

TL331B、TL391B および TL331 シングルコンパレータ

1 特長

- 新しい **TL331B** および **TL391B**
- **B** バージョンの仕様を改善
 - 最大定格: 最大 38V
 - ESD 定格 (HBM): 2 kV
 - 優れた逆電圧性能
 - 低入力オフセット: 0.37 mV
 - 低い入力バイアス電流: 3.5nA
 - 低消費電流: 430µA
 - 1µsec の短い応答時間
 - **ピン配置が異なる TL391B**
- TL331 をそのまま置き換えることができる改良された代替品 **TL331B** を提供
- 同相入力電圧範囲にグランドを含む
- 差動入力電圧範囲が最大定格電源電圧と同じ: ±38V
- 低い出力飽和電圧
- TTL、MOS、CMOS 互換出力

2 アプリケーション

- ロボット掃除機
- 単相 UPS
- サーバー PSU
- コードレス電動工具
- ワイヤレス・インフラ
- 家電製品
- ビル・オートメーション
- ファクトリ・オートメーション / 制御
- モータ・ドライブ
- インフォテインメント / クラスタ

3 概要

TL331B および **TL391B** デバイスは、業界標準の TL331 コンパレータの次世代バージョンです。これらの次世代デバイスは、コスト重視のアプリケーション向けに非常に手頃な価格で提供しています。小さいオフセット電圧、高い電源電圧への対応、小さい消費電流、小さい入力バイアス電流、小さい伝搬遅延、優れた 2kV の ESD 性能などの特長と、そのまま置き換えることができる利便性を兼ね備えています。**TL331B** は、**TL331I** と **TL331K** の両方のバージョンをそのまま置き換えることができる改良された代替品です。一方 **TL391B** は、競合デバイスを置き換えるために **TL331B** のピン配置を変更したデバイスです。

デュアル電源でも、2 つの電源間の差分が 2V~36V の範囲内であり、VCC が入力同相電圧より 1.5V 以上高ければ、動作可能です。電流ドレインは、電源電圧に依存しません。出力を他のオープン コレクタ出力に接続し、ワイヤード AND 関係を構築できます。

製品情報

| 部品番号 ⁽¹⁾ | パッケージ | 本体サイズ (公称) ⁽²⁾ |
|-----------------------------|------------|---------------------------|
| TL331、 TL331B、 TL391B | SOT-23 (5) | 2.90mm × 1.60mm |

- (1) 利用可能なすべてのパッケージについては、データシートの末尾にある注文情報を参照してください。
- (2) パッケージ サイズ (長さ × 幅) は公称値であり、該当する場合はピンも含まれます。

ファミリー比較表

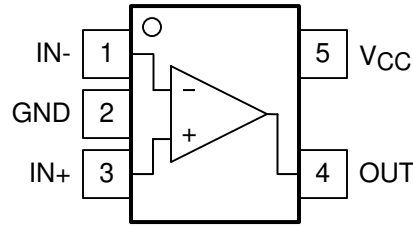
| 仕様 | TL331B TL391B | TL331I | TL331K | 単位 |
|----------------------|--------------------------------|---------------|---------------|------|
| 電源電圧 | 2~36 | 2~36 | 2~36 | V |
| 総消費電流 (5V~最大値 36V) | 0.43 | 0.7 | 0.7 | mA |
| 温度範囲 | -40~125 | -40~85 | -40~105 | °C |
| 静電気放電 (HBM) | 2000 | 1000 | 1000 | V |
| オフセット電圧 (全温度範囲での最大値) | ±4 | ±9 | ±9 | mV |
| 入力バイアス電流 (代表値 / 最大値) | 3.5 / 25 | 25 / 250 | 25 / 250 | nA |
| 応答時間 (代表値) | 1 | 1.3 | 1.3 | µsec |



Table of Contents

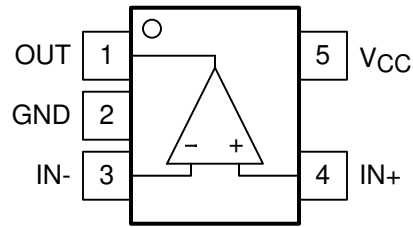
| | | | |
|---|---|--|----|
| 1 特長 | 1 | 5.12 Typical Characteristics..... | 8 |
| 2 アプリケーション | 1 | 6 Detailed Description | 14 |
| 3 概要 | 1 | 6.1 Overview..... | 14 |
| 4 Pin Configuration and Functions | 3 | 6.2 Functional Block Diagram..... | 14 |
| Pin Functions..... | 3 | 6.3 Feature Description..... | 14 |
| 5 Specifications | 4 | 6.4 Device Functional Modes..... | 14 |
| 5.1 Absolute Maximum Ratings, TL331 and TL331K..... | 4 | 7 Application and Implementation | 15 |
| 5.2 Absolute Maximum Ratings, TL331B and TL391B..... | 4 | 7.1 Application Information..... | 15 |
| 5.3 ESD Ratings - TL331B and TL391B..... | 5 | 7.2 Typical Application..... | 15 |
| 5.4 ESD Ratings, TL331 and TL331K..... | 5 | 8 Device and Documentation Support | 18 |
| 5.5 Recommended Operating Conditions, TL331B and TL391B..... | 5 | 8.1 Documentation Support..... | 18 |
| 5.6 Recommended Operating Conditions, TL331 and TL331K..... | 5 | 8.2 Receiving Notification of Documentation Updates... 18 | 18 |
| 5.7 Thermal Information..... | 5 | 8.3 サポート・リソース..... | 18 |
| 5.8 Electrical Characteristics, TL331B and TL391B..... | 6 | 8.4 Trademarks..... | 18 |
| 5.9 Switching Characteristics, TL331B and TL391B..... | 6 | 8.5 静電気放電に関する注意事項..... | 18 |
| 5.10 Electrical Characteristics, TL331 and TL331K..... | 7 | 8.6 用語集..... | 18 |
| 5.11 Switching Characteristics, TL331 and TL331K..... | 7 | 9 Revision History | 19 |
| | | 10 Mechanical, Packaging, and Orderable Information | 19 |

4 Pin Configuration and Functions



Note reversed inputs compared to similar common pinout

4-1. TL331, TL331B DBV Package, 5-Pin SOT-23, Top View



Note reversed inputs compared to similar common pinout

4-2. TL391B DBV Package, 5-Pin SOT-23, Top View

Pin Functions

| NAME | PIN | | TYPE | DESCRIPTION |
|-----------------|----------------------|---------------|------|-----------------------------|
| | TL331, TL331B NO. | TL391B NO. | | |
| IN+ | 3 | 4 | I | Positive Input |
| IN- | 1 | 3 | I | Negative Input |
| OUT | 4 | 1 | O | Open Collector/Drain Output |
| V _{CC} | 5 | 5 | — | Power Supply Input |
| GND | 2 | 2 | — | Ground |

5 Specifications

5.1 Absolute Maximum Ratings, TL331 and TL331K

over operating free-air temperature range (unless otherwise noted)⁽¹⁾

| | MIN | MAX | UNIT |
|---|-----------|-----|------|
| V _{CC} Supply voltage ⁽²⁾ | 0 | 36 | V |
| V _{ID} Differential input voltage ⁽³⁾ | –36 | 36 | V |
| V _I Input voltage range (either input) | –0.3 | 36 | V |
| V _O Output voltage | 0 | 36 | V |
| I _O Output current | 0 | 20 | mA |
| Duration of output short-circuit to ground ⁽⁴⁾ | Unlimited | | |
| I _{IK} Input current ⁽⁵⁾ | | –50 | mA |
| T _J Operating virtual junction temperature | –40 | 150 | °C |
| T _{stg} Storage temperature | –65 | 150 | °C |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltage values, except differential voltages, are with respect to the network ground.
- (3) Differential voltages are at IN+ with respect to IN–.
- (4) Short circuits from outputs to V_{CC} can cause excessive heating and eventual destruction.
- (5) Input current flows through parasitic diode to ground and will turn on parasitic transistors that will increase ICC and may cause output to be incorrect. Normal operation resumes when input current is removed.

