | 91 | | | | |
| $r_{i(d)}$ | Differential input resistance | | | 25°C | | 10^9 | | Ω | |
| C_{IC} | Common-mode input capacitance | | $f = 10$ kHz | 25°C | | 4.5 | | pF | |
| z_o | Closed-loop output impedance | | $f = 10$ kHz, $A_V = 10$ | 25°C | | 45 | | Ω | |
| CMRR | Common-mode rejection ratio | | $V_{IC} = 0$ to 5 V, $R_S = 50$ Ω | 25°C | 70 | 80 | | dB | |
| | | | | Full range | 68 | | | | |
| k_{SVR} | Supply voltage rejection ratio ($\Delta V_{DD} / \Delta V_{IO}$) | | $V_{DD} = 2.7$ V to 6 V, No load $V_{IC} = V_{DD}/2$ | 25°C | 76 | 89 | | dB | |
| | | | | Full range | 74 | | | | |
| | | | | 25°C | 88 | 106 | | | |
| | | | | Full range | 84 | | | | |
| I_{DD} | Supply current (per channel) | | $V_O = 2.5$ V, No load | 25°C | | 23 | 42 | μ A | |
| | | | | Full range | | | 44 | | |
| | | | | Full range | | | 46 | | |
| $I_{DD(SHDN)}$ | Supply current in shutdown mode (TLV2450, TLV2453, TLV2455) (per channel) | | $\overline{SHDN} = -V_{DD}$ | 25°C | | 16 | 70 | nA | |
| | | | | Full range | | | 70 | | |
| | | | | Full range | | | 80 | | |

† 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
FAMILY OF 23- μ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT
OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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

| PARAMETER | | TEST CONDITIONS | | T_A † | MIN | TYP | MAX | UNIT |
|-------------|--------------------------------------|--|---------------------------|------------|------|-------------|---------|------------------------|
| SR | Slew rate at unity gain | $V_{O(PP)} = 2\text{ V}$, $R_L = 10\text{ k}\Omega$ | $C_L = 150\text{ pF}$ | 25°C | 0.05 | 0.11 | | V/ μ 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 | $V_{O(PP)} = 3\text{ V}$, $R_L = 10\text{ k}\Omega$, f = 1 kHz | | 25°C | | $A_V = 1$ | 0.02% | |
| | | | | | | $A_V = 10$ | 0.18% | |
| | | | | | | $A_V = 100$ | 0.9% | |
| $t_{(on)}$ | Amplifier turnon time | $A_V = 5$, $R_L = \text{OPEN}$, | | 25°C | | 59 | | μ s |
| $t_{(off)}$ | Amplifier turnoff time | Measured at 50% point | | 25°C | | 836 | | ns |
| | Gain-bandwidth product | f = 10 kHz, | $R_L = 10\text{ k}\Omega$ | 25°C | | 220 | | kHz |
| t_s | Settling time | $V_{(STEP)PP} = 2\text{ V}$, $A_V = -1$, $C_L = 10\text{ pF}$, $R_L = 10\text{ k}\Omega$ | 0.1% | 25°C | | 24 | μ s | |
| | | | 0.01% | | | 30 | | |
| | | $V_{(STEP)PP} = 2\text{ V}$, $A_V = -1$, $C_L = 56\text{ pF}$, $R_L = 10\text{ k}\Omega$ | 0.1% | | | 25 | | |
| | | | 0.01% | | | 30 | | |
| ϕ_m | Phase margin | $R_L = 10\text{ k}\Omega$, | $C_L = 1000\text{ pF}$ | 25°C | | 56° | | |
| | Gain margin | $R_L = 10\text{ k}\Omega$, | $C_L = 1000\text{ pF}$ | 25°C | | 7 | | dB |

† 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

| | | | FIGURE |
|-------------|--------------------------------------|---|--------------|
| V_{IO} | Input offset voltage | vs Common-mode input voltage | 1, 2 |
| I_{IO} | Input offset current | vs Common-mode input voltage vs Free-air temperature | 3, 4 7, 8 |
| I_{IB} | Input bias current | vs Common-mode input voltage vs Free-air temperature | 5, 6 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 |
| ϕ_m | Phase margin | vs Load capacitance | 24 |
| | Gain-bandwidth product | vs Supply voltage | 25 |
| SR | Slew rate | vs Supply voltage vs Free-air temperature | 26 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- μ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT
OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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TYPICAL CHARACTERISTICS

INPUT OFFSET VOLTAGE
vs
COMMON-MODE INPUT VOLTAGE

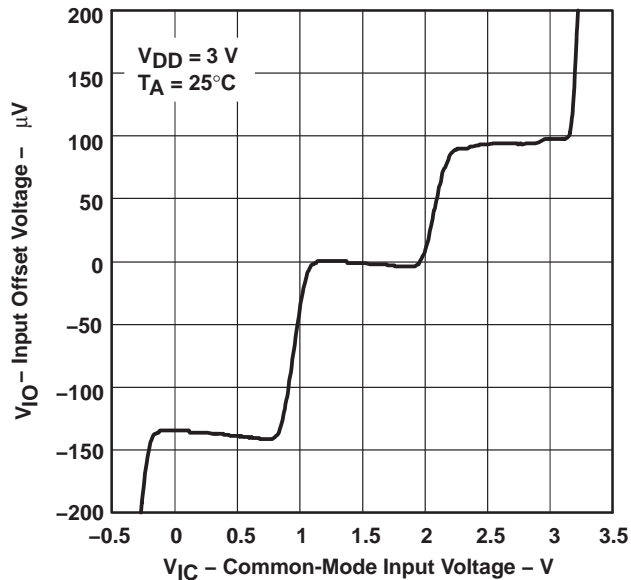


Figure 1

INPUT OFFSET VOLTAGE
vs
COMMON-MODE INPUT VOLTAGE

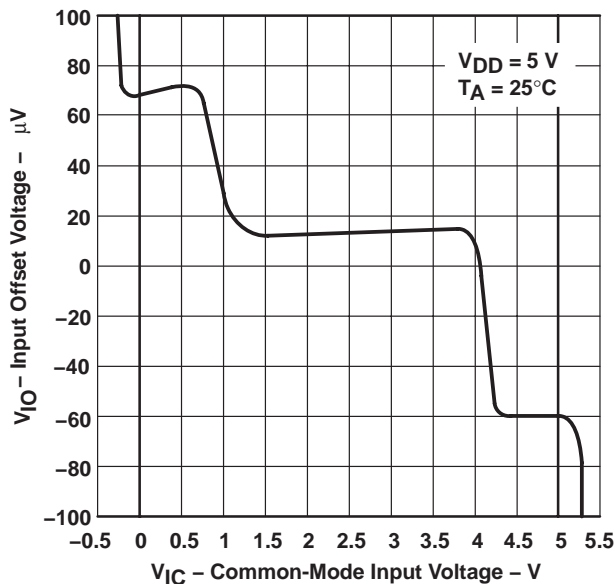


Figure 2

INPUT OFFSET CURRENT
vs
COMMON-MODE INPUT VOLTAGE

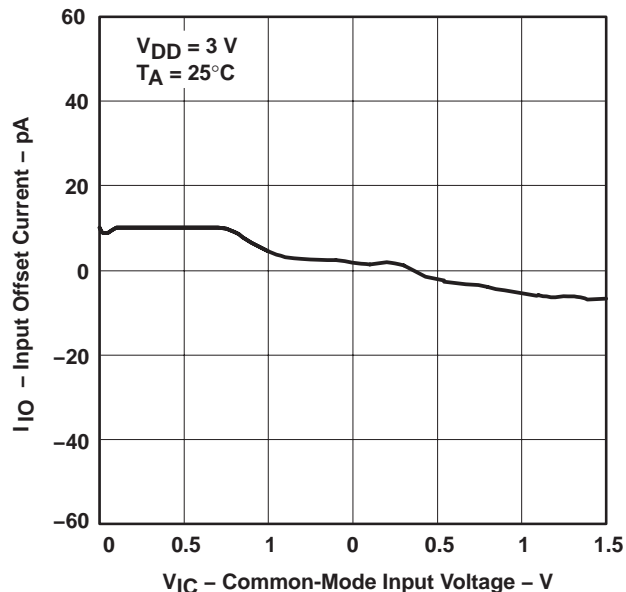


Figure 3

INPUT OFFSET CURRENT
vs
COMMON-MODE INPUT VOLTAGE

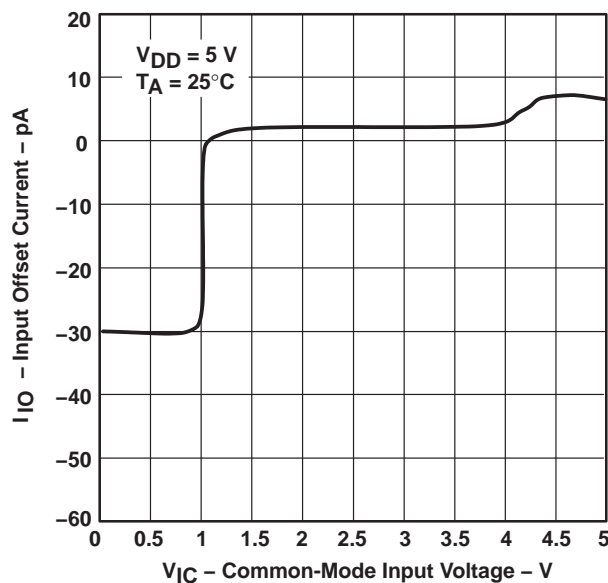


Figure 4

TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA
 FAMILY OF 23- μ A 220-KHz RAIL-TO-RAIL INPUT/OUTPUT
 OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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TYPICAL CHARACTERISTICS

