TL331B, TL391B and TL331 Single Comparators

1 Features

- NEW TL331B and TL391B
- Improved specifications of B-version
  - Maximum rating: up to 38V
  - ESD rating (HBM): 2kV
  - Improved reverse voltage performance
  - Low input offset: 0.37mV
  - Low input bias current: 3.5nA
  - Low supply-current: 430µA
  - Faster response time of 1µsec
  - TL391B provides an alternate pinout
- TL331B is improved drop-in replacement for TL331
- Common-mode input voltage range includes ground
- Differential input voltage range equal to maximum-rated supply voltage: ±38V
- Low output saturation voltage
- Output compatible with TTL, MOS, and CMOS

2 Applications

- Vacuum robot
- Single phase UPS
- Server PSU
- Cordless power tool
- Wireless infrastructure
- Appliances
- Building automation
- Factory automation & control
- Motor drives
- Infotainment & cluster

3 Description

The TL331B and TL391B devices are the next generation versions of the industry-standard TL331 comparator. These next generation devices provide outstanding value for cost-sensitive applications, with features including lower offset voltage, higher supply voltage capability, lower supply current, lower input bias current, lower propagation delay, wider temperature range and improved 2kV ESD performance with drop-in replacement convenience. The TL331B is a drop-in improved replacement for both the TL331I and TL331K versions, while the TL391B provides an alternate pinout of the TL331B to replace competitive devices.

Operation from dual supplies also is possible as long as the difference between the two supplies is within 2V to 36V, and VCC is at least 1.5V more positive than the input common-mode voltage. Current drain is independent of the supply voltage. The outputs can be connected to other open-collector outputs to achieve wired-AND relationships.

Device Information

PART NUMBER(1)	PACKAGE	BODY SIZE (NOM) (2)
TL331, TL331B, TL391B	SOT-23 (5)	2.90mm × 1.60mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.
(2) The package size (length × width) is a nominal value and includes pins, where applicable.

Family Comparison Table

Specification	TL331B TL391B	TL331I	TL331K	Units
Supply Voltage	2 to 36	2 to 36	2 to 36	V
Total Supply Current (5V to 36V maximum)	0.43	0.7	0.7	mA
Temperature Range	−40 to 125	-40 to 85	-40 to 105	°C
ESD (HBM)	2000	1000	1000	V
Offset Voltage (maximum over temp)	± 4	± 9	± 9	mV
Input Bias Current (typical / maximum)	3.5 / 25	25 / 250	25 / 250	nA
Response Time (typical)	1	1.3	1.3	µsec

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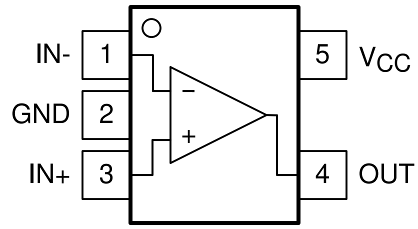
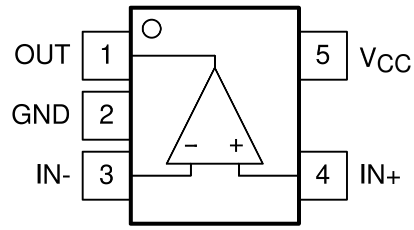
4 Pin Configuration and Functions



Note reversed inputs compared to similar common pinout

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



Note reversed inputs compared to similar common pinout

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

Pin Functions

PIN			TYPE	DESCRIPTION
	TL331, TL331B	TL391B		
NAME	NO.	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 thorough 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.
(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 thorough 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	V
		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	V
		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	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	211.7	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	133.6	°C/W
$R_{\theta JB}$	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°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°C to +125°C	–4		4	
I_B	Input bias current			–3.5	–25	nA
		T_A = –40°C to +125°C			–50	nA
I_{OS}	Input offset current		–10	±0.5	10	nA
		T_A = –40°C to +125°C	–25		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°C to +125°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 ≥ 15k to (V+)	50	200		V/mV
V_{OL}	Low level output Voltage {swing from (V–)}	I_{SINK} ≤ 4mA, V_{ID} = -1V		110	400	mV
		I_{SINK} ≤ 4mA, V_{ID} = -1V T_A = –40°C to +125°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°C to +125°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°C to +125°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°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 ≥ 15 kΩ 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 = ∞, 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°C to +85°C for I-suffix devices and –40°C to +105°C for K-suffix devices.