5.2 Absolute Maximum Ratings, TL331B and TL391B

over operating free-air temperature range (unless otherwise noted)⁽¹⁾

| | MIN | MAX | UNIT |
|---|-----------|-----|------|
| V _{CC} Supply voltage ⁽²⁾ | –0.3 | 38 | V |
| V _{ID} Differential input voltage ⁽³⁾ | –38 | 38 | V |
| V _I Input voltage range (either input) | –0.3 | 38 | V |
| V _O Output voltage | –0.3 | 38 | V |
| I _O Output current | | 20 | mA |
| Duration of output short-circuit to ground ⁽⁴⁾ | Unlimited | | |
| I _{IK} Input current ⁽⁵⁾ | | –50 | mA |
| T _J Operating virtual junction temperature | –40 | 150 | °C |
| T _{stg} Storage temperature | –65 | 150 | °C |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
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- (3) Differential voltages are at IN+ with respect to IN–.
- (4) Short circuits from outputs to V_{CC} can cause excessive heating and eventual destruction.
- (5) Input current flows through parasitic diode to ground and will turn on parasitic transistors that will increase ICC and may cause output to be incorrect. Normal operation resumes when input current is removed.

5.3 ESD Ratings - TL331B and TL391B

| | | VALUE | UNIT |
|--------------------|-------------------------|--|-------|
| V _(ESD) | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾ | ±2000 |
| | | Charged device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾ | ±750 |

- (1) JEDEC document JEP155 states that 500V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250V CDM allows safe manufacturing with a standard ESD control process.

5.4 ESD Ratings, TL331 and TL331K

| | | VALUE | UNIT |
|--------------------|-------------------------|--|-------|
| V _(ESD) | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾ | ±1000 |
| | | Charged device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾ | ±750 |

- (1) JEDEC document JEP155 states that 500V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250V CDM allows safe manufacturing with a standard ESD control process.

5.5 Recommended Operating Conditions, TL331B and TL391B

over operating free-air temperature range (unless otherwise noted)

| | | MIN | MAX | UNIT |
|-----------------|----------------------|-----|-----|------|
| V _{CC} | Supply voltage | 2 | 36 | V |
| T _J | Junction temperature | −40 | 125 | °C |

5.6 Recommended Operating Conditions, TL331 and TL331K

over operating free-air temperature range (unless otherwise noted)

| | | MIN | MAX | UNIT |
|-----------------|------------------------------|-----|-----|------|
| V _{CC} | Supply voltage | 2 | 36 | V |
| T _J | Junction temperature, TL331 | −40 | 85 | °C |
| T _J | Junction temperature, TL331K | −40 | 105 | °C |

5.7 Thermal Information

| THERMAL METRIC ⁽¹⁾ | | TL331x, TL391x | UNIT |
|-------------------------------|--|----------------|------|
| | | DBV (SOT-23) | |
| | | 5 PINS | |
| R _{θJA} | Junction-to-ambient thermal resistance | 211.7 | °C/W |
| R _{θJC(top)} | Junction-to-case (top) thermal resistance | 133.6 | °C/W |
| R _{θJB} | Junction-to-board thermal resistance | 79.9 | °C/W |
| ψ _{JT} | Junction-to-top characterization parameter | 56.4 | °C/W |
| ψ _{JB} | Junction-to-board characterization parameter | 79.6 | °C/W |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) report.

5.8 Electrical Characteristics, TL331B and TL391B

$V_S = 5V$, $V_{CM} = (V-)$; $T_A = 25^\circ C$ (unless otherwise noted).

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--------------|---|---|---------------|------------|--------------|---------|
| V_{IO} | Input offset voltage | $V_S = 5$ to $36V$ | -2.5 | ± 0.37 | 2.5 | mV |
| | | $V_S = 5$ to $36V$, $T_A = -40^\circ C$ to $+125^\circ C$ | -4 | | 4 | |
| I_B | Input bias current | | | -3.5 | -25 | nA |
| | | $T_A = -40^\circ C$ to $+125^\circ C$ | | | -50 | nA |
| I_{OS} | Input offset current | | -10 | ± 0.5 | 10 | nA |
| | | $T_A = -40^\circ C$ to $+125^\circ C$ | | | 25 | nA |
| V_{CM} | Input voltage range | $V_S = 3$ to $36V$ | $(V-) - 0.1$ | | $(V+) - 1.5$ | V |
| | | $V_S = 3$ to $36V$, $T_A = -40^\circ C$ to $+125^\circ C$ | $(V-) - 0.05$ | | $(V+) - 2.0$ | V |
| A_{VD} | Large signal differential voltage amplification | $V_S = 15V$, $V_O = 1.4V$ to $11.4V$; $R_L \geq 15k$ to $(V+)$ | 50 | 200 | | V/mV |
| V_{OL} | Low level output Voltage {swing from $(V-)$ } | $I_{SINK} \leq 4mA$, $V_{ID} = -1V$ | | 110 | 400 | mV |
| | | $I_{SINK} \leq 4mA$, $V_{ID} = -1V$ $T_A = -40^\circ C$ to $+125^\circ C$ | | | 550 | mV |
| I_{OH-LKG} | High-level output leakage current | $(V+) = V_O = 5V$; $V_{ID} = 1V$ | | 0.1 | 20 | nA |
| I_{OH-LKG} | High-level output leakage current | $(V+) = V_O = 36V$; $V_{ID} = 1V$; $T_A = -40^\circ C$ to $+125^\circ C$ | | | 1000 | nA |
| I_{OL} | Low level output current | $V_{OL} = 1.5V$; $V_{ID} = -1V$; $V_S = 5V$ | 6 | 18 | | mA |
| I_Q | Quiescent current | $V_S = 5V$, no load | | 210 | 330 | μA |
| | | $V_S = 36V$, no load, $T_A = -40^\circ C$ to $+125^\circ C$ | | 275 | 430 | μA |

5.9 Switching Characteristics, TL331B and TL391B

$V_S = 5V$, $V_O_{PULLUP} = 5V$, $V_{CM} = V_S/2$, $C_L = 15pF$, $R_L = 5.1k$ Ohm, $T_A = 25^\circ C$ (unless otherwise noted).

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|----------------|--|--|-----|------|-----|------|
| $t_{response}$ | Propagation delay time, high-to-low; Small scale input signal ⁽¹⁾ | Input overdrive = $5mV$, Input step = $100mV$ | | 1000 | | ns |
| $t_{response}$ | Propagation delay time, high-to-low; TTL input signal ⁽¹⁾ | TTL input with $V_{ref} = 1.4V$ | | 300 | | ns |

(1) High-to-low and low-to-high refers to the transition at the input.

5.10 Electrical Characteristics, TL331 and TL331K

at specified free-air temperature, $V_{CC} = 5V$ (unless otherwise noted)

| PARAMETER | TEST CONDITIONS ⁽¹⁾ | T_A ⁽³⁾ | MIN | TYP | MAX | UNIT |
|--|--|----------------------|---------------------|-----|------|---------|
| V_{IO} Input offset voltage | $V_{CC} = 5V$ to $30V$, $V_O = 1.4V$, $V_{IC} = V_{IC(min)}$ | 25°C | | 2 | 5 | mV |
| | | Full range | | | 9 | |
| I_{IO} Input offset current | $V_O = 1.4V$ | 25°C | | 5 | 50 | nA |
| | | Full range | | | 250 | |
| I_{IB} Input bias current | $V_O = 1.4V$ | 25°C | | -25 | -250 | nA |
| | | Full range | | | -400 | |
| V_{ICR} Common-mode input voltage range ⁽²⁾ | | Full range | 0 to $V_{CC} - 1.5$ | | | V |
| A_{VD} Large-signal differential voltage amplification | $V_{CC} = 15V$, $V_O = 1.4V$ to $11.4V$, $R_L \geq 15\text{ k}\Omega$ to V_{CC} | 25°C | 50 | 200 | | V/mV |
| I_{OH} High-level output current | $V_{OH} = 5V$, $V_{ID} = 1V$ | 25°C | | 0.1 | 50 | nA |
| | $V_{OH} = 30V$, $V_{ID} = 1V$ | Full range | | | 1 | μA |
| V_{OL} Low-level output voltage | $I_{OL} = 4mA$, $V_{ID} = -1V$ | 25°C | | 150 | 400 | mV |
| | | Full range | | | 700 | |
| I_{OL} Low-level output current | $V_{OL} = 1.5V$, $V_{ID} = -1V$ | 25°C | 6 | | | mA |
| I_{CC} Supply current | $R_L = \infty$, $V_{CC} = 5V$ | 25°C | | 0.4 | 0.7 | mA |

- (1) All characteristics are measured with zero common-mode input voltage, unless otherwise specified.
(2) The voltage at either input or common-mode must not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is $V_{CC+} - 1.5V$, but either or both inputs can go to 30V without damage.
(3) Full range T_A is $-40^\circ C$ to $+85^\circ C$ for I-suffix devices and $-40^\circ C$ to $+105^\circ C$ for K-suffix devices.