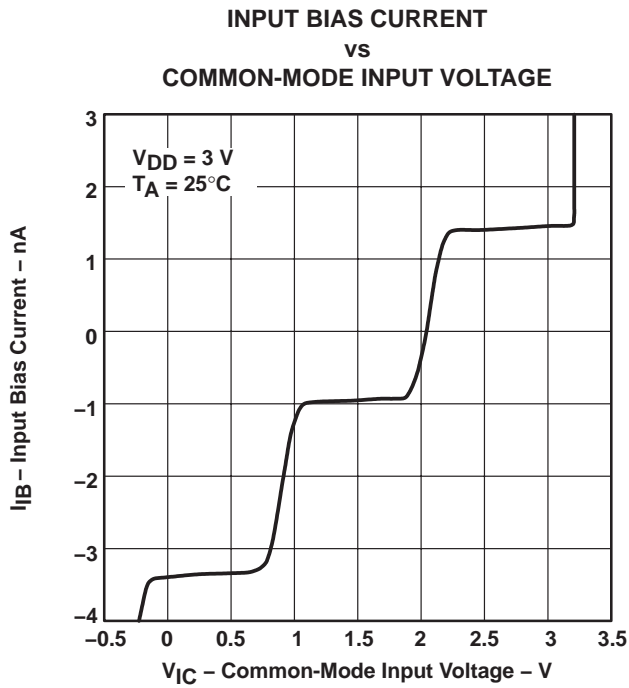


Figure 5

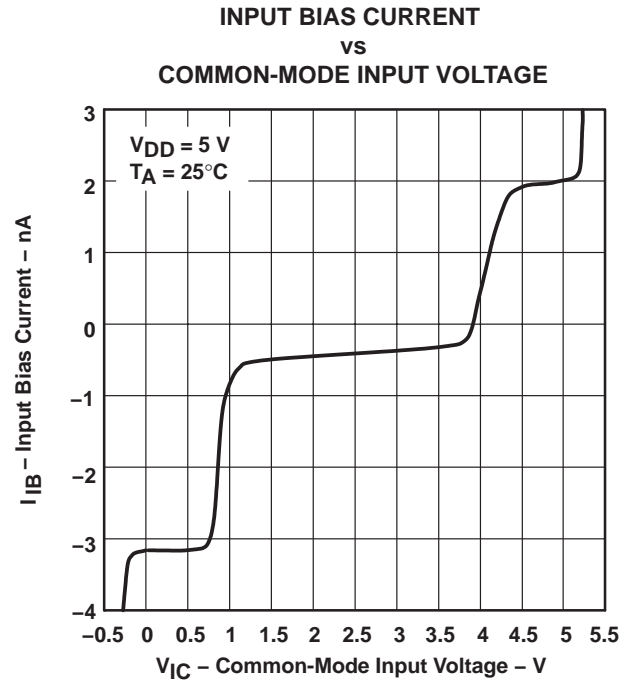


Figure 6

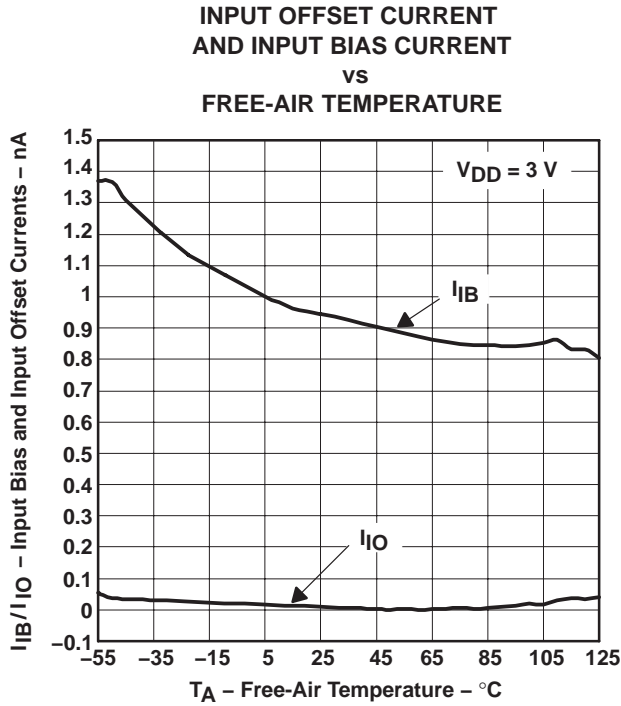


Figure 7

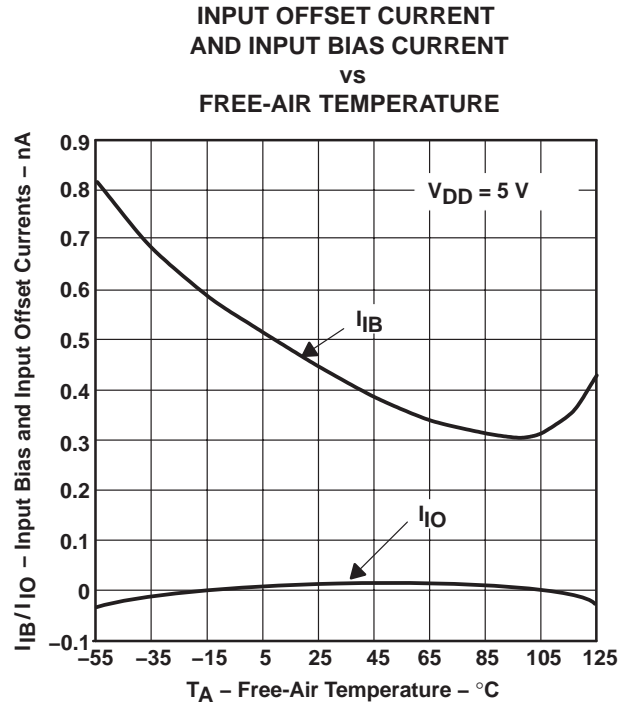


Figure 8

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

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TYPICAL CHARACTERISTICS

DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE
vs
FREQUENCY

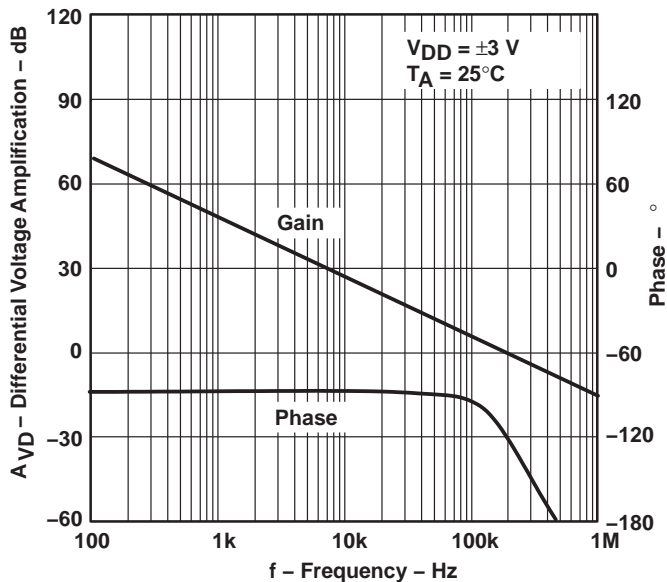


Figure 9

DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE
vs
FREQUENCY

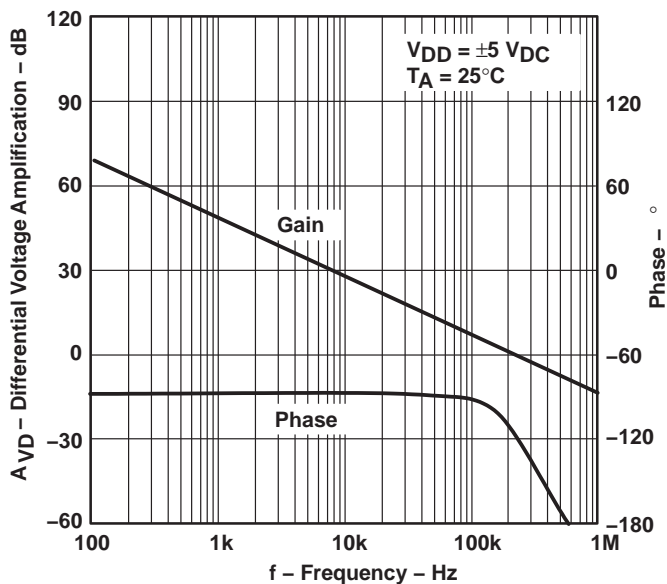


Figure 10



TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA
 FAMILY OF 23- μ A 220-KHz RAIL-TO-RAIL INPUT/OUTPUT
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TYPICAL CHARACTERISTICS