5.11 Switching Characteristics, TL331 and TL331K

V_{CC} = 5V, T_A = 25°C

PARAMETER	TEST CONDITIONS		TYP	UNIT
Response time	R_L connected to 5V through 5.1kΩ, C_L = 15pF[1] [2]	100mV input step with 5mV overdrive	1.3	μs
		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°C, V_S = 5V, R_{PULLUP} = 5.1k, C_L = 15pF, V_{CM} = 0V, $V_{UNDERDRIVE}$ = 100mV, $V_{OVERDRIVE}$ = 100mV unless otherwise noted.

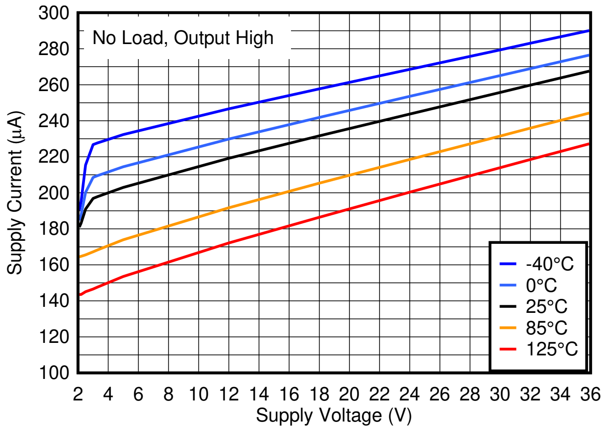


Figure 5-1. Supply Current vs. Supply Voltage

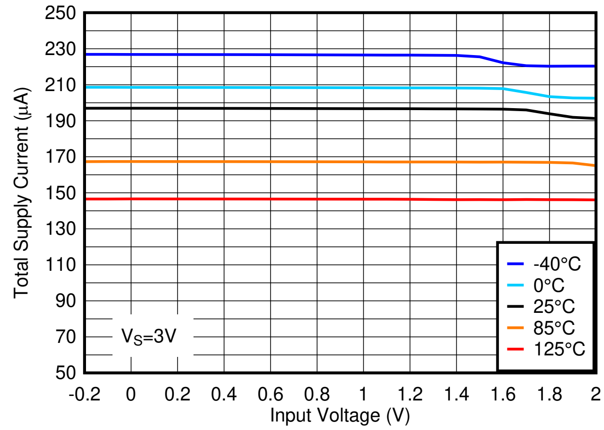


Figure 5-2. Total Supply Current vs. Input Voltage at 3V

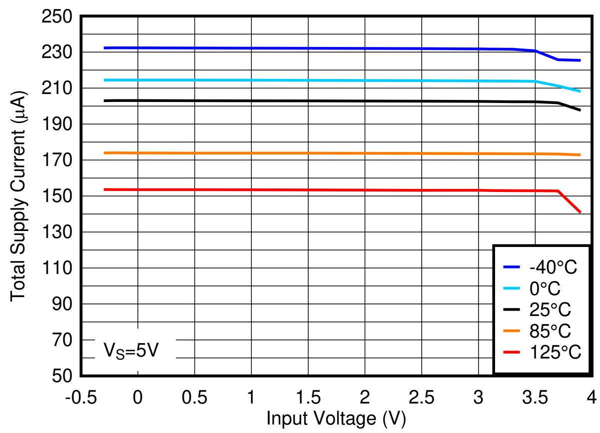