5.11 Switching Characteristics, TL331 and TL331K

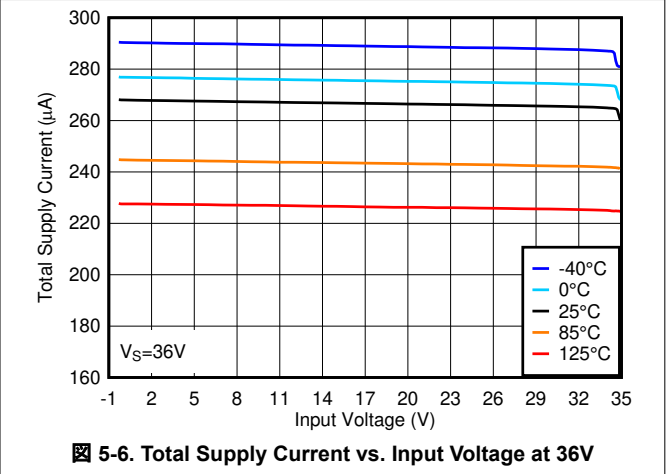
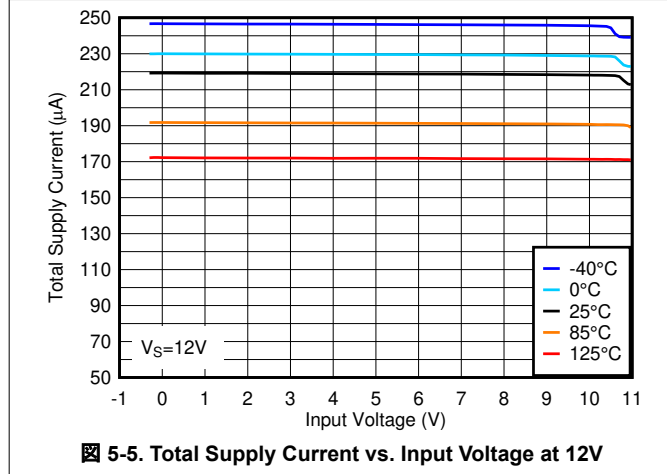
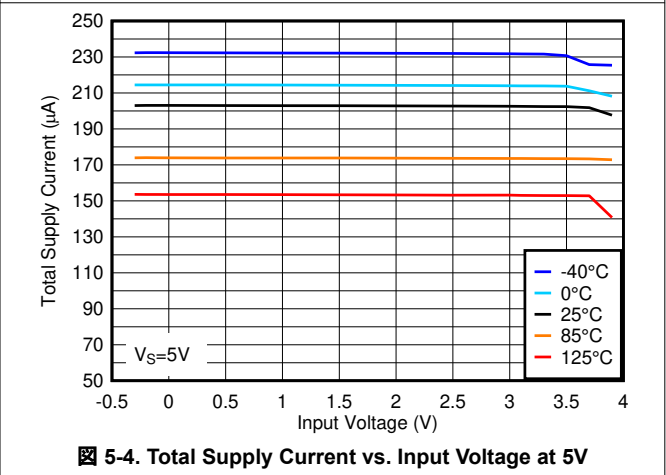
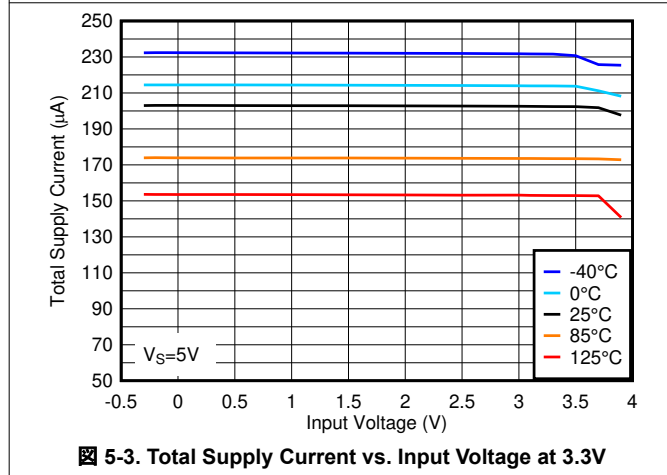
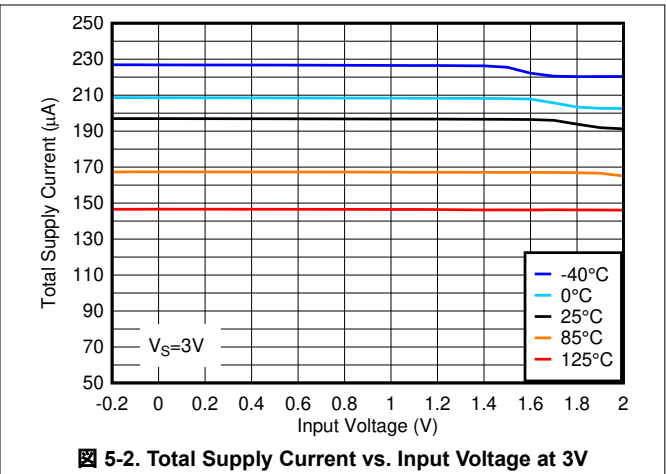
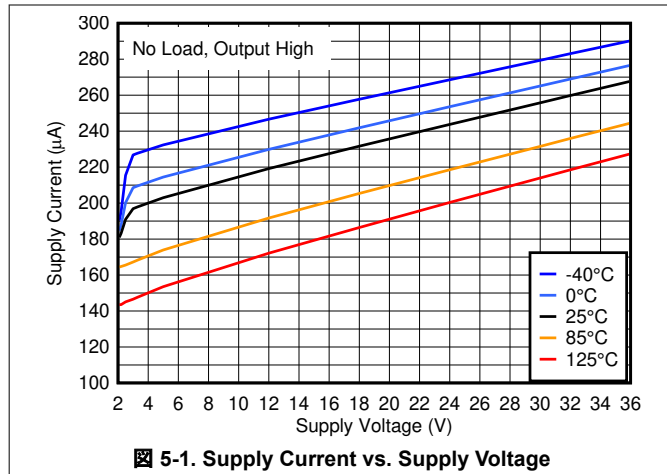
$V_{CC} = 5V$, $T_A = 25^\circ C$

| PARAMETER | TEST CONDITIONS | TYP | UNIT |
|---------------|---|-------------------------------------|------|
| Response time | R_L connected to 5V through 5.1k Ω , $C_L = 15pF$ ^{(1) (2)} | 100mV input step with 5mV overdrive | 1.3 |
| | | TTL-level input step | 0.3 |

- (1) C_L includes probe and jig capacitance.
(2) The response time specified is the interval between the input step function and the instant when the output crosses 1.4V.

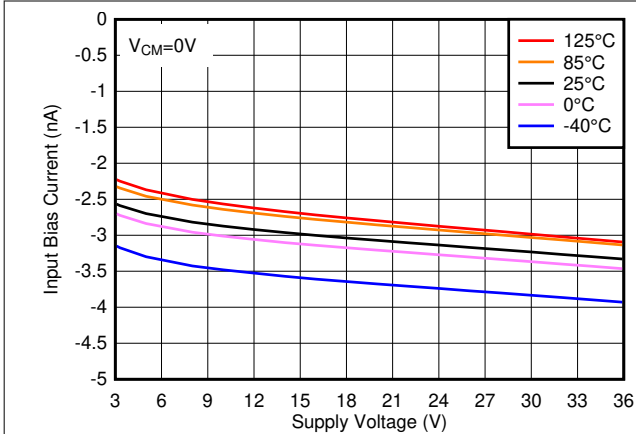
5.12 Typical Characteristics

$T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, $R_{\text{PULLUP}} = 5.1\text{k}$, $C_L = 15\text{pF}$, $V_{\text{CM}} = 0\text{V}$, $V_{\text{UNDERDRIVE}} = 100\text{mV}$, $V_{\text{OVERDRIVE}} = 100\text{mV}$ unless otherwise noted.