LOW-LEVEL OUTPUT VOLTAGE
 vs
 LOW-LEVEL OUTPUT CURRENT

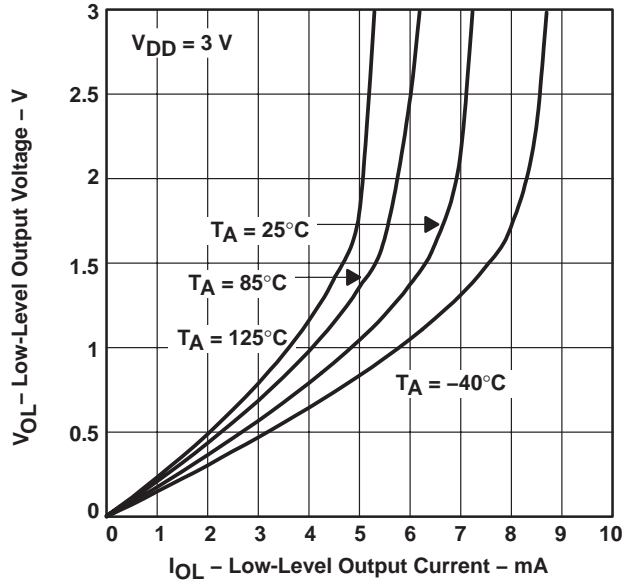


Figure 11

HIGH-LEVEL OUTPUT VOLTAGE
 vs
 HIGH-LEVEL OUTPUT CURRENT

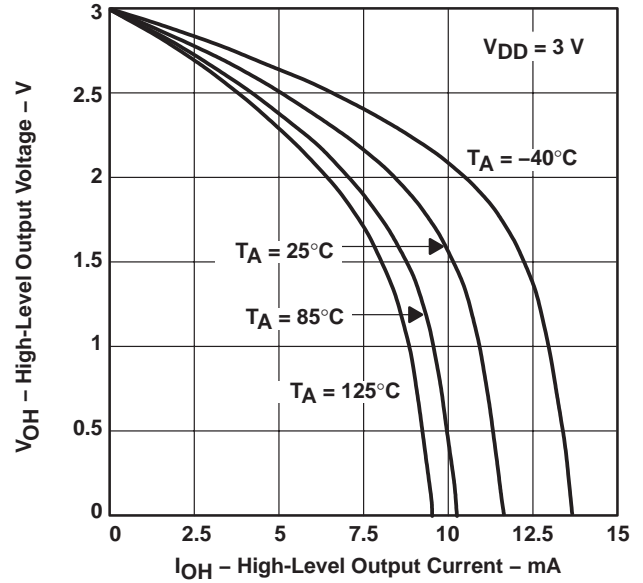


Figure 12

LOW-LEVEL OUTPUT VOLTAGE
 vs
 LOW-LEVEL OUTPUT CURRENT

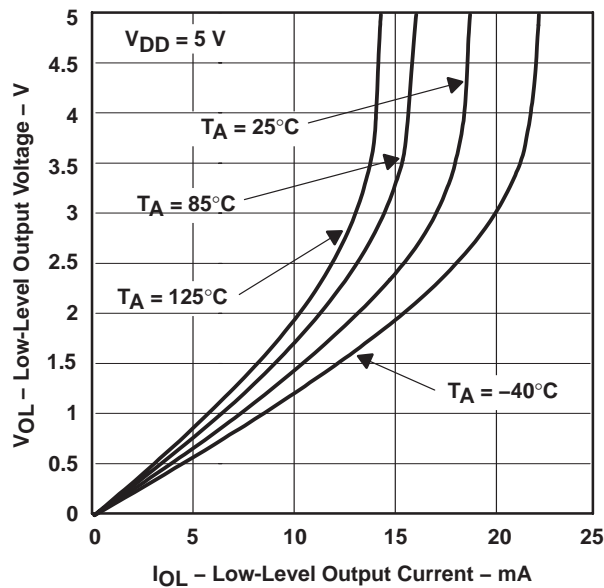


Figure 13

HIGH-LEVEL OUTPUT VOLTAGE
 vs
 HIGH-LEVEL OUTPUT CURRENT

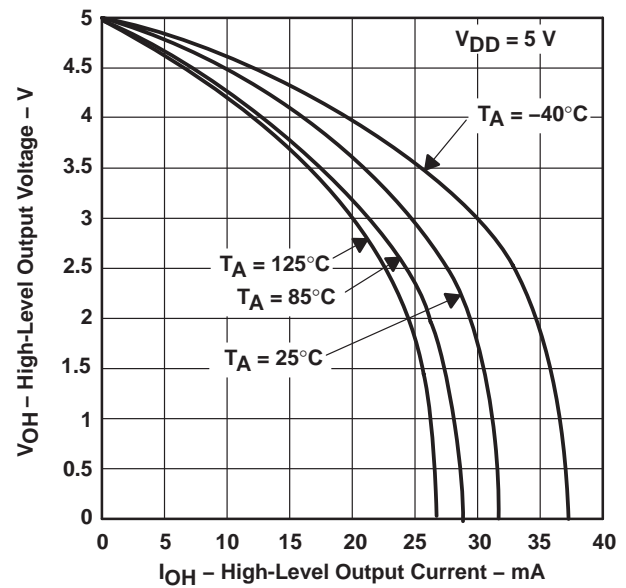


Figure 14

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

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TYPICAL CHARACTERISTICS

**OUTPUT IMPEDANCE
VS
FREQUENCY**

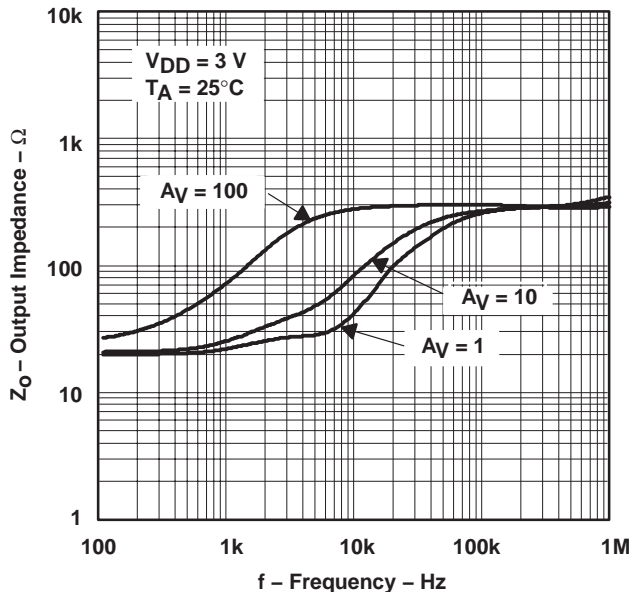


Figure 15

**OUTPUT IMPEDANCE
VS
FREQUENCY**

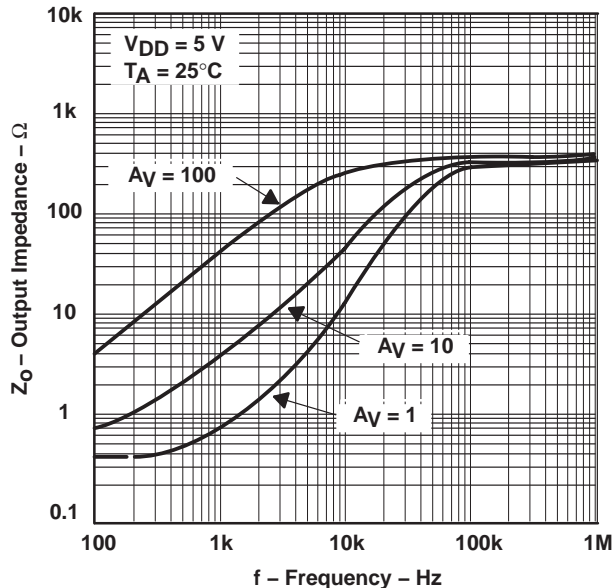


Figure 16

**COMMON-MODE REJECTION RATIO
VS
FREQUENCY**

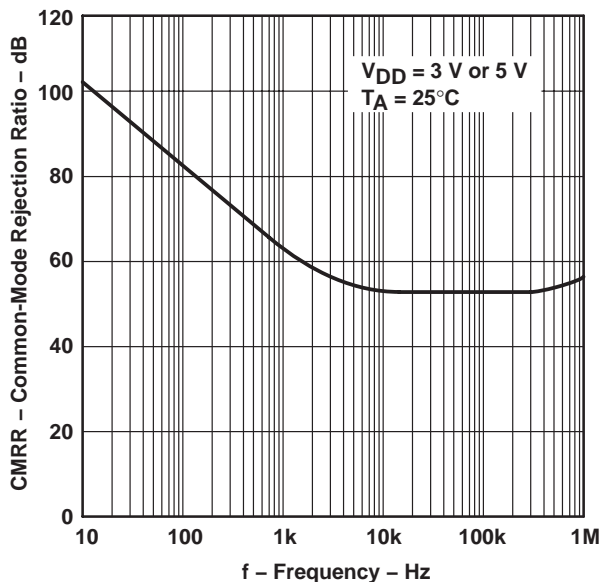


Figure 17



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

POWER SUPPLY REJECTION RATIO
 vs
 FREQUENCY

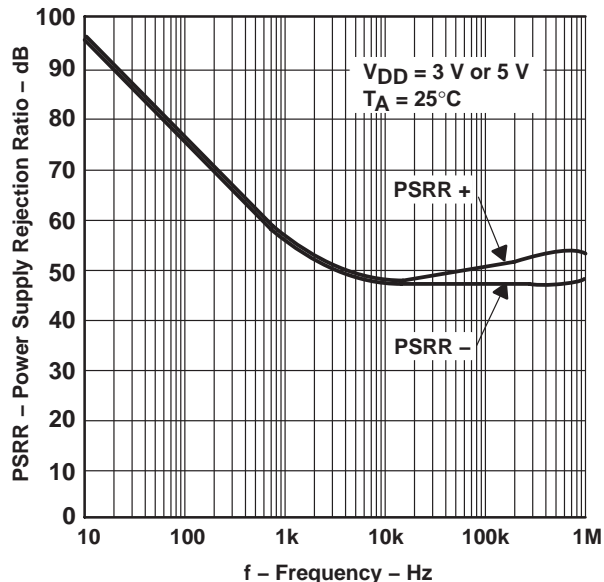


Figure 18

SUPPLY CURRENT
 vs
 SUPPLY VOLTAGE

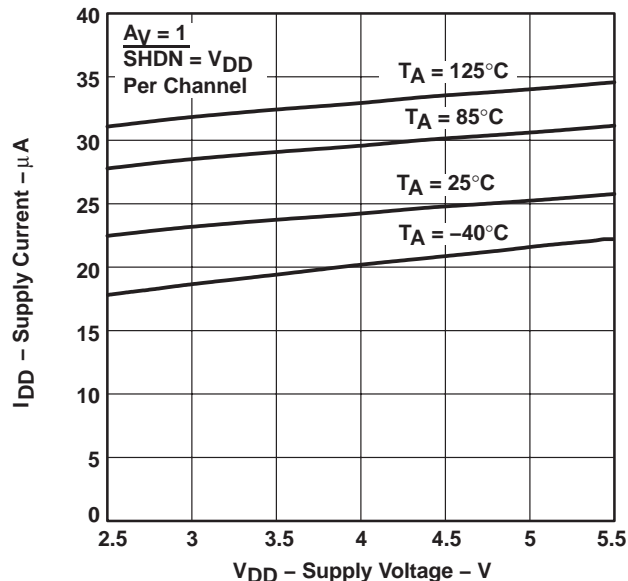


Figure 19

SUPPLY CURRENT
 vs
 FREE-AIR TEMPERATURE

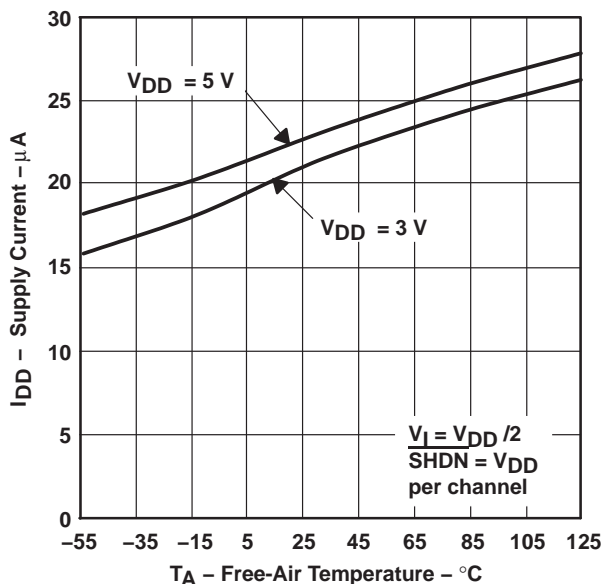


Figure 20

EQUIVALENT INPUT NOISE VOLTAGE
 vs
 FREQUENCY

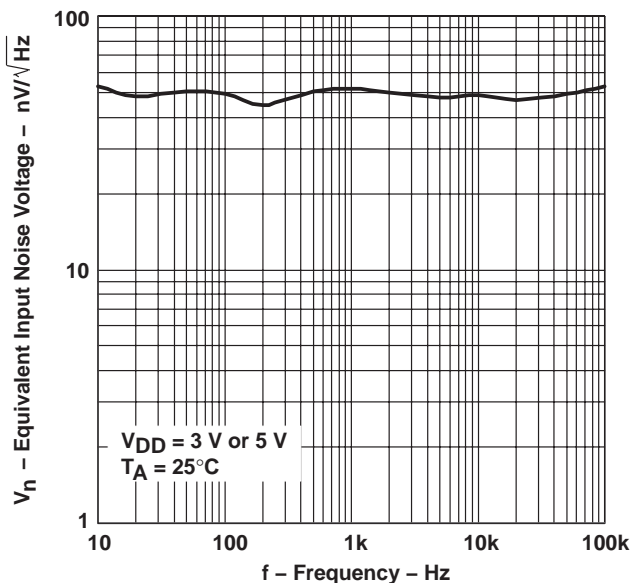


Figure 21



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

FAMILY OF 23- μ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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TYPICAL CHARACTERISTICS

**TOTAL HARMONIC DISTORTION PLUS NOISE
VS
FREQUENCY**

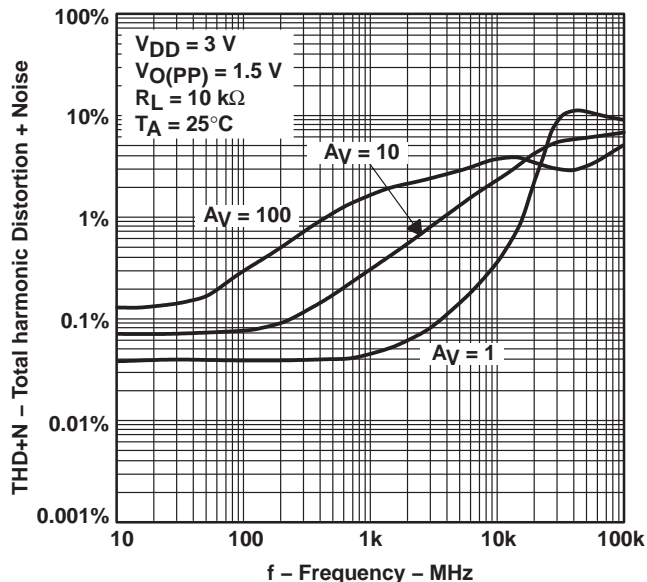


Figure 22

**TOTAL HARMONIC DISTORTION PLUS NOISE
VS
FREQUENCY**

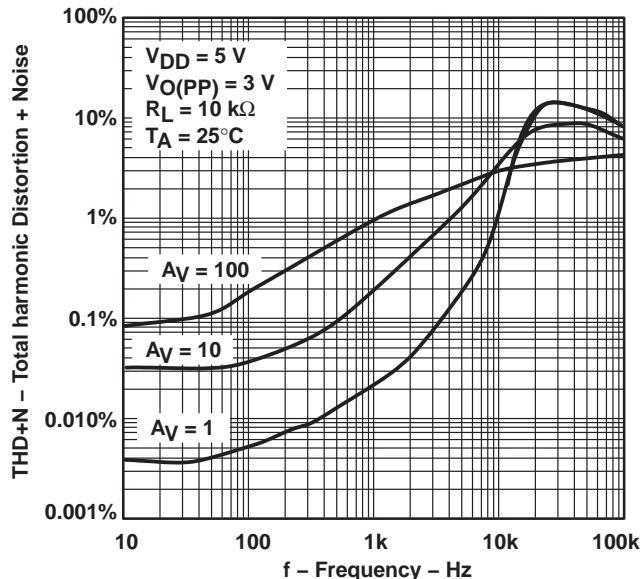


Figure 23

**PHASE MARGIN
VS
LOAD CAPACITANCE**

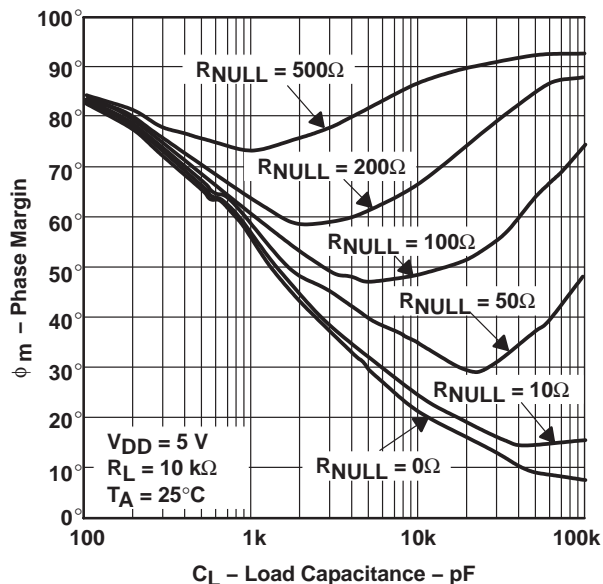


Figure 24

**GAIN-BANDWIDTH PRODUCT
VS
SUPPLY VOLTAGE**

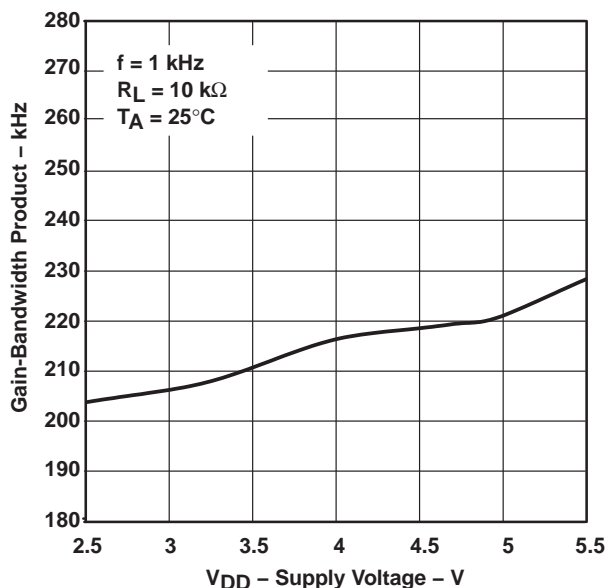


Figure 25



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

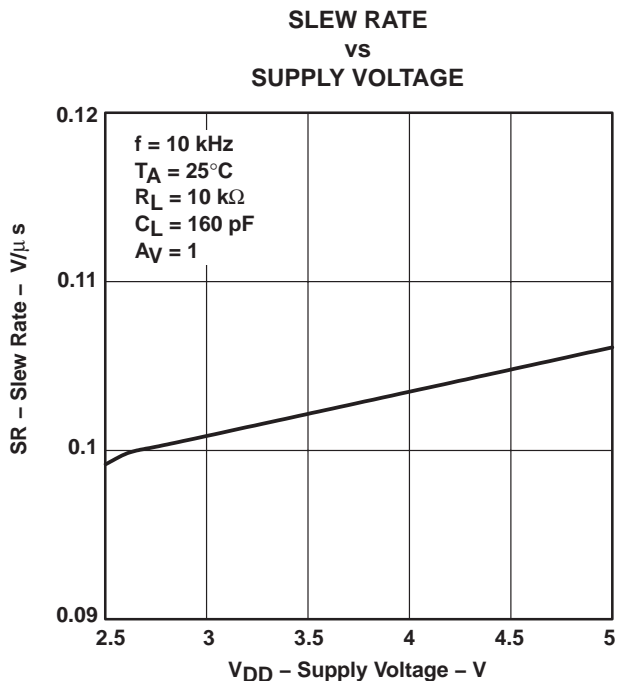


Figure 26

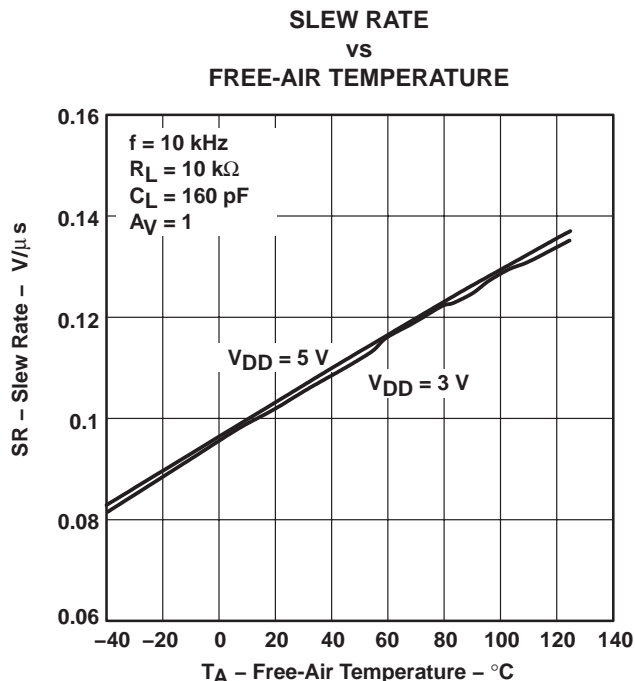


Figure 27

**MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE
vs
FREQUENCY**

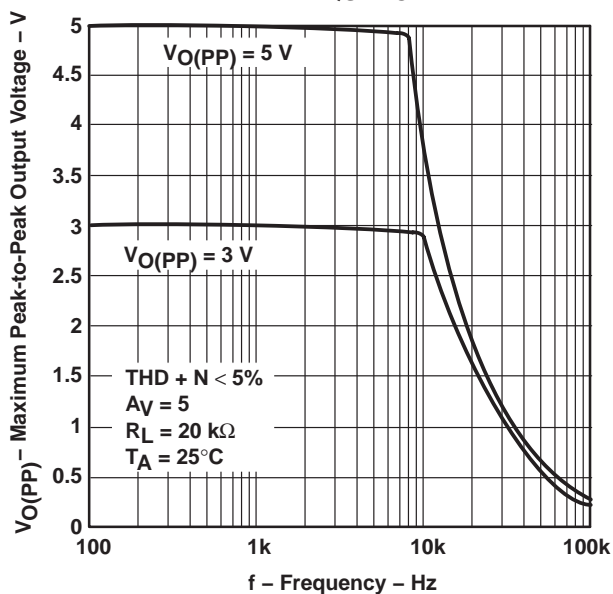


Figure 28

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

CROSSTALK
vs
FREQUENCY

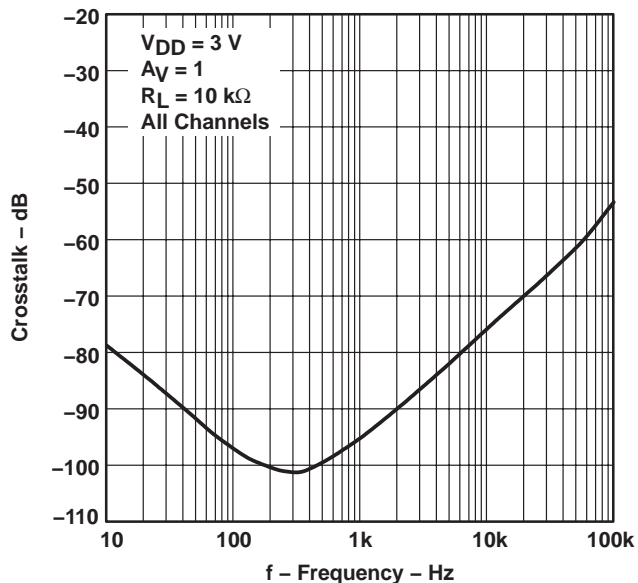


Figure 29

CROSSTALK
vs
FREQUENCY

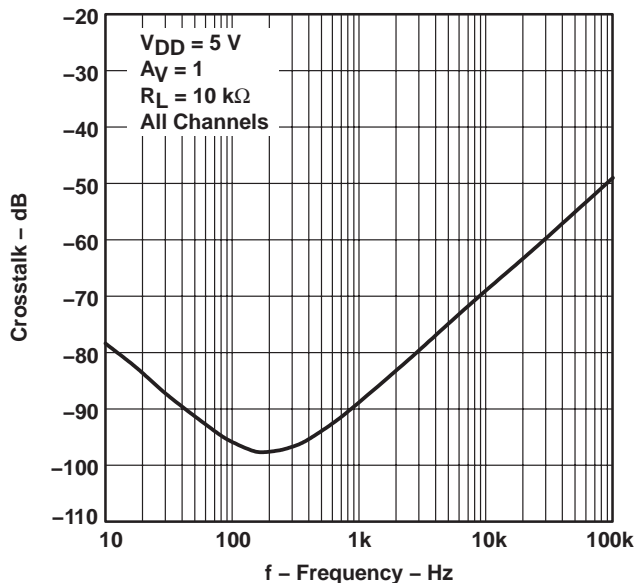


Figure 30

SMALL-SIGNAL FOLLOWER PULSE RESPONSE
vs
TIME

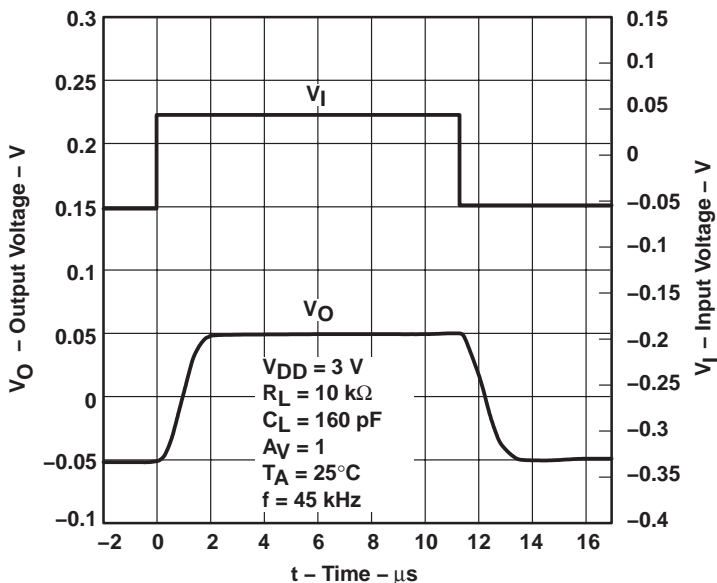


Figure 31



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

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TYPICAL CHARACTERISTICS

LARGE-SIGNAL FOLLOWER PULSE RESPONSE
 vs
 TIME

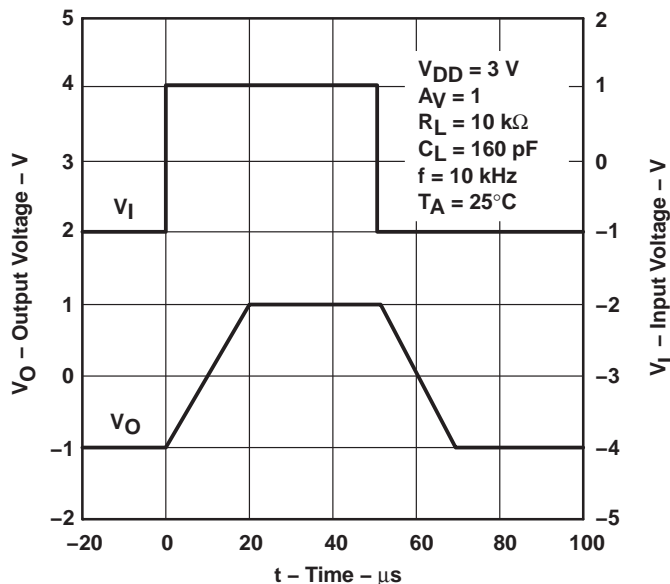


Figure 32

SMALL-SIGNAL FOLLOWER PULSE RESPONSE
 vs
 TIME

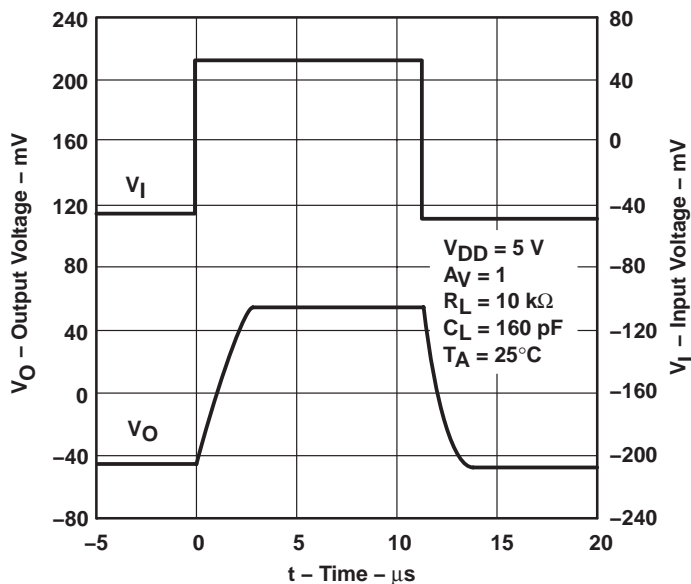


Figure 33

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

LARGE-SIGNAL FOLLOWER PULSE RESPONSE
vs
TIME

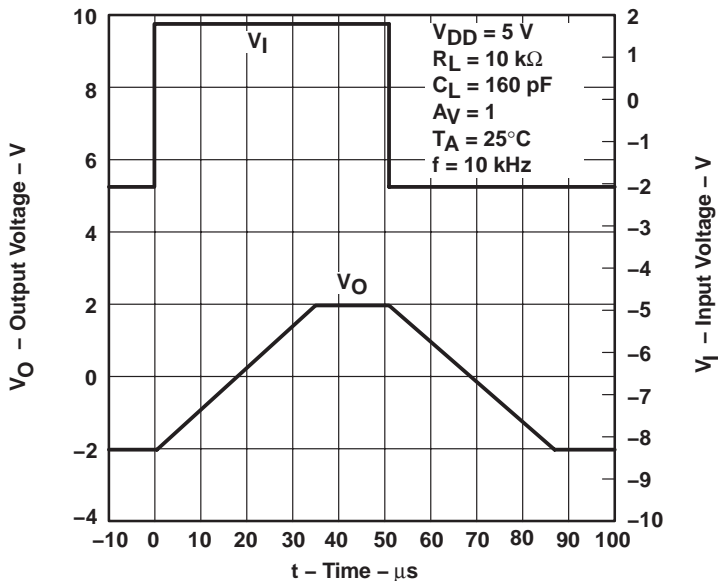


Figure 34

SHUTDOWN ON SUPPLY CURRENT
vs
TIME

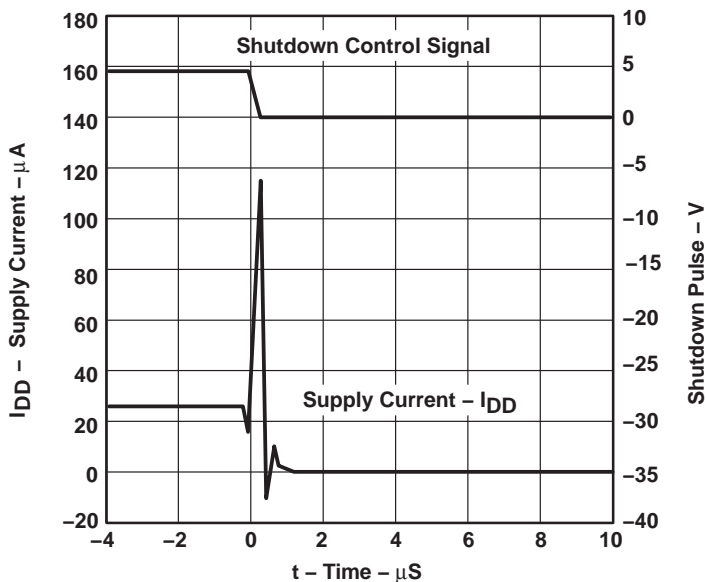


Figure 35



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

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TYPICAL CHARACTERISTICS

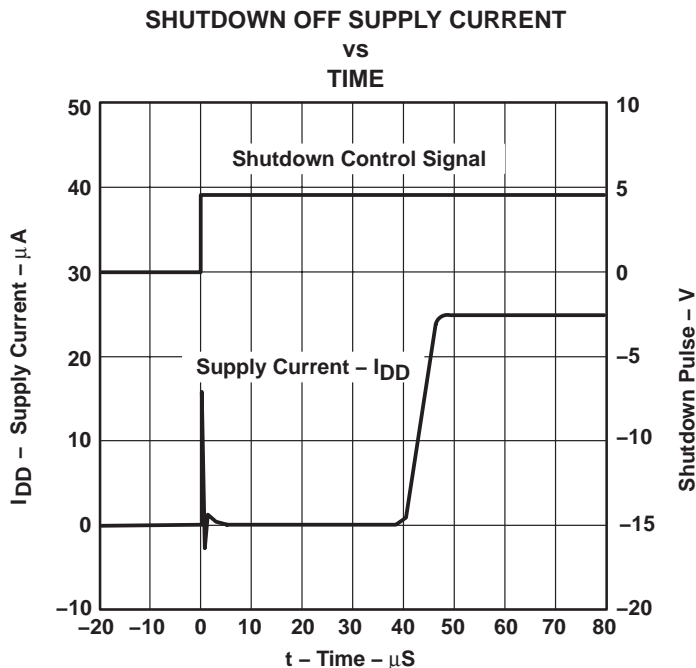


Figure 36

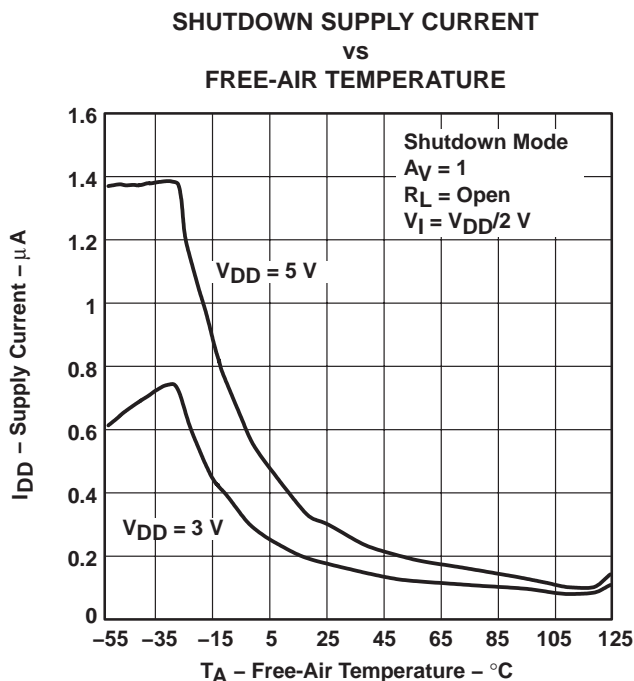


Figure 37



TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA
FAMILY OF 23- μ 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

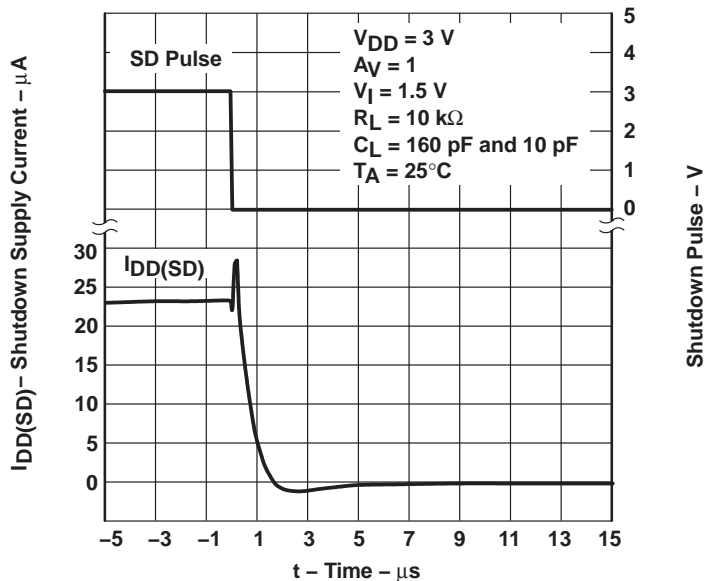


Figure 38

SHUTDOWN SUPPLY CURRENT AND SHUTDOWN PULSE
vs
TIME

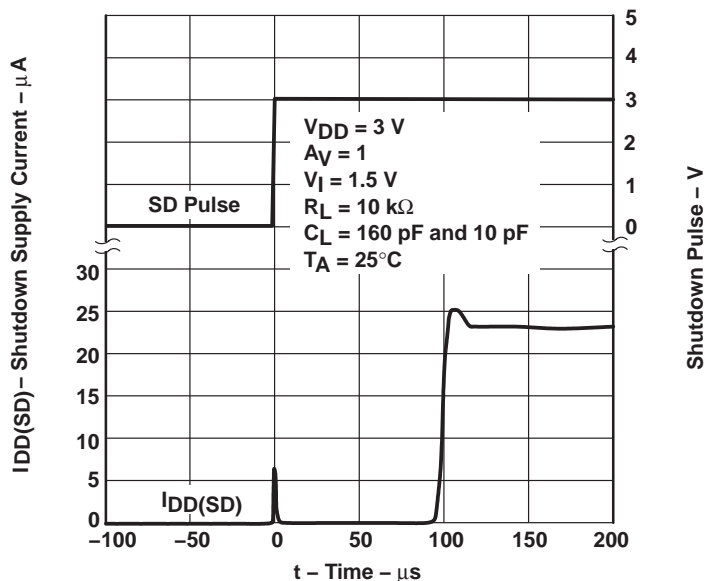


Figure 39



TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA
 FAMILY OF 23- μ 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