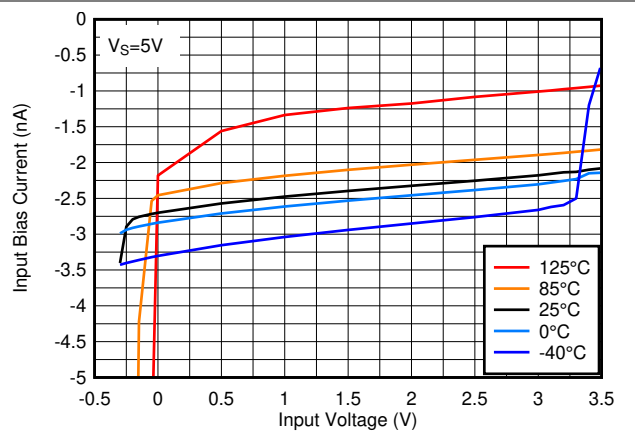


5.12 Typical Characteristics (continued)

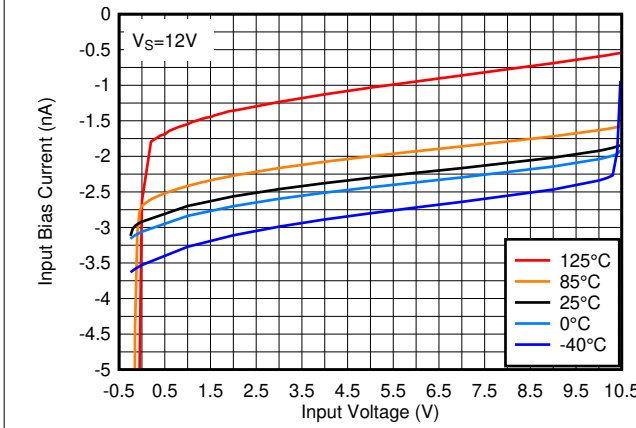
$T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, $R_{\text{PULLUP}} = 5.1\text{k}$, $C_L = 15\text{pF}$, $V_{\text{CM}} = 0\text{V}$, $V_{\text{UNDERDRIVE}} = 100\text{mV}$, $V_{\text{OVERDRIVE}} = 100\text{mV}$ unless otherwise noted.



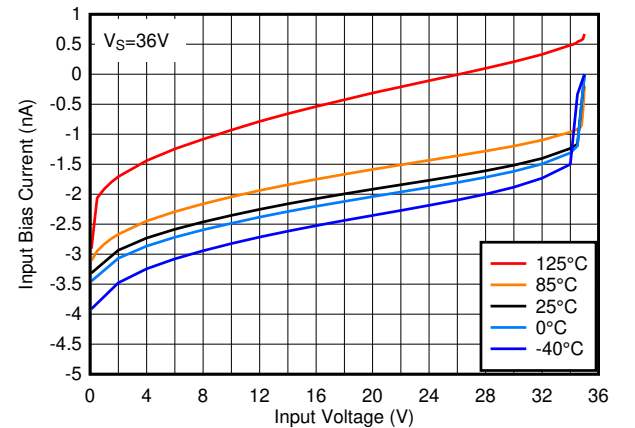
5-7. Input Bias Current vs. Supply Voltage



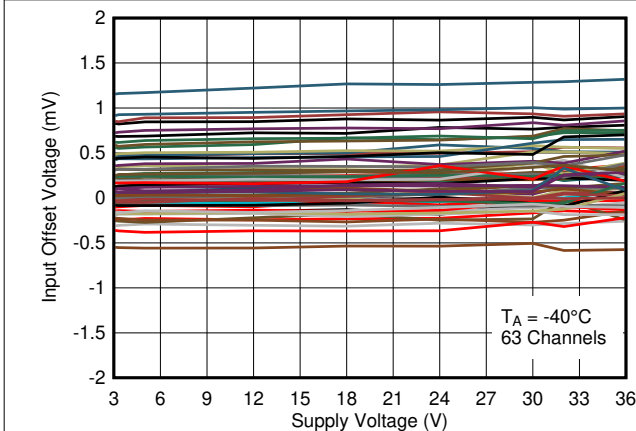
5-8. Input Bias Current vs. Input Voltage at 5V



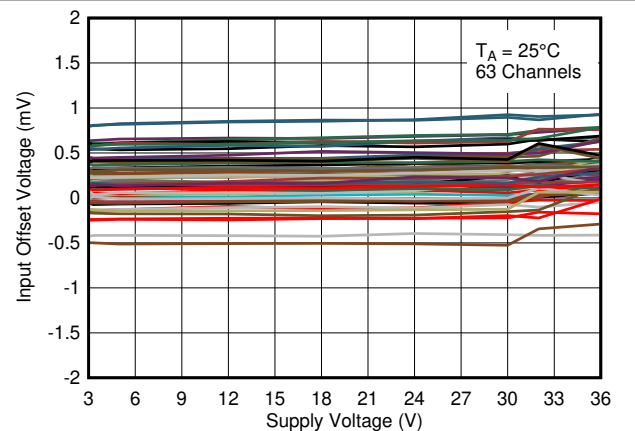
5-9. Input Bias Current vs. Input Voltage at 12V



5-10. Input Bias Current vs. Input Voltage at 36V



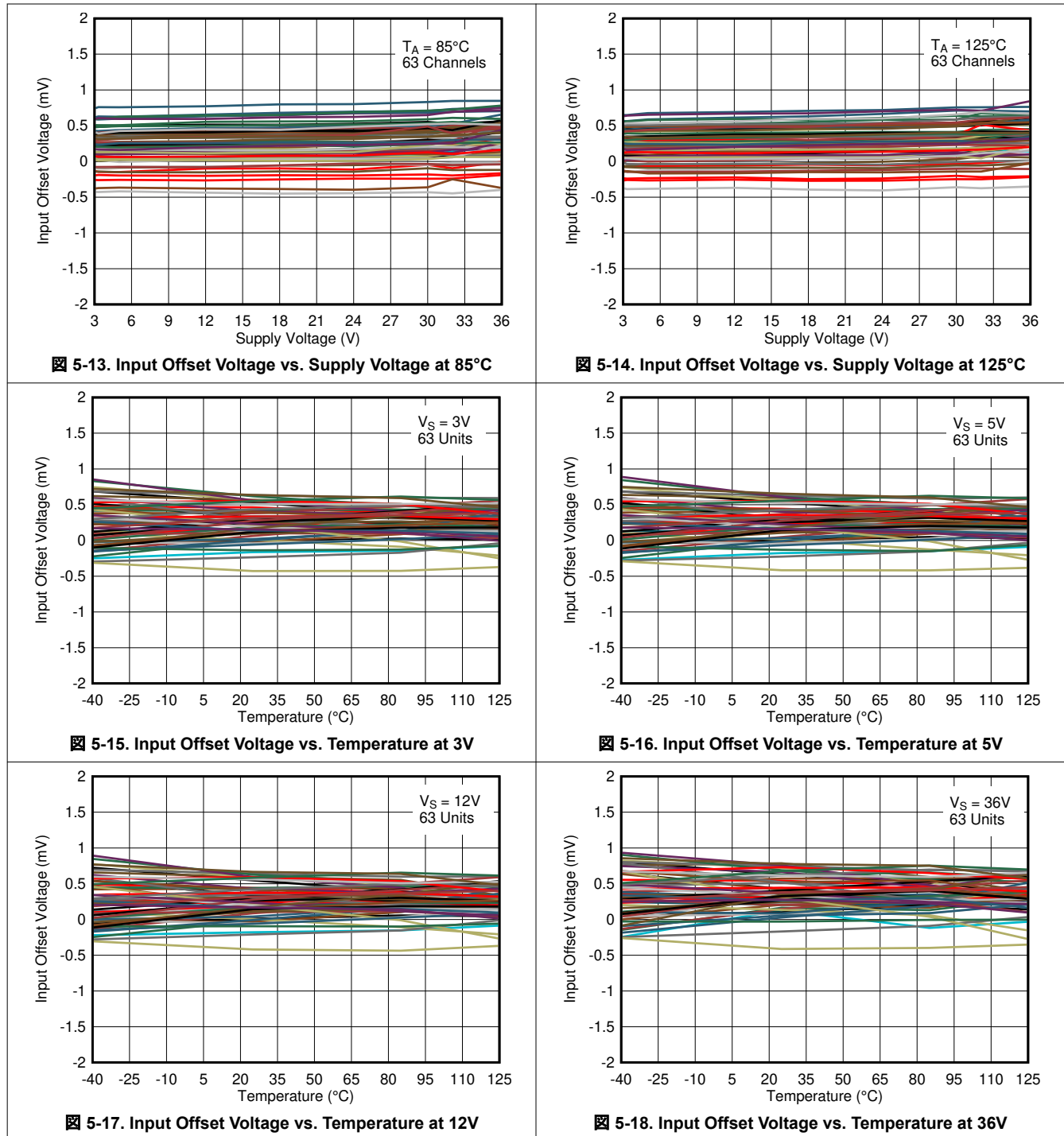
5-11. Input Offset Voltage vs. Supply Voltage at -40°C