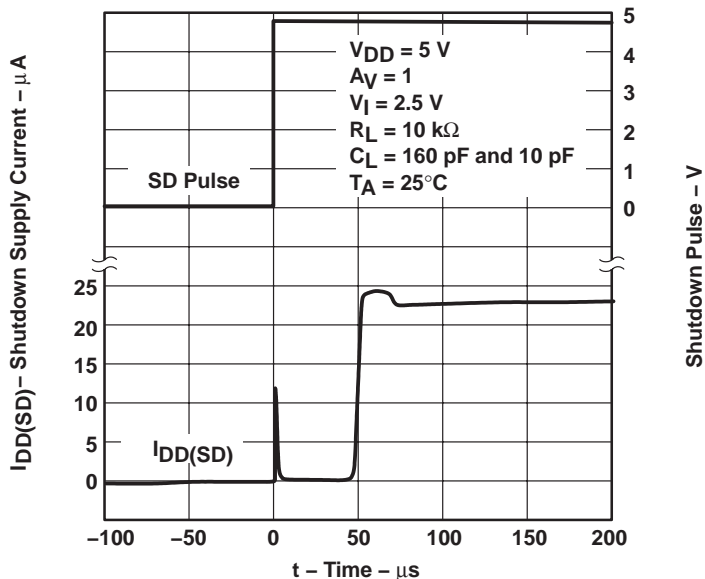


Figure 40

SHUTDOWN SUPPLY CURRENT AND SHUTDOWN PULSE
 vs
 TIME

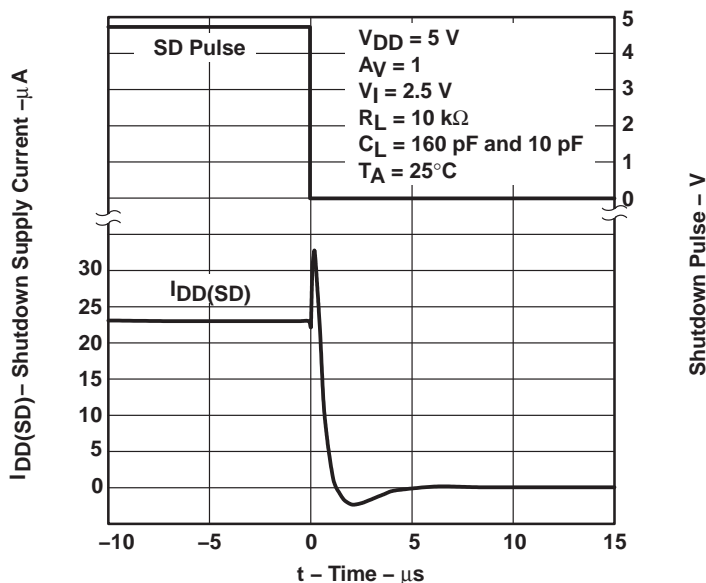


Figure 41

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

SHUTDOWN OFF PULSE RESPONSE
VS
TIME

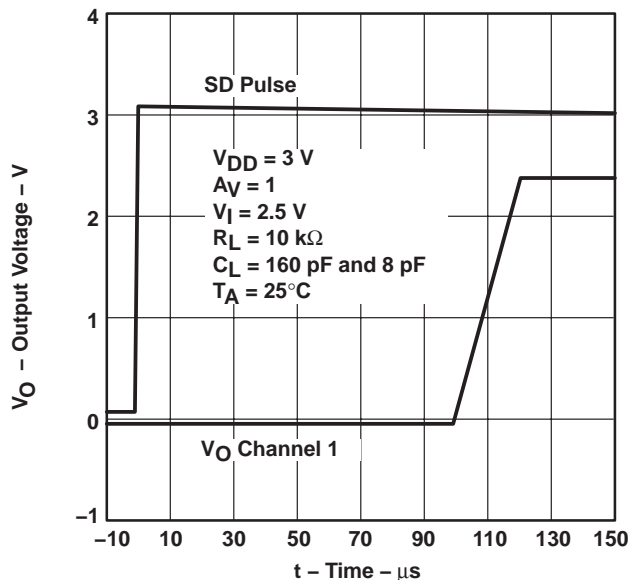


Figure 42

SHUTDOWN OFF PULSE RESPONSE
VS
TIME

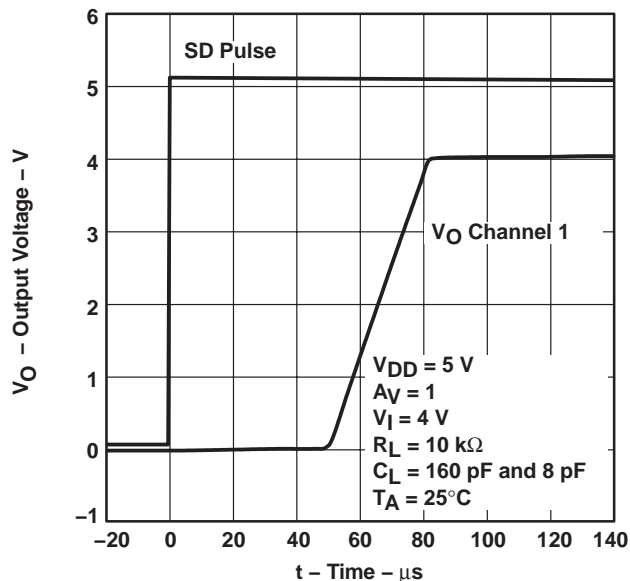


Figure 43

SHUTDOWN ON PULSE RESPONSE
VS
TIME

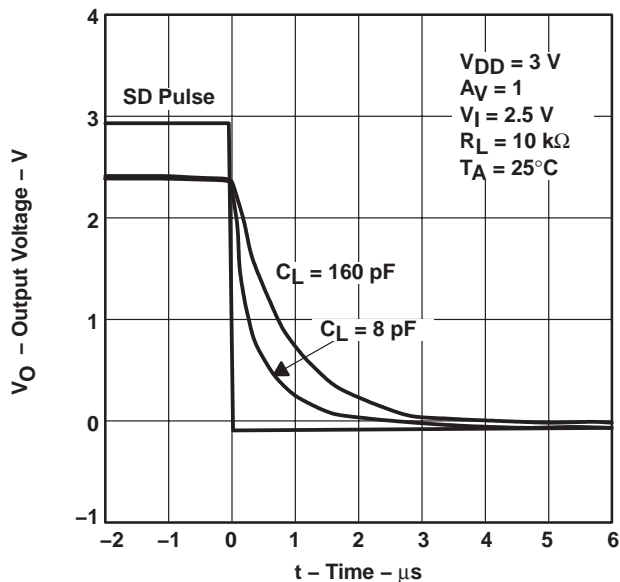


Figure 44

SHUTDOWN ON PULSE RESPONSE
VS
TIME

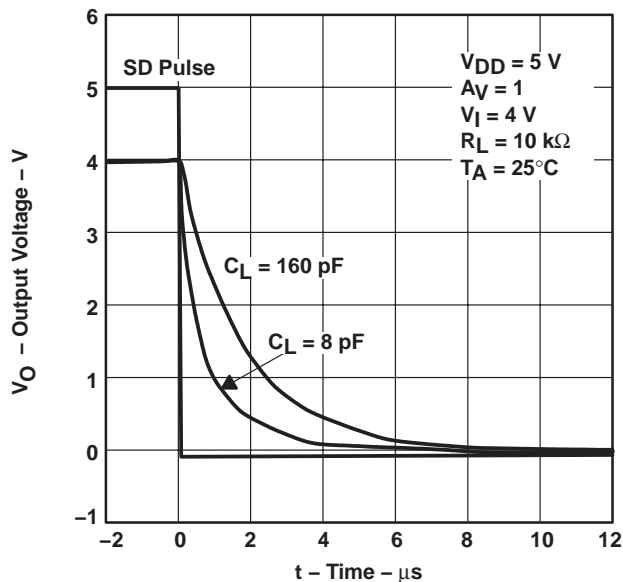


Figure 45

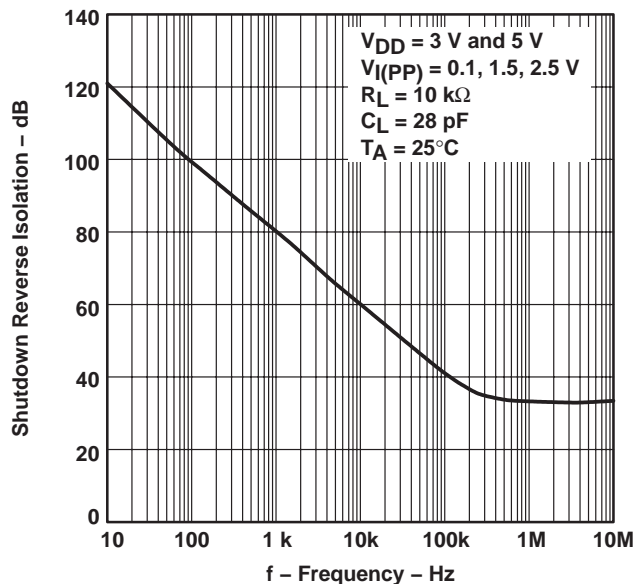


TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA
 FAMILY OF 23- μ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT
 OPERATIONAL AMPLIFIERS WITH SHUTDOWN

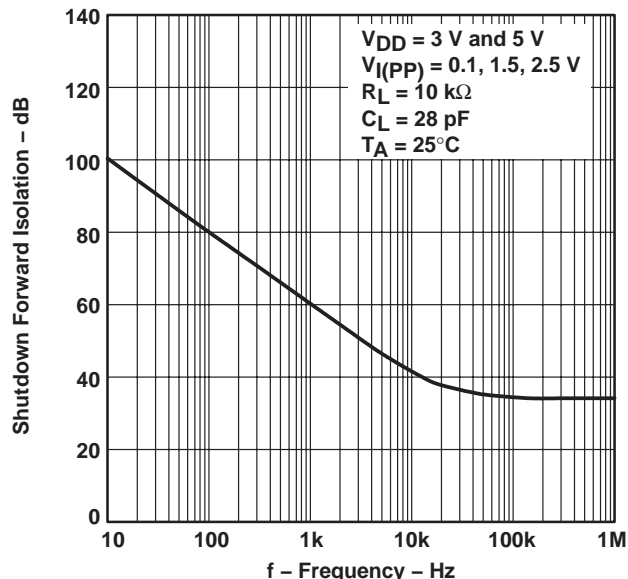
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TYPICAL CHARACTERISTICS

SHUTDOWN REVERSE ISOLATION
 VS
 FREQUENCY



SHUTDOWN FORWARD ISOLATION
 VS
 FREQUENCY



PARAMETER MEASUREMENT INFORMATION

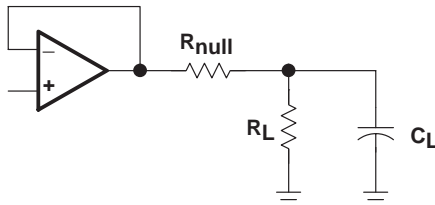


Figure 48

TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA FAMILY OF 23- μ 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. ± 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 ± 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 ± 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 Ω should work well for most applications.

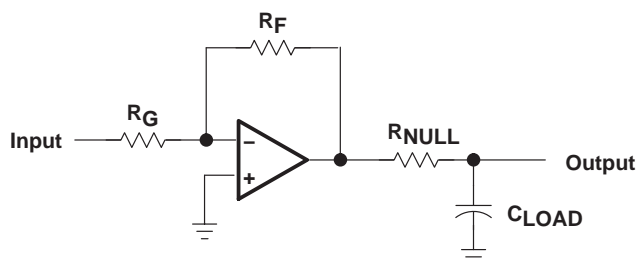


Figure 49. Driving a Capacitive Load

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:

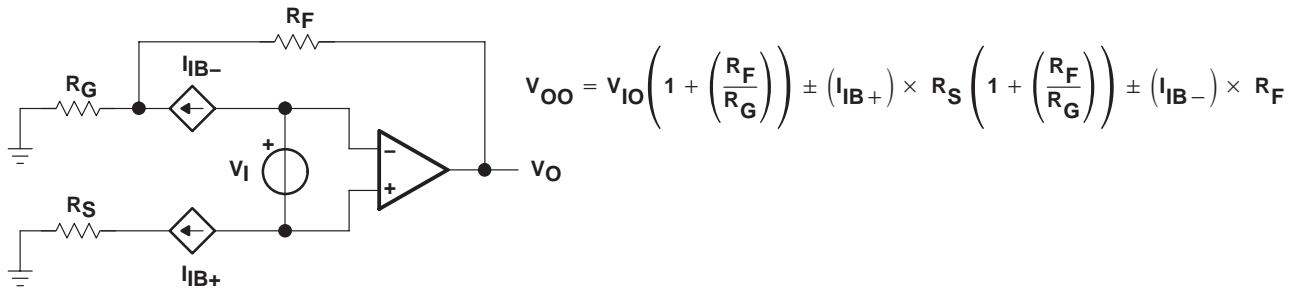


Figure 50. Output Offset Voltage Model

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).

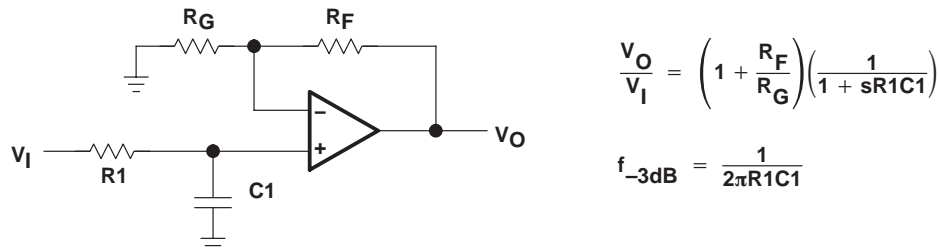


Figure 51. Single-Pole Low-Pass Filter

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.

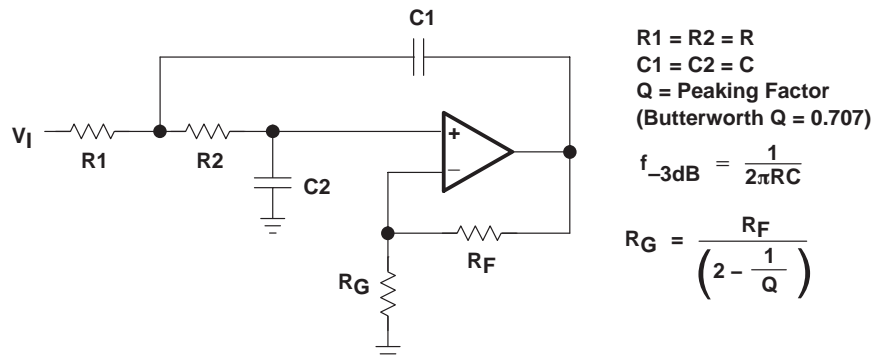


Figure 52. 2-Pole Low-Pass Sallen-Key Filter

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APPLICATION INFORMATION

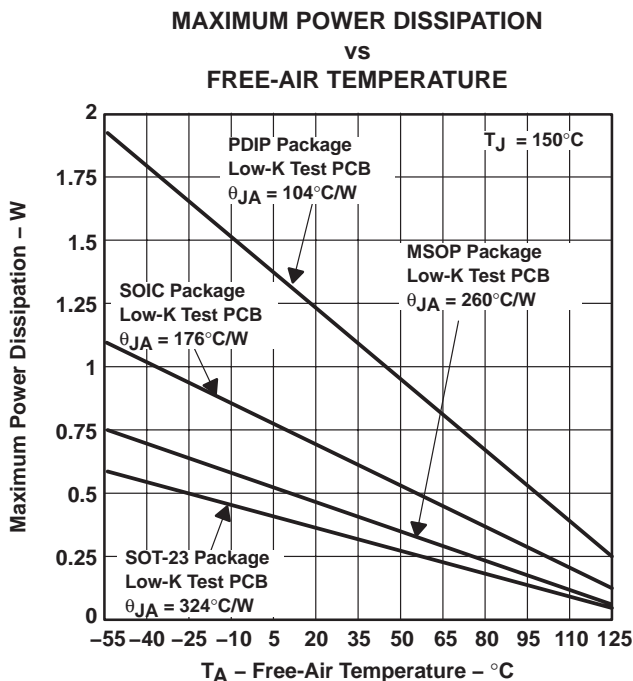
general power dissipation considerations

For a given θ_{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)
- θ_{JA} = $\theta_{JC} + \theta_{CA}$
- θ_{JC} = Thermal coefficient from junction to case
- θ_{CA} = Thermal coefficient from case to ambient air (°C/W)



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

Figure 53. Maximum Power Dissipation vs Free-Air Temperature



TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA FAMILY OF 23- μ A 220-KHz RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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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).

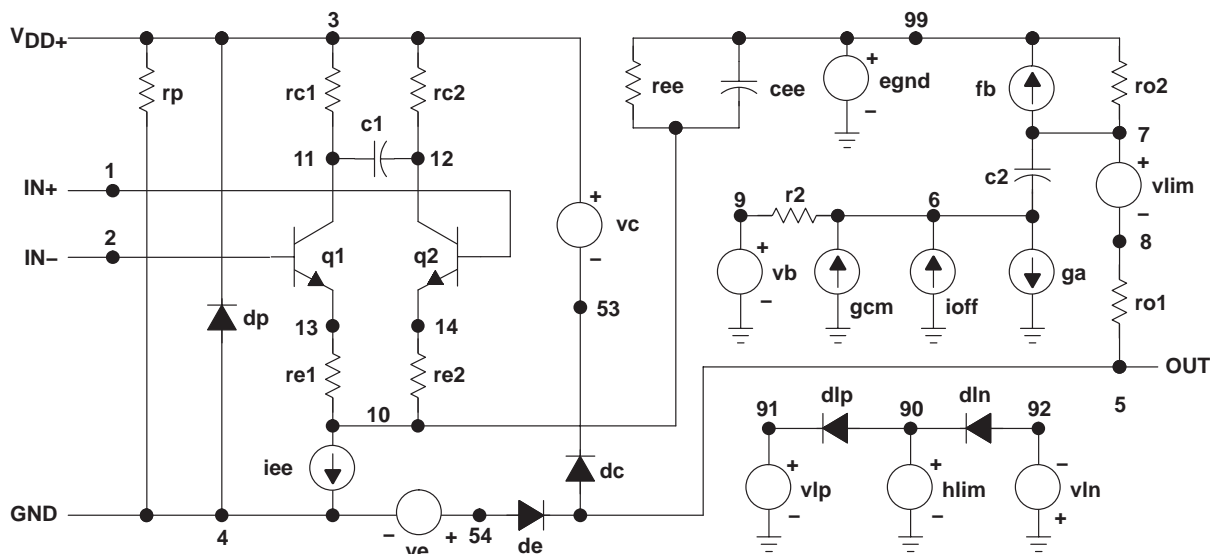
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TLV2450, TLV2451, TLV2452, TLV2453, TLV2454, TLV2455, TLV245xA FAMILY OF 23- μ A 220-kHz RAIL-TO-RAIL INPUT/OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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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 part number | Status (1) | Material type (2) | Package Pins | Package qty Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| TLV2450AIDR | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2450AI |
| TLV2450AIDR.A | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2450AI |
| TLV2450AIP | Active | Production | PDIP (P) 8 | 50 TUBE | Yes | NIPDAU | N/A for Pkg Type | -40 to 125 | TLV2450AI |
| TLV2450AIP.A | Active | Production | PDIP (P) 8 | 50 TUBE | Yes | NIPDAU | N/A for Pkg Type | -40 to 125 | TLV2450AI |
| TLV2450CDBVR | Active | Production | SOT-23 (DBV) 6 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | 0 to 70 | VAQC |
| TLV2450CDBVR.A | Active | Production | SOT-23 (DBV) 6 | 3000 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | 0 to 70 | VAQC |
| TLV2450CDBVT | Obsolete | Production | SOT-23 (DBV) 6 | - | - | Call TI | Call TI | 0 to 70 | VAQC |
| TLV2450CP | Active | Production | PDIP (P) 8 | 50 TUBE | Yes | NIPDAU | N/A for Pkg Type | 0 to 70 | TLV2450C |
| TLV2450CP.A | Active | Production | PDIP (P) 8 | 50 TUBE | Yes | NIPDAU | N/A for Pkg Type | 0 to 70 | TLV2450C |
| TLV2450ID | Active | Production | SOIC (D) 8 | 75 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2450I |
| TLV2450ID.A | Active | Production | SOIC (D) 8 | 75 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2450I |
| TLV2450IDBVR | Active | Production | SOT-23 (DBV) 6 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 125 | VAQI |
| TLV2450IDBVR.A | Active | Production | SOT-23 (DBV) 6 | 3000 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 125 | VAQI |
| TLV2450IDBVT | Active | Production | SOT-23 (DBV) 6 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 125 | VAQI |
| TLV2450IDBVT.A | Active | Production | SOT-23 (DBV) 6 | 250 SMALL T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 125 | VAQI |
| TLV2451AIDR | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2451AI |
| TLV2451AIDR.A | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2451AI |
| TLV2451AIP | Active | Production | PDIP (P) 8 | 50 TUBE | Yes | NIPDAU | N/A for Pkg Type | -40 to 125 | TLV2451AI |
| TLV2451AIP.A | Active | Production | PDIP (P) 8 | 50 TUBE | Yes | NIPDAU | N/A for Pkg Type | -40 to 125 | TLV2451AI |
| TLV2451CD | Active | Production | SOIC (D) 8 | 75 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 2451C |
| TLV2451CD.A | Active | Production | SOIC (D) 8 | 75 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 2451C |
| TLV2451CDBVR | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | 0 to 70 | VARC |
| TLV2451CDBVR.A | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | 0 to 70 | VARC |
| TLV2451CDBVT | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | 0 to 70 | VARC |
| TLV2451CDBVT.A | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | SN | Level-1-260C-UNLIM | 0 to 70 | VARC |
| TLV2451CDG4 | Active | Production | SOIC (D) 8 | 75 TUBE | - | Call TI | Call TI | 0 to 70 | |
| TLV2451CDR | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 2451C |
| TLV2451CDR.A | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 2451C |
| TLV2451CP | Active | Production | PDIP (P) 8 | 50 TUBE | Yes | NIPDAU | N/A for Pkg Type | 0 to 70 | TLV2451C |

| Orderable part number | Status (1) | Material type (2) | Package Pins | Package qty Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| TLV2451CP.A | Active | Production | PDIP (P) 8 | 50 TUBE | Yes | NIPDAU | N/A for Pkg Type | 0 to 70 | TLV2451C |
| TLV2451IDBVR | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 125 | VARI |
| TLV2451IDBVR.A | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 125 | VARI |
| TLV2451IDBVT | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 125 | VARI |
| TLV2451IDBVT.A | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | SN | Level-1-260C-UNLIM | -40 to 125 | VARI |
| TLV2451IDR | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2451I |
| TLV2451IDR.A | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2451I |
| TLV2451IP | Active | Production | PDIP (P) 8 | 50 TUBE | Yes | NIPDAU | N/A for Pkg Type | -40 to 125 | TLV2451I |
| TLV2451IP.A | Active | Production | PDIP (P) 8 | 50 TUBE | Yes | NIPDAU | N/A for Pkg Type | -40 to 125 | TLV2451I |
| TLV2452AID | Active | Production | SOIC (D) 8 | 75 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2452AI |
| TLV2452AID.A | Active | Production | SOIC (D) 8 | 75 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2452AI |
| TLV2452AIDR | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2452AI |
| TLV2452AIDR.A | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2452AI |
| TLV2452AIP | Active | Production | PDIP (P) 8 | 50 TUBE | Yes | NIPDAU | N/A for Pkg Type | -40 to 125 | TLV2452AI |
| TLV2452AIP.A | Active | Production | PDIP (P) 8 | 50 TUBE | Yes | NIPDAU | N/A for Pkg Type | -40 to 125 | TLV2452AI |
| TLV2452CD | Active | Production | SOIC (D) 8 | 75 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 2452C |
| TLV2452CD.A | Active | Production | SOIC (D) 8 | 75 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 2452C |
| TLV2452CDGK | Active | Production | VSSOP (DGK) 8 | 80 TUBE | Yes | NIPDAU NIPDAUAG | Level-1-260C-UNLIM | 0 to 70 | ABI |
| TLV2452CDGK.A | Active | Production | VSSOP (DGK) 8 | 80 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | ABI |
| TLV2452CDGKR | Active | Production | VSSOP (DGK) 8 | 2500 LARGE T&R | Yes | NIPDAU NIPDAUAG | Level-1-260C-UNLIM | 0 to 70 | ABI |
| TLV2452CDGKR.A | Active | Production | VSSOP (DGK) 8 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | ABI |
| TLV2452CDR | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 2452C |
| TLV2452CDR.A | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | 2452C |
| TLV2452ID | Active | Production | SOIC (D) 8 | 75 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2452I |
| TLV2452ID.A | Active | Production | SOIC (D) 8 | 75 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2452I |
| TLV2452IDGK | Active | Production | VSSOP (DGK) 8 | 80 TUBE | Yes | NIPDAU NIPDAUAG | Level-1-260C-UNLIM | -40 to 125 | ABJ |
| TLV2452IDGK.A | Active | Production | VSSOP (DGK) 8 | 80 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | ABJ |
| TLV2452IDGKR | Active | Production | VSSOP (DGK) 8 | 2500 LARGE T&R | Yes | NIPDAU NIPDAUAG | Level-1-260C-UNLIM | -40 to 125 | ABJ |
| TLV2452IDGKR.A | Active | Production | VSSOP (DGK) 8 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | ABJ |
| TLV2452IDGKRG4 | Active | Production | VSSOP (DGK) 8 | 2500 LARGE T&R | - | Call TI | Call TI | -40 to 125 | |
| TLV2452IDR | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2452I |

| Orderable part number | Status (1) | Material type (2) | Package Pins | Package qty Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| TLV2452IDR.A | Active | Production | SOIC (D) 8 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2452I |
| TLV2452IP | Active | Production | PDIP (P) 8 | 50 TUBE | Yes | NIPDAU | N/A for Pkg Type | -40 to 125 | TLV2452IP |
| TLV2452IP.A | Active | Production | PDIP (P) 8 | 50 TUBE | Yes | NIPDAU | N/A for Pkg Type | -40 to 125 | TLV2452IP |
| TLV2453CDGSR | Active | Production | VSSOP (DGS) 10 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | ABK |
| TLV2453CDGSR.A | Active | Production | VSSOP (DGS) 10 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | ABK |
| TLV2453CDR | Active | Production | SOIC (D) 14 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | TLV2453C |
| TLV2453CDR.A | Active | Production | SOIC (D) 14 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | TLV2453C |
| TLV2453IDGSR | Active | Production | VSSOP (DGS) 10 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | ABL |
| TLV2453IDGSR.A | Active | Production | VSSOP (DGS) 10 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | ABL |
| TLV2454AID | Active | Production | SOIC (D) 14 | 50 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2454AI |
| TLV2454AID.A | Active | Production | SOIC (D) 14 | 50 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2454AI |
| TLV2454AIDR | Active | Production | SOIC (D) 14 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2454AI |
| TLV2454AIDR.A | Active | Production | SOIC (D) 14 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2454AI |
| TLV2454AIN | Active | Production | PDIP (N) 14 | 25 TUBE | Yes | NIPDAU | N/A for Pkg Type | -40 to 125 | TLV2454AI |
| TLV2454AIN.A | Active | Production | PDIP (N) 14 | 25 TUBE | Yes | NIPDAU | N/A for Pkg Type | -40 to 125 | TLV2454AI |
| TLV2454AIPW | Obsolete | Production | TSSOP (PW) 14 | - | - | Call TI | Call TI | - | TY2454A |
| TLV2454AIPWR | Active | Production | TSSOP (PW) 14 | 2000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TY2454A |
| TLV2454AIPWR.A | Active | Production | TSSOP (PW) 14 | 2000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TY2454A |
| TLV2454CD | Obsolete | Production | SOIC (D) 14 | - | - | Call TI | Call TI | 0 to 70 | 2454C |
| TLV2454CN | Active | Production | PDIP (N) 14 | 25 TUBE | Yes | NIPDAU | N/A for Pkg Type | 0 to 70 | TLV2454C |
| TLV2454CN.A | Active | Production | PDIP (N) 14 | 25 TUBE | Yes | NIPDAU | N/A for Pkg Type | 0 to 70 | TLV2454C |
| TLV2454CPW | Active | Production | TSSOP (PW) 14 | 90 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | TV2454 |
| TLV2454CPW.A | Active | Production | TSSOP (PW) 14 | 90 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | TV2454 |
| TLV2454CPWR | Active | Production | TSSOP (PW) 14 | 2000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | TV2454 |
| TLV2454CPWR.A | Active | Production | TSSOP (PW) 14 | 2000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | 0 to 70 | TV2454 |
| TLV2454ID | Active | Production | SOIC (D) 14 | 50 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2454I |
| TLV2454ID.A | Active | Production | SOIC (D) 14 | 50 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2454I |
| TLV2454IDR | Active | Production | SOIC (D) 14 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2454I |
| TLV2454IDR.A | Active | Production | SOIC (D) 14 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 2454I |
| TLV2454IN | Active | Production | PDIP (N) 14 | 25 TUBE | Yes | NIPDAU | N/A for Pkg Type | -40 to 125 | TLV2454I |
| TLV2454IN.A | Active | Production | PDIP (N) 14 | 25 TUBE | Yes | NIPDAU | N/A for Pkg Type | -40 to 125 | TLV2454I |

| Orderable part number | Status (1) | Material type (2) | Package Pins | Package qty Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|------------------------------|---------------|----------------------|-----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| TLV2454IPW | Active | Production | TSSOP (PW) 14 | 90 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TY2454 |
| TLV2454IPW.A | Active | Production | TSSOP (PW) 14 | 90 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TY2454 |
| TLV2454IPWR | Active | Production | TSSOP (PW) 14 | 2000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TY2454 |
| TLV2454IPWR.A | Active | Production | TSSOP (PW) 14 | 2000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TY2454 |
| TLV2455AID | Active | Production | SOIC (D) 16 | 40 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TLV2455AI |
| TLV2455AID.A | Active | Production | SOIC (D) 16 | 40 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TLV2455AI |
| TLV2455AIDR | Active | Production | SOIC (D) 16 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TLV2455AI |
| TLV2455AIDR.A | Active | Production | SOIC (D) 16 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TLV2455AI |
| TLV2455AIN | Active | Production | PDIP (N) 16 | 25 TUBE | Yes | NIPDAU | N/A for Pkg Type | -40 to 125 | TLV2455AI |
| TLV2455AIN.A | Active | Production | PDIP (N) 16 | 25 TUBE | Yes | NIPDAU | N/A for Pkg Type | -40 to 125 | TLV2455AI |
| TLV2455AIPWR | Active | Production | TSSOP (PW) 16 | 2000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TY2455A |
| TLV2455AIPWR.A | Active | Production | TSSOP (PW) 16 | 2000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TY2455A |
| TLV2455IDR | Active | Production | SOIC (D) 16 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TLV2455I |
| TLV2455IDR.A | Active | Production | SOIC (D) 16 | 2500 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TLV2455I |
| TLV2455IPW | Active | Production | TSSOP (PW) 16 | 90 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TY2455 |
| TLV2455IPW.A | Active | Production | TSSOP (PW) 16 | 90 TUBE | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | TY2455 |

(1) **Status:** For more details on status, see our [product life cycle](#).