5-12. Input Offset Voltage vs. Supply Voltage at 25°C

5.12 Typical Characteristics (continued)

$T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, $R_{\text{PULLUP}} = 5.1\text{k}$, $C_L = 15\text{pF}$, $V_{\text{CM}} = 0\text{V}$, $V_{\text{UNDERDRIVE}} = 100\text{mV}$, $V_{\text{OVERDRIVE}} = 100\text{mV}$ unless otherwise noted.



5.12 Typical Characteristics (continued)

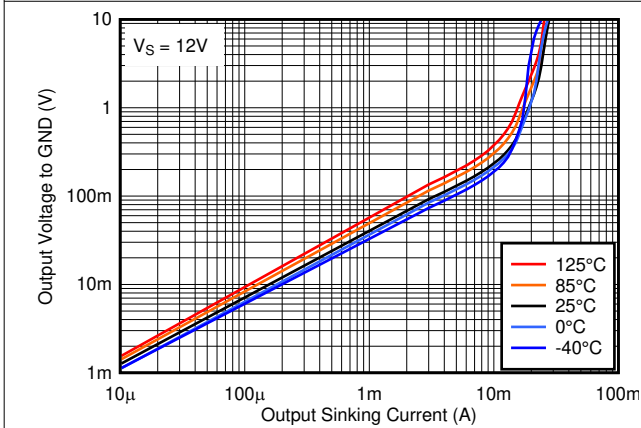
$T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, $R_{\text{PULLUP}} = 5.1\text{k}$, $C_L = 15\text{pF}$, $V_{\text{CM}} = 0\text{V}$, $V_{\text{UNDERDRIVE}} = 100\text{mV}$, $V_{\text{OVERDRIVE}} = 100\text{mV}$ unless otherwise noted.



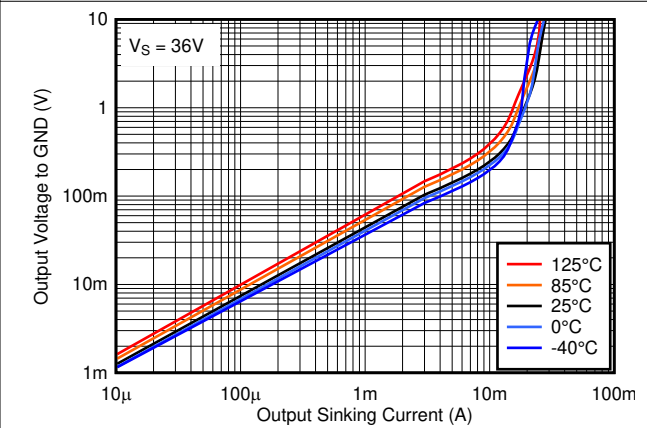
5-19. Output Low Voltage vs. Output Sinking Current at 3V



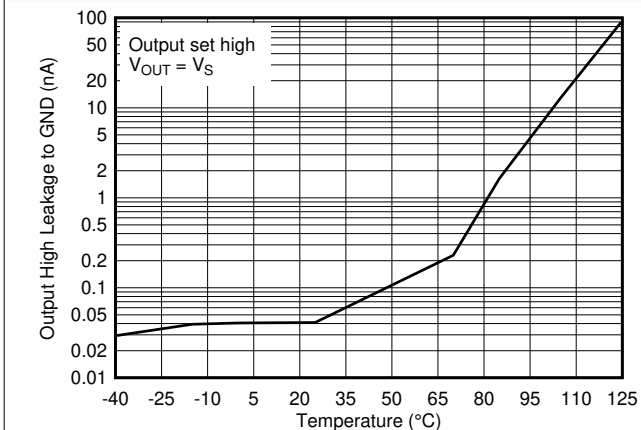
5-20. Output Low Voltage vs. Output Sinking Current at 5V



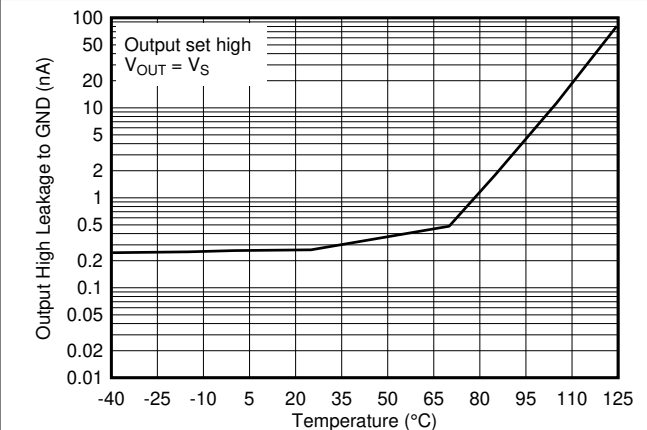
5-21. Output Low Voltage vs. Output Sinking Current at 12V