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

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

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "-" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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

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TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| 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 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV2450IDBVR | SOT-23 | DBV | 6 | 3000 | 180.0 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV2450IDBVT | SOT-23 | DBV | 6 | 250 | 180.0 | 8.4 | 3.2 | 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 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV2451CDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 8.4 | 3.2 | 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 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TLV2451IDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 8.4 | 3.2 | 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 |
| 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 |
| TLV2452IDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 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 |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| 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 | 210.0 | 185.0 | 35.0 |
| TLV2450IDBVR | SOT-23 | DBV | 6 | 3000 | 210.0 | 185.0 | 35.0 |
| TLV2450IDBVT | SOT-23 | DBV | 6 | 250 | 210.0 | 185.0 | 35.0 |
| TLV2451AIDR | SOIC | D | 8 | 2500 | 353.0 | 353.0 | 32.0 |
| TLV2451CDBVR | SOT-23 | DBV | 5 | 3000 | 210.0 | 185.0 | 35.0 |
| TLV2451CDBVT | SOT-23 | DBV | 5 | 250 | 210.0 | 185.0 | 35.0 |
| TLV2451CDR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| TLV2451IDBVR | SOT-23 | DBV | 5 | 3000 | 210.0 | 185.0 | 35.0 |
| TLV2451IDBVT | SOT-23 | DBV | 5 | 250 | 210.0 | 185.0 | 35.0 |
| TLV2451IDR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| TLV2452AIDR | SOIC | D | 8 | 2500 | 353.0 | 353.0 | 32.0 |
| TLV2452CDGKR | VSSOP | DGK | 8 | 2500 | 358.0 | 335.0 | 35.0 |
| TLV2452CDR | SOIC | D | 8 | 2500 | 353.0 | 353.0 | 32.0 |
| TLV2452IDGKR | VSSOP | DGK | 8 | 2500 | 358.0 | 335.0 | 35.0 |
| TLV2452IDR | SOIC | D | 8 | 2500 | 353.0 | 353.0 | 32.0 |
| TLV2453CDGSR | VSSOP | DGS | 10 | 2500 | 358.0 | 335.0 | 35.0 |
| TLV2453CDR | SOIC | D | 14 | 2500 | 350.0 | 350.0 | 43.0 |

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| 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 | 353.0 | 353.0 | 32.0 |
| TLV2454CPWR | TSSOP | PW | 14 | 2000 | 353.0 | 353.0 | 32.0 |
| TLV2454IDR | SOIC | D | 14 | 2500 | 350.0 | 350.0 | 43.0 |
| TLV2454IPWR | TSSOP | PW | 14 | 2000 | 353.0 | 353.0 | 32.0 |
| TLV2455AIDR | SOIC | D | 16 | 2500 | 350.0 | 350.0 | 43.0 |
| TLV2455AIPWR | TSSOP | PW | 16 | 2000 | 353.0 | 353.0 | 32.0 |
| TLV2455IDR | SOIC | D | 16 | 2500 | 350.0 | 350.0 | 43.0 |

TUBE


*All dimensions are nominal

| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (µm) | B (mm) |
|--------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| TLV2450AIP | P | PDIP | 8 | 50 | 506 | 13.97 | 11230 | 4.32 |
| TLV2450AIP.A | P | PDIP | 8 | 50 | 506 | 13.97 | 11230 | 4.32 |
| TLV2450CP | P | PDIP | 8 | 50 | 506 | 13.97 | 11230 | 4.32 |
| TLV2450CP.A | P | PDIP | 8 | 50 | 506 | 13.97 | 11230 | 4.32 |
| TLV2450ID | D | SOIC | 8 | 75 | 507 | 8 | 3940 | 4.32 |
| TLV2450ID | D | SOIC | 8 | 75 | 505.46 | 6.76 | 3810 | 4 |
| TLV2450ID.A | D | SOIC | 8 | 75 | 505.46 | 6.76 | 3810 | 4 |
| TLV2450ID.A | D | SOIC | 8 | 75 | 507 | 8 | 3940 | 4.32 |
| TLV2451AIP | P | PDIP | 8 | 50 | 506 | 13.97 | 11230 | 4.32 |
| TLV2451AIP.A | P | PDIP | 8 | 50 | 506 | 13.97 | 11230 | 4.32 |
| TLV2451CD | D | SOIC | 8 | 75 | 507 | 8 | 3940 | 4.32 |
| TLV2451CD | D | SOIC | 8 | 75 | 505.46 | 6.76 | 3810 | 4 |
| TLV2451CD.A | D | SOIC | 8 | 75 | 505.46 | 6.76 | 3810 | 4 |
| TLV2451CD.A | D | SOIC | 8 | 75 | 507 | 8 | 3940 | 4.32 |
| TLV2451CP | P | PDIP | 8 | 50 | 506 | 13.97 | 11230 | 4.32 |
| TLV2451CP.A | P | PDIP | 8 | 50 | 506 | 13.97 | 11230 | 4.32 |
| TLV2451IP | P | PDIP | 8 | 50 | 506 | 13.97 | 11230 | 4.32 |
| TLV2451IP.A | P | PDIP | 8 | 50 | 506 | 13.97 | 11230 | 4.32 |
| TLV2452AID | D | SOIC | 8 | 75 | 505.46 | 6.76 | 3810 | 4 |
| TLV2452AID | D | SOIC | 8 | 75 | 507 | 8 | 3940 | 4.32 |
| TLV2452AID.A | D | SOIC | 8 | 75 | 507 | 8 | 3940 | 4.32 |
| TLV2452AID.A | D | SOIC | 8 | 75 | 505.46 | 6.76 | 3810 | 4 |
| TLV2452AIP | P | PDIP | 8 | 50 | 506 | 13.97 | 11230 | 4.32 |
| TLV2452AIP.A | P | PDIP | 8 | 50 | 506 | 13.97 | 11230 | 4.32 |
| TLV2452CD | D | SOIC | 8 | 75 | 505.46 | 6.76 | 3810 | 4 |
| TLV2452CD | D | SOIC | 8 | 75 | 507 | 8 | 3940 | 4.32 |
| TLV2452CD.A | D | SOIC | 8 | 75 | 505.46 | 6.76 | 3810 | 4 |
| TLV2452CD.A | D | SOIC | 8 | 75 | 507 | 8 | 3940 | 4.32 |
| TLV2452CDGK | DGK | VSSOP | 8 | 80 | 330 | 6.55 | 500 | 2.88 |

| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (µm) | B (mm) |
|---------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| TLV2452CDGK.A | DGK | VSSOP | 8 | 80 | 330 | 6.55 | 500 | 2.88 |
| TLV2452ID | D | SOIC | 8 | 75 | 507 | 8 | 3940 | 4.32 |
| TLV2452ID | D | SOIC | 8 | 75 | 505.46 | 6.76 | 3810 | 4 |
| TLV2452ID.A | D | SOIC | 8 | 75 | 505.46 | 6.76 | 3810 | 4 |
| TLV2452ID.A | D | SOIC | 8 | 75 | 507 | 8 | 3940 | 4.32 |
| TLV2452IDGK | DGK | VSSOP | 8 | 80 | 330 | 6.55 | 500 | 2.88 |
| TLV2452IDGK.A | DGK | VSSOP | 8 | 80 | 330 | 6.55 | 500 | 2.88 |
| TLV2452IP | P | PDIP | 8 | 50 | 506 | 13.97 | 11230 | 4.32 |
| TLV2452IP.A | P | PDIP | 8 | 50 | 506 | 13.97 | 11230 | 4.32 |
| TLV2454AID | D | SOIC | 14 | 50 | 505.46 | 6.76 | 3810 | 4 |
| TLV2454AID.A | D | SOIC | 14 | 50 | 505.46 | 6.76 | 3810 | 4 |
| TLV2454AIN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| TLV2454AIN.A | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| TLV2454CN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| TLV2454CN.A | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| TLV2454CPW | PW | TSSOP | 14 | 90 | 530 | 10.2 | 3600 | 3.5 |
| TLV2454CPW.A | PW | TSSOP | 14 | 90 | 530 | 10.2 | 3600 | 3.5 |
| TLV2454ID | D | SOIC | 14 | 50 | 505.46 | 6.76 | 3810 | 4 |
| TLV2454ID.A | D | SOIC | 14 | 50 | 505.46 | 6.76 | 3810 | 4 |
| TLV2454IN | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| TLV2454IN.A | N | PDIP | 14 | 25 | 506 | 13.97 | 11230 | 4.32 |
| TLV2454IPW | PW | TSSOP | 14 | 90 | 530 | 10.2 | 3600 | 3.5 |
| TLV2454IPW.A | PW | TSSOP | 14 | 90 | 530 | 10.2 | 3600 | 3.5 |
| TLV2455AID | D | SOIC | 16 | 40 | 505.46 | 6.76 | 3810 | 4 |
| TLV2455AID.A | D | SOIC | 16 | 40 | 505.46 | 6.76 | 3810 | 4 |
| TLV2455AIN | N | PDIP | 16 | 25 | 506 | 13.97 | 11230 | 4.32 |
| TLV2455AIN.A | N | PDIP | 16 | 25 | 506 | 13.97 | 11230 | 4.32 |
| TLV2455IPW | PW | TSSOP | 16 | 90 | 530 | 10.2 | 3600 | 3.5 |
| TLV2455IPW.A | PW | TSSOP | 16 | 90 | 530 | 10.2 | 3600 | 3.5 |

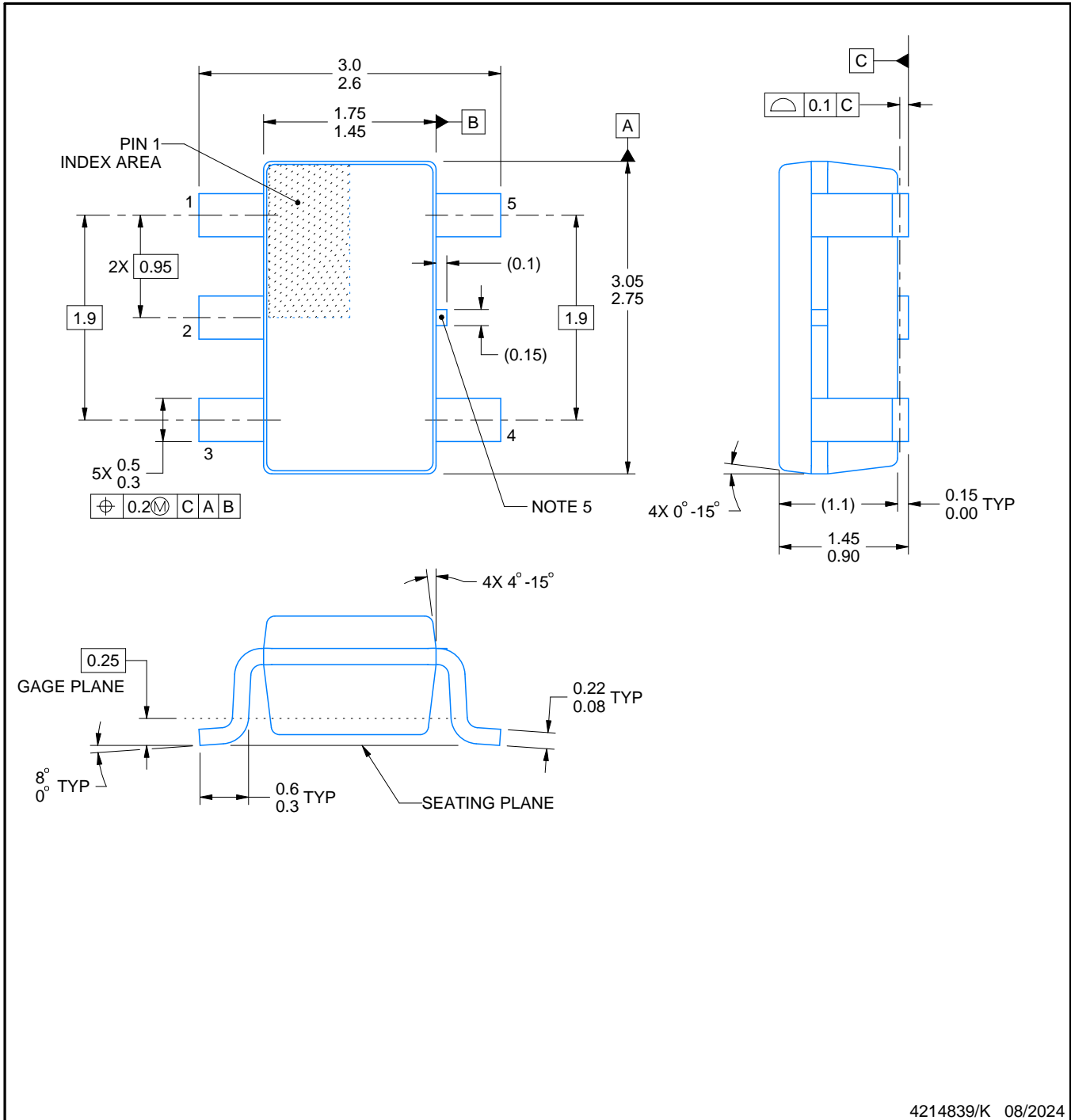
DBV0005A



PACKAGE OUTLINE

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



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 0.25 mm per side.
5. Support pin may differ or may not be present.

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/K 08/2024

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

DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



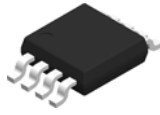
SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:15X

4214839/K 08/2024

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.

DGK0008A



PACKAGE OUTLINE

VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



4214862/A 04/2023

NOTES:

PowerPAD is a trademark of Texas Instruments.

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.

EXAMPLE BOARD LAYOUT

DGK0008A

™ VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 15X



SOLDER MASK DETAILS

4214862/A 04/2023

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.
8. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.
9. Size of metal pad may vary due to creepage requirement.

EXAMPLE STENCIL DESIGN

DGK0008A

™ VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE
SCALE: 15X

4214862/A 04/2023

NOTES: (continued)

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



D0014A

PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



4220718/A 09/2016

NOTES:

1. All linear dimensions are in millimeters. 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 0.43 mm, per side.
5. Reference JEDEC registration MS-012, variation AB.

EXAMPLE BOARD LAYOUT

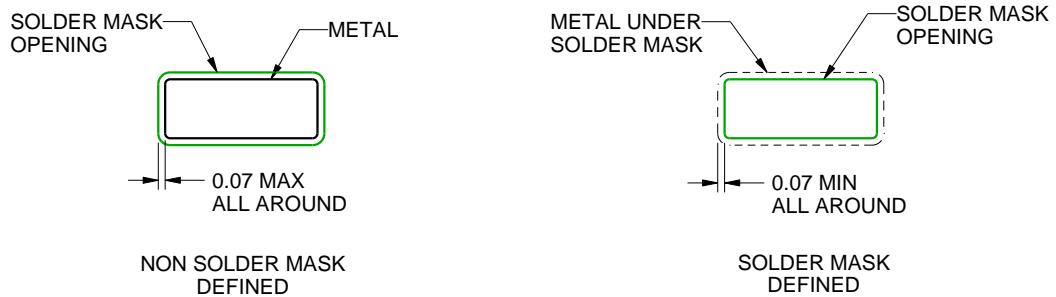
D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE
SCALE:8X



SOLDER MASK DETAILS

4220718/A 09/2016

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

D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:8X

4220718/A 09/2016

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.