5-22. Output Low Voltage vs. Output Sinking Current at 36V



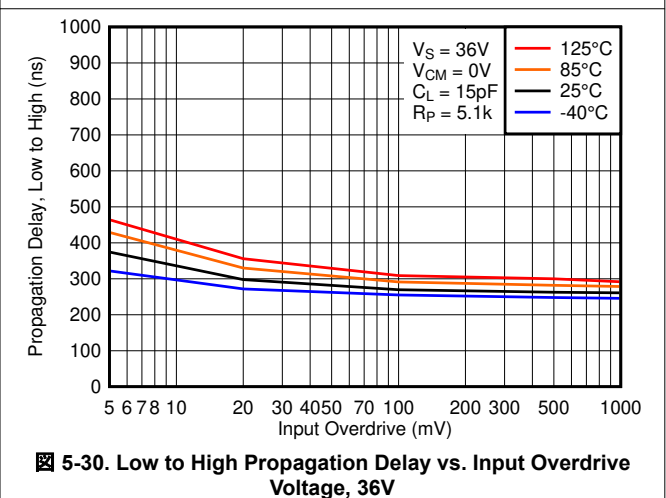
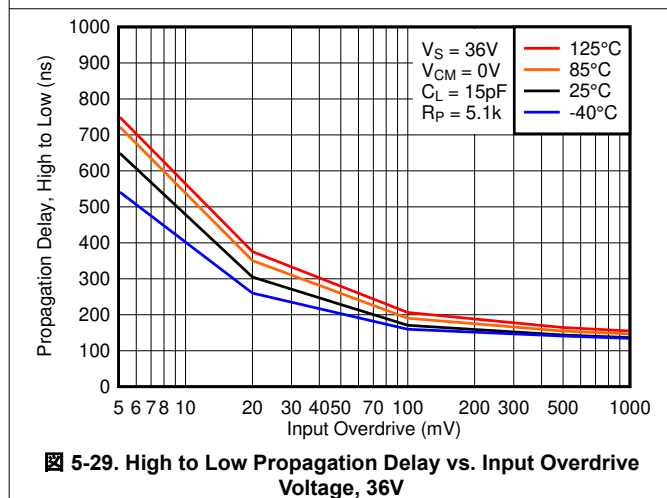
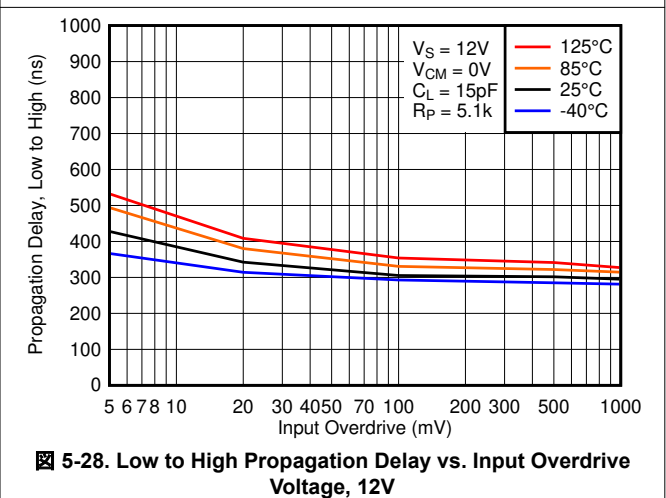
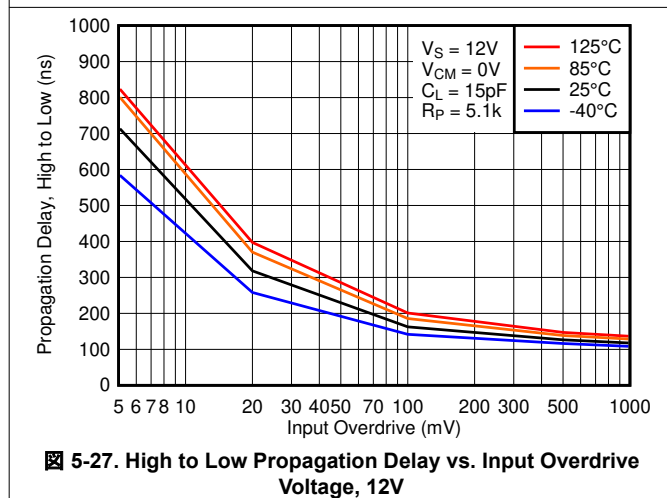
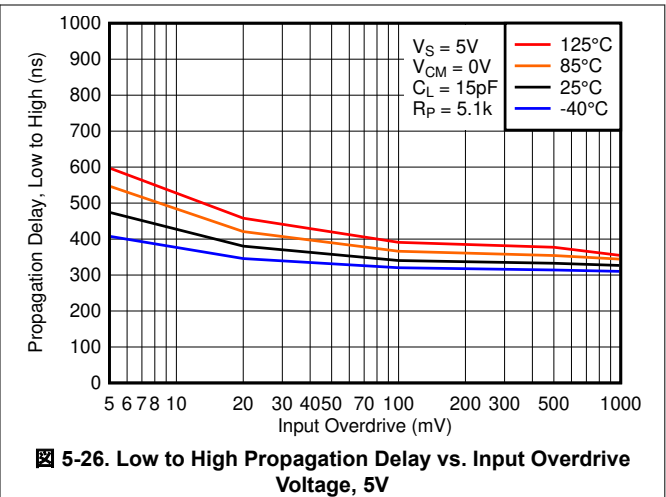
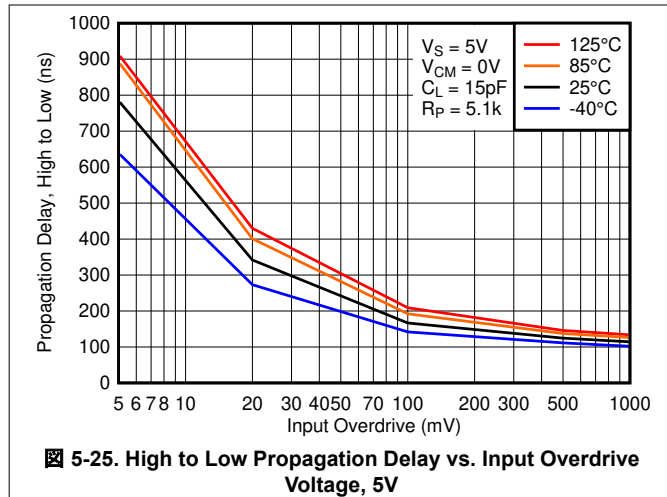
5-23. Output High Leakage Current vs. Temperature at 5V



5-24. Output High Leakage Current vs. Temperature at 36V

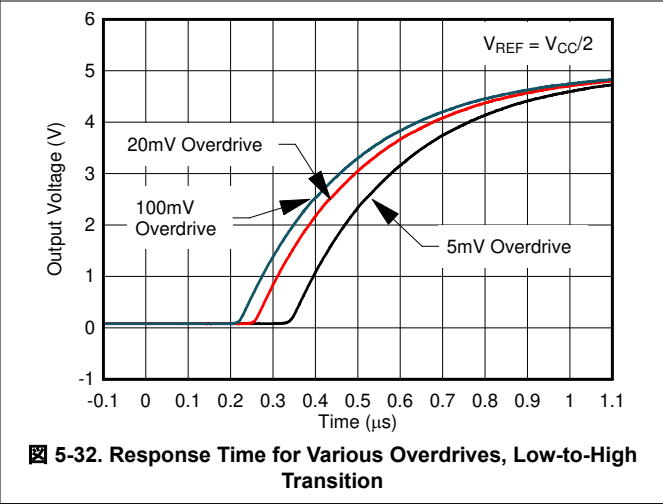
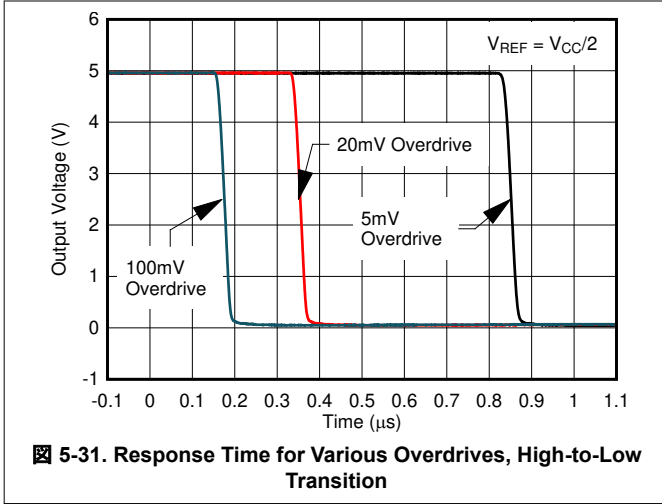
5.12 Typical Characteristics (continued)

$T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, $R_{\text{PULLUP}} = 5.1\text{k}$, $C_L = 15\text{pF}$, $V_{\text{CM}} = 0\text{V}$, $V_{\text{UNDERDRIVE}} = 100\text{mV}$, $V_{\text{OVERDRIVE}} = 100\text{mV}$ unless otherwise noted.



5.12 Typical Characteristics (continued)

$T_A = 25^\circ\text{C}$, $V_S = 5\text{V}$, $R_{\text{PULLUP}} = 5.1\text{k}$, $C_L = 15\text{pF}$, $V_{\text{CM}} = 0\text{V}$, $V_{\text{UNDERDRIVE}} = 100\text{mV}$, $V_{\text{OVERDRIVE}} = 100\text{mV}$ unless otherwise noted.



6 Detailed Description

6.1 Overview

The TL331 family is a single comparator with the ability to operate up to 36V on the supply pin. This standard device has proven ubiquity and versatility across a wide range of applications. This is due to its very wide supply voltages range (2V to 36V), low I_q , and fast response.

The open-collector output allows the user to configure the output's logic low voltage (V_{OL}) and can be utilized to enable the comparator to be used in AND functionality.

The TL331B and TL391B are performance upgrades to standard TL331 using the latest process technologies allowing for lower offset voltages, lower input bias and supply currents and faster response time over an extended temperature range. The TL331B can drop-in replace the "I" or "K" versions of TL331. The TL391B is an alternate pinout for replacing competitive devices.

6.2 Functional Block Diagram



6.3 Feature Description

TL331x family consists of a PNP Darlington pair input, allowing the device to operate with very high gain and fast response with minimal input bias current. The input Darlington pair creates a limit on the input common mode voltage capability, allowing TL331x to accurately function from ground to $V_{CC} - 1.5V$ differential input. In later revisions, a clamp was added around Q3 to mimic the outside-of-input voltage range behavior of the original classic silicon.

The output consists of an open collector NPN (pull-down or low side) transistor. The output NPN will sink current when the negative input voltage is higher than the positive input voltage and the offset voltage. The V_{OL} is resistive and will scale with the output current. Please see the "Output Low Voltage vs. Output Sinking Current" graphs in [Typical Characteristics](#) for V_{OL} values with respect to the output current.

6.4 Device Functional Modes

6.4.1 Voltage Comparison

The TL331x operates solely as a voltage comparator, comparing the differential voltage between the positive and negative pins and outputting a logic low or high impedance (logic high with pull-up) based on the input differential polarity.

7 Application and Implementation

注

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

7.1 Application Information

TL331x will typically be used to compare a single signal to a reference or two signals against each other. Many users take advantage of the open drain output to drive the comparison logic output to a logic voltage level to an MCU or logic device. The wide supply range and high voltage capability makes TL331x optimal for level shifting to a higher or lower voltage.

7.2 Typical Application

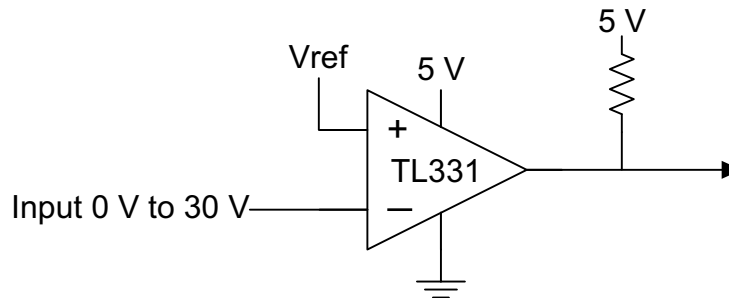


図 7-1. Typical Application Schematic

7.2.1 Design Requirements

For this design example, use the parameters listed in 表 7-1 as the input parameters.

表 7-1. Design Parameters

| DESIGN PARAMETER | EXAMPLE VALUE |
|--|-----------------------|
| Input Voltage Range | 0V to $V_{CC} - 1.5V$ |
| Supply Voltage | 2V to 36V |
| Logic Supply Voltage (R_{PULLUP} Voltage) | 2V to 36V |
| Output Current (V_{LOGIC}/R_{PULLUP}) | 1 μ A to 4mA |
| Input Overdrive Voltage | 100mV |
| Reference Voltage | 2.5V |
| Load Capacitance (C_L) | 15pF |

7.2.2 Detailed Design Procedure

When using TL331x in a general comparator application, determine the following:

- Input voltage range
- Minimum overdrive voltage
- Output and drive current
- Response time

7.2.2.1 Input Voltage Range

When choosing the input voltage range, the input common mode voltage range (V_{ICR}) must be taken in to account. If temperature operation is above or below 25°C the V_{ICR} can range from 0V to $V_{CC} - 1.5V$. This limits the input voltage range to as high as $V_{CC} - 1.5V$ and as low as 0V. Operation outside of this range can yield incorrect comparisons.

Below is a list of input voltage situation and their outcomes:

1. When both IN- and IN+ are both within the common mode range:
 - a. If IN- is higher than IN+ and the offset voltage, the output is low and the output transistor is sinking current
 - b. If IN- is lower than IN+ and the offset voltage, the output is high impedance and the output transistor is not conducting
2. When IN- is higher than common mode and IN+ is within common mode, the output is low and the output transistor is sinking current
3. When IN+ is higher than common mode and IN- is within common mode, the output is high impedance and the output transistor is not conducting
4. When IN- and IN+ are both higher than common mode, please see the *Both Inputs Above Input Range Behavior* section of the [LM339 Family Application Note \(SNOAA35\)](#).

7.2.2.2 Minimum Overdrive Voltage

Overdrive Voltage is the differential voltage produced between the positive and negative inputs of the comparator over the offset voltage (V_{IO}). To make an accurate comparison the Overdrive Voltage (V_{OD}) should be higher than the input offset voltage (V_{IO}). Overdrive voltage can also determine the response time of the comparator, with the response time decreasing with increasing overdrive. [Figure 7-2](#) and [Figure 7-3](#) show positive and negative response times with respect to overdrive voltage.

7.2.2.3 Output and Drive Current

Output current is determined by the load/pull-up resistance and logic/pull-up voltage. The output current produces a output low voltage (V_{OL}) from the comparator. In which V_{OL} is proportional to the output current. Use *Output Low Voltage vs Output Current (I_{OL})* to determine V_{OL} based on the output current.

The output current can also effect the transient response. More is explained in the next section.

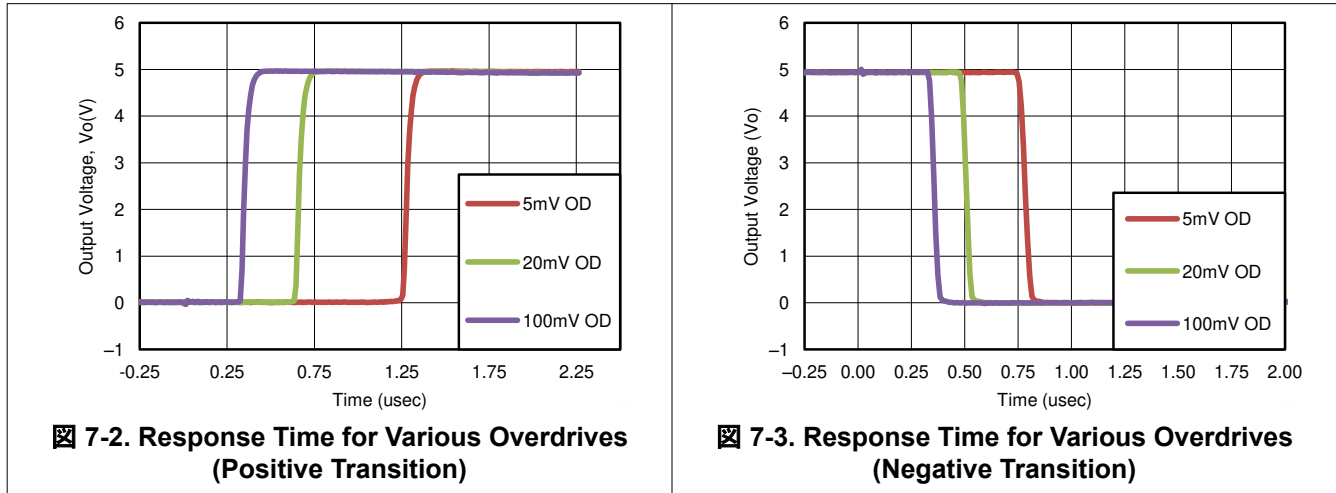
7.2.2.4 Response Time

Response time is a function of input over drive. See [Section 7.2.3](#) for typical response times. The rise and fall times can be determined by the load capacitance (C_L), load/pullup resistance (R_{PULLUP}), and equivalent collector-emitter resistance (R_{CE}).

- The rise time (τ_R) is approximately $\tau_R \sim R_{PULLUP} \times C_L$
- The fall time (τ_F) is approximately $\tau_F \sim R_{CE} \times C_L$
 - R_{CE} can be determined by taking the slope of *Output Low Voltage vs Output Current (I_{OL})* in its linear region at the desired temperature, or by dividing the V_{OL} by I_{out}

7.2.3 Application Curves

The following curves were generated with 5V on V_{CC} and V_{Logic} , $R_{PULLUP} = 5.1k\Omega$, and 50pF scope probe.



7.2.4 ESD Protection

The "B" and TiB versions add dedicated ESD protections on all the pins for improved ESD performance. Please see Application Note [SNOAA35](#) for more information.

7.2.5 Power Supply Recommendations

For fast response and comparison applications with noisy or AC inputs, it is recommended to use a bypass capacitor on the supply pin to reject any variation on the supply voltage. This variation can eat into the comparator's input common mode range and create an inaccurate comparison.

7.2.6 Layout

7.2.6.1 Layout Guidelines

For accurate comparator applications without hysteresis it is important maintain a stable power supply with minimized noise and glitches, which can affect the high level input common mode voltage range. To achieve this, it is best to add a bypass capacitor between the supply voltage and ground. This should be implemented on the positive power supply and negative supply (if available). If a negative supply is not being used, do not put a capacitor between the IC's GND pin and system ground.