DGS0010A



PACKAGE OUTLINE

VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE



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

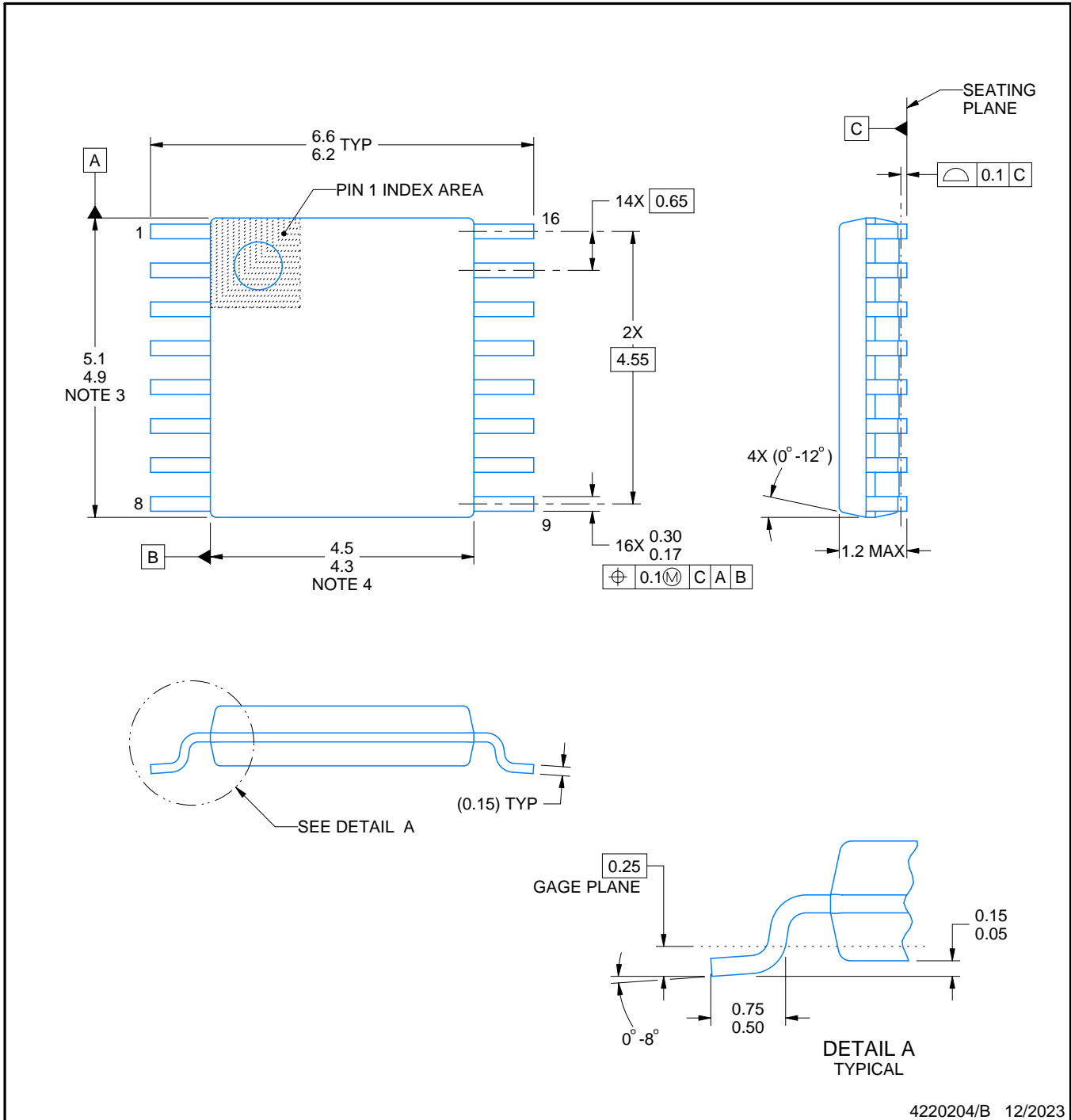
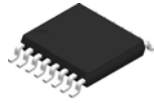


SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:10X

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.



4220204/B 12/2023

NOTES:

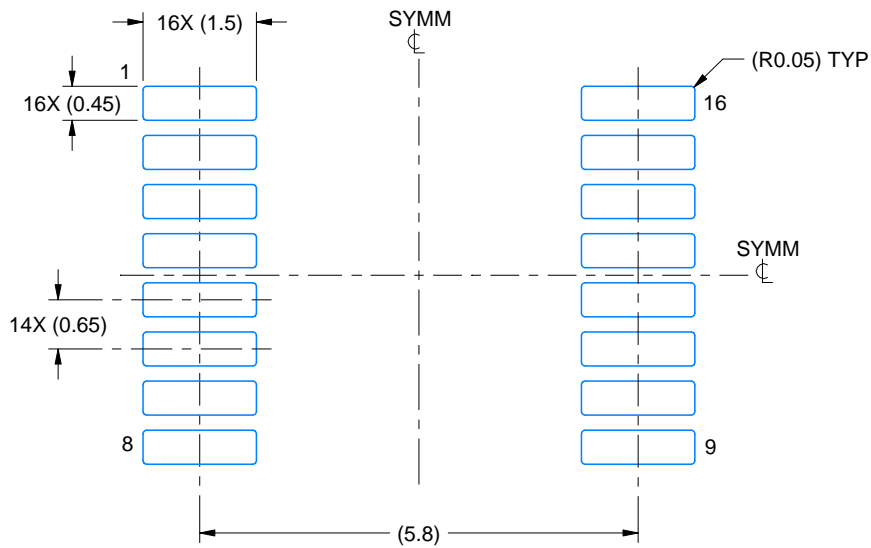
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or 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

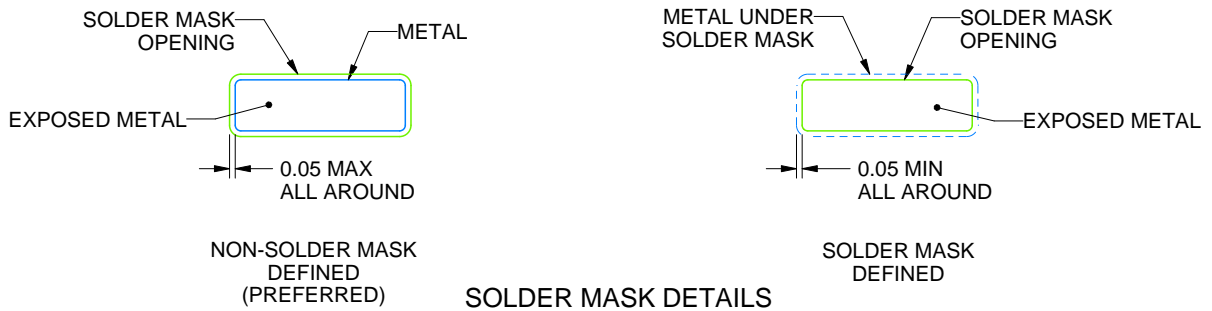
PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



SOLDER MASK DETAILS

4220204/B 12/2023

NOTES: (continued)

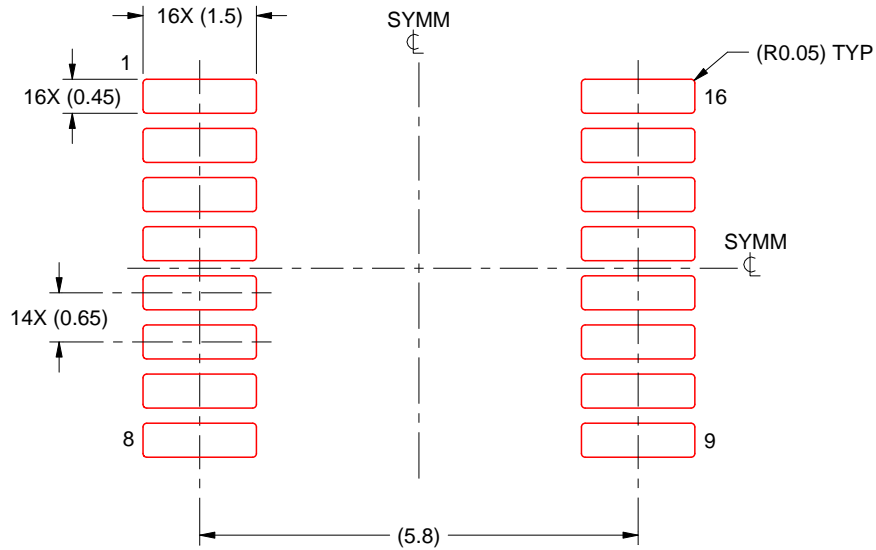
- 6. Publication IPC-7351 may have alternate designs.
- 7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



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

4220204/B 12/2023

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.



D0008A

PACKAGE OUTLINE

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



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



LAND PATTERN EXAMPLE
 EXPOSED METAL SHOWN
 SCALE:8X



SOLDER MASK DETAILS

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**)

PLASTIC DUAL-IN-LINE PACKAGE

16 PINS SHOWN



- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - 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.

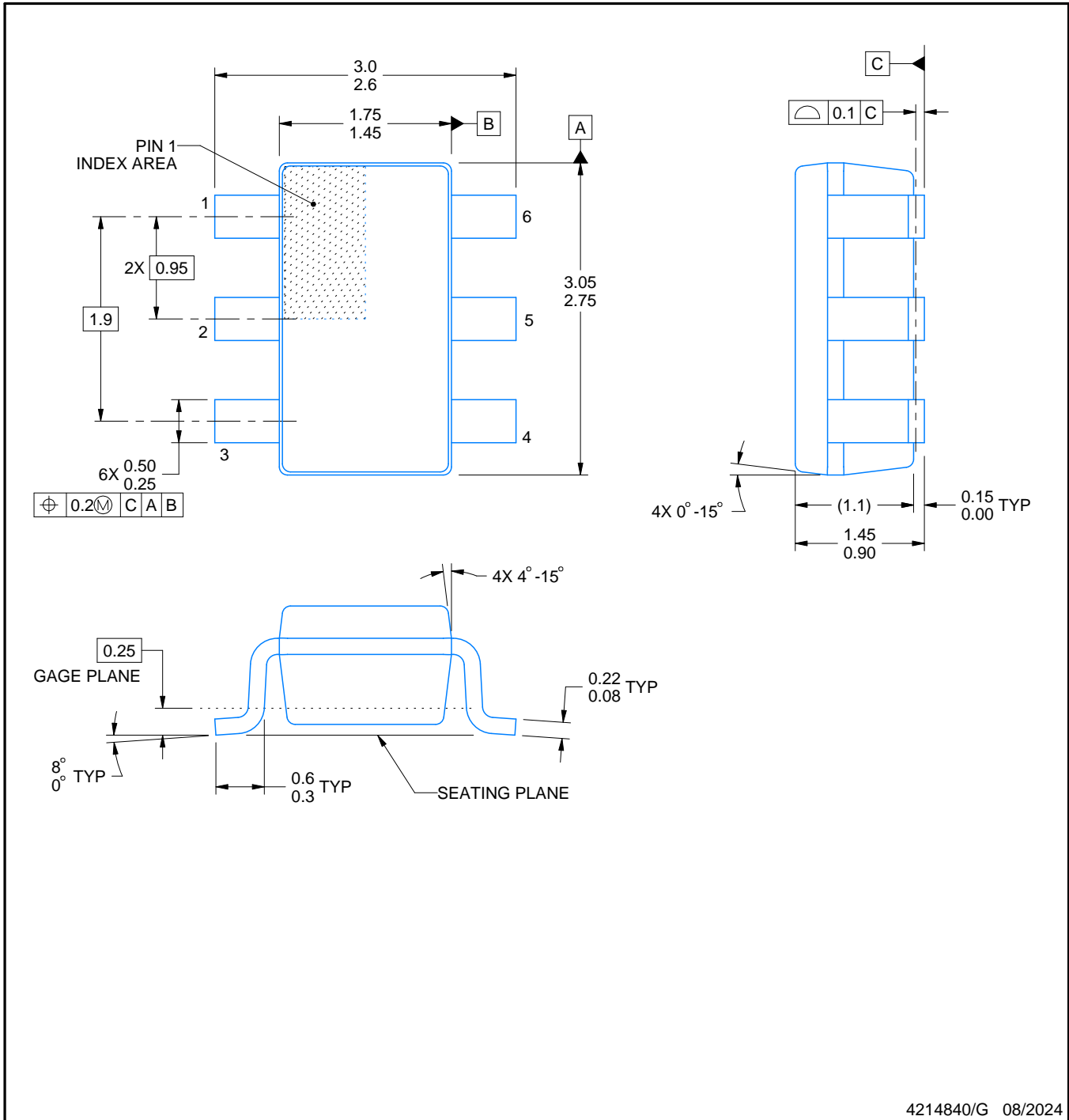
DBV0006A



PACKAGE OUTLINE

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



4214840/G 08/2024

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. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.25 per side.
4. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
5. Reference JEDEC MO-178.

EXAMPLE BOARD LAYOUT

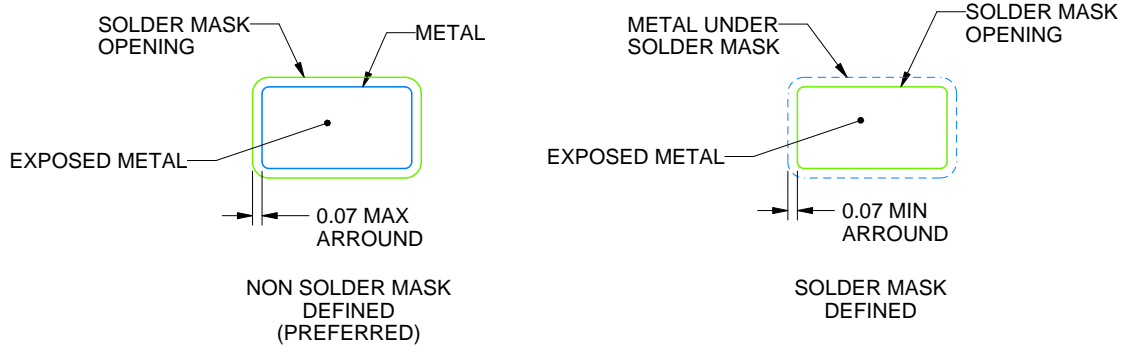
DBV0006A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X



SOLDER MASK DETAILS

4214840/G 08/2024

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/G 08/2024

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.



4220202/B 12/2023

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

PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



4220202/B 12/2023

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

PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



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

4220202/B 12/2023

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.

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