7.2.6.2 Layout Example

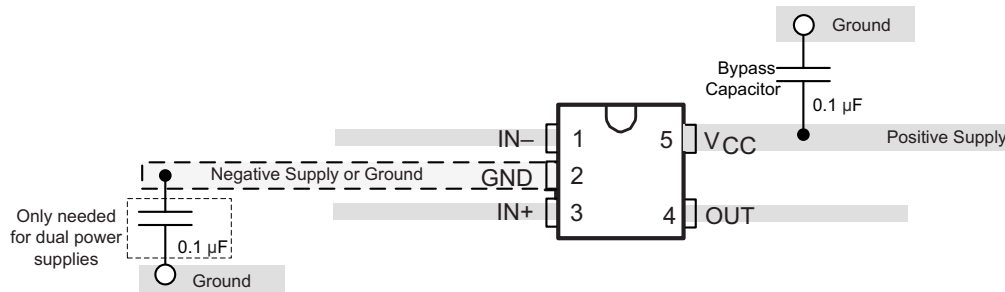


Figure 7-4. TL331 Layout Example

8 Device and Documentation Support

8.1 Documentation Support

8.1.1 Related Documentation

[Application Design Guidelines for LM339, LM393, TL331 Family Comparators - SNOAA35](#)

[Analog Engineers Circuit Cookbook: Amplifiers \(See Comparators section\) - SLYY137](#)

[Precision Design, Comparator with Hysteresis Reference Design- TIDU020](#)

[Window comparator circuit - SBOA221](#)

[Reference Design, Window Comparator Reference Design- TIPD178](#)

[Comparator with and without hysteresis circuit - SBOA219](#)

[Inverting comparator with hysteresis circuit - SNOA997](#)

[Non-Inverting Comparator With Hysteresis Circuit - SBOA313](#)

[Zero crossing detection using comparator circuit - SNOA999](#)

[PWM generator circuit - SBOA212](#)

[How to Implement Comparators for Improving Performance of Rotary Encoder in Industrial Drive Applications - SNOAA41](#)

[A Quad of Independently Func Comparators - SNOA654](#)

8.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

8.3 サポート・リソース

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8.6 用語集

[テキサス・インスツルメンツ用語集](#)

この用語集には、用語や略語の一覧および定義が記載されています。

9 Revision History

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

| Changes from Revision K (September 2023) to Revision L (November 2024) | Page |
|--|------|
| • Combined thermal table..... | 5 |
| • Removed outdated graphs..... | 8 |
| • Updated Functional Block Diagram and text..... | 14 |

| Changes from Revision J (November 2020) to Revision K (September 2023) | Page |
|--|------|
| • Added link to application note..... | 16 |

| Changes from Revision I (August 2020) to Revision J (November 2020) | Page |
|---|------|
| • ファミリ比較表の「B」、「K」、「I」バージョンの電源電圧を訂正..... | 1 |

| Changes from Revision H (April 2020) to Revision I (August 2020) | Page |
|--|------|
| • ドキュメント全体にわたって表、図、相互参照の採番方法を更新。..... | 1 |
| • Added "B" device Typical Char graphs..... | 8 |

| Changes from Revision G (January 2015) to Revision H (April 2020) | Page |
|--|------|
| • TL331B と TL391B の表とピン配置を追加、APL 用の新しい B デバイスのために先頭ページを更新..... | 1 |
| • Added Input current, I_{IK} in <i>Absolute Maximum Ratings</i> | 4 |
| • Changed incorrect TL331 and TL331K Temp Ranges in <i>Recommended Operating Conditions</i> | 5 |
| • Changed text from: open-drain output to: open-collector output | 14 |
| • Removed sentence: This is enables much head room for modern day supplies of 3.3V and 5.0V..... | 14 |
| • Removed sentence: This is enables much head room for modern day supplies of 3.3V and 5.0V. | 14 |
| • Changed Output Current specifications from: to: in <i>Design Parameters</i> | 15 |
| • Changed first paragraph of the <i>Response Time</i> section | 16 |
| • Added <i>Receiving Notification of Documentation Updates</i> section and <i>Community Resources</i> section..... | 18 |

10 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

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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) |
|------------------------------|---------------|----------------------|------------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|-----------------------------|
| TL331BIDBVR | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 125 | 331B |
| TL331BIDBVR.B | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 331B |
| TL331BIDBVRG4 | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 331B |
| TL331BIDBVRG4.B | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 331B |
| TL331IDBVR | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | (T1I8, T1IG, T1IL, T1IS) |
| TL331IDBVR.A | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | (T1I8, T1IG, T1IL, T1IS) |
| TL331IDBVT | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 85 | (T1I8, T1IG, T1IL, T1IU) |
| TL331IDBVT.A | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | (T1I8, T1IG, T1IL, T1IU) |
| TL331IDBVT.B | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 85 | (T1I8, T1IG, T1IL, T1IU) |
| TL331IDBVTG4 | Obsolete | Production | SOT-23 (DBV) 5 | - | - | Call TI | Call TI | -40 to 85 | T1IG |
| TL331KDBVR | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 105 | (T1K8, T1KG, T1KJ, T1KL) |
| TL331KDBVR.A | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 105 | (T1K8, T1KG, T1KJ, T1KL) |
| TL331KDBVR.B | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 105 | (T1K8, T1KG, T1KJ, T1KL) |
| TL331KDBVT | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 105 | (T1K8, T1KG, T1KJ, T1KL) |
| TL331KDBVT.A | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 105 | (T1K8, T1KG, T1KJ, T1KL) |
| TL331KDBVT.B | Active | Production | SOT-23 (DBV) 5 | 250 SMALL T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 105 | (T1K8, T1KG, T1KJ, T1KL) |
| TL391BIDBVR | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU SN | Level-1-260C-UNLIM | -40 to 125 | 391B |
| TL391BIDBVR.B | Active | Production | SOT-23 (DBV) 5 | 3000 LARGE T&R | Yes | NIPDAU | Level-1-260C-UNLIM | -40 to 125 | 391B |

(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.

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OTHER QUALIFIED VERSIONS OF TL331, TL331B, TL391B :

- Automotive : [TL331-Q1](#), [TL331B-Q1](#), [TL391B-Q1](#)
- Enhanced Product : [TL331-EP](#)

NOTE: Qualified Version Definitions:

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

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 |
|---------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TL331BIDBVR | SOT-23 | DBV | 5 | 3000 | 178.0 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TL331BIDBVRG4 | SOT-23 | DBV | 5 | 3000 | 180.0 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TL331IDBVR | SOT-23 | DBV | 5 | 3000 | 180.0 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TL331IDBVR | SOT-23 | DBV | 5 | 3000 | 180.0 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TL331IDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TL331IDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TL331KDBVR | SOT-23 | DBV | 5 | 3000 | 180.0 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TL331KDBVR | SOT-23 | DBV | 5 | 3000 | 180.0 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TL331KDBVT | SOT-23 | DBV | 5 | 250 | 180.0 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |
| TL391BIDBVR | SOT-23 | DBV | 5 | 3000 | 178.0 | 8.4 | 3.2 | 3.2 | 1.4 | 4.0 | 8.0 | Q3 |

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TL331BIDBVR | SOT-23 | DBV | 5 | 3000 | 208.0 | 191.0 | 35.0 |
| TL331BIDBVRG4 | SOT-23 | DBV | 5 | 3000 | 210.0 | 185.0 | 35.0 |
| TL331IDBVR | SOT-23 | DBV | 5 | 3000 | 210.0 | 185.0 | 35.0 |
| TL331IDBVR | SOT-23 | DBV | 5 | 3000 | 210.0 | 185.0 | 35.0 |
| TL331IDBVT | SOT-23 | DBV | 5 | 250 | 210.0 | 185.0 | 35.0 |
| TL331IDBVT | SOT-23 | DBV | 5 | 250 | 210.0 | 185.0 | 35.0 |
| TL331KDBVR | SOT-23 | DBV | 5 | 3000 | 210.0 | 185.0 | 35.0 |
| TL331KDBVR | SOT-23 | DBV | 5 | 3000 | 210.0 | 185.0 | 35.0 |
| TL331KDBVT | SOT-23 | DBV | 5 | 250 | 210.0 | 185.0 | 35.0 |
| TL391BIDBVR | SOT-23 | DBV | 5 | 3000 | 208.0 | 191.0 | 35.0 |

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.

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