Figure 5-3. Total Supply Current vs. Input Voltage at 3.3V

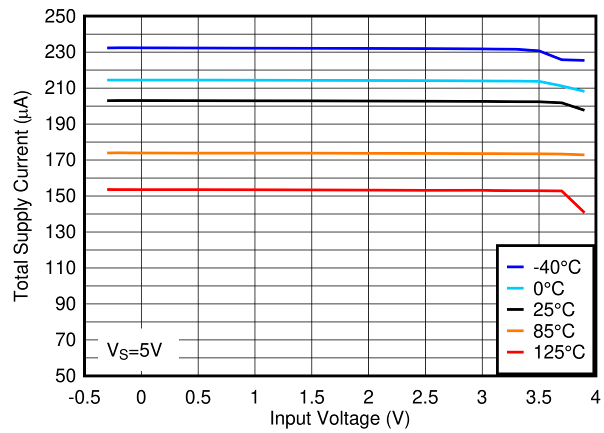


Figure 5-4. Total Supply Current vs. Input Voltage at 5V

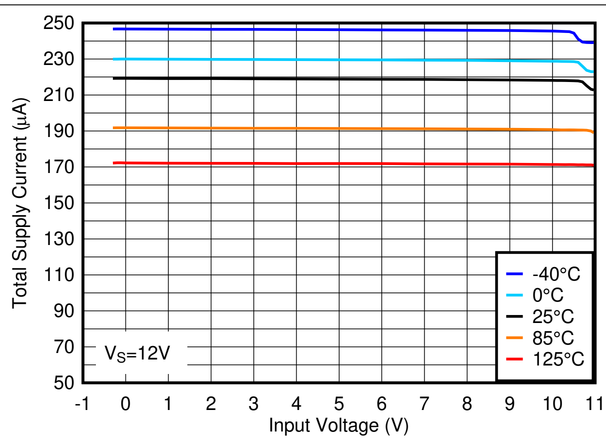


Figure 5-5. Total Supply Current vs. Input Voltage at 12V

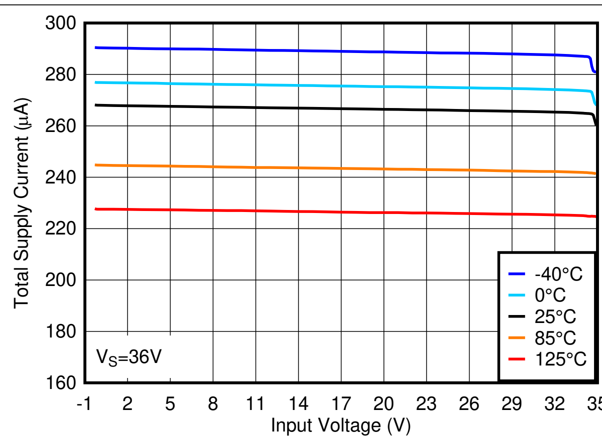


Figure 5-6. Total Supply Current vs. Input Voltage at 36V

5.12 Typical Characteristics (continued)

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

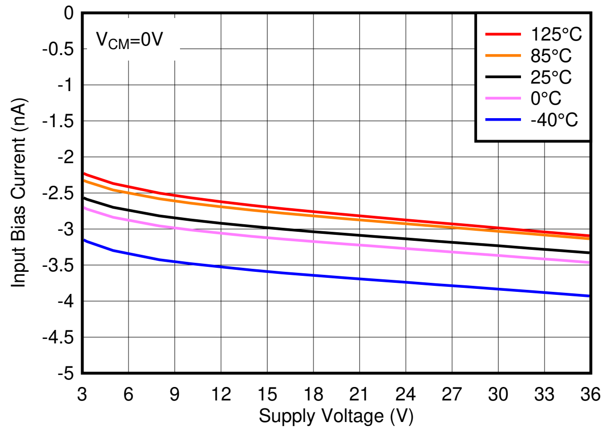


Figure 5-7. Input Bias Current vs. Supply Voltage

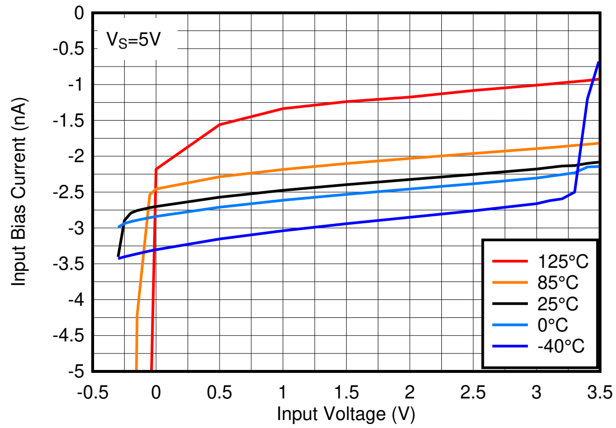


Figure 5-8. Input Bias Current vs. Input Voltage at 5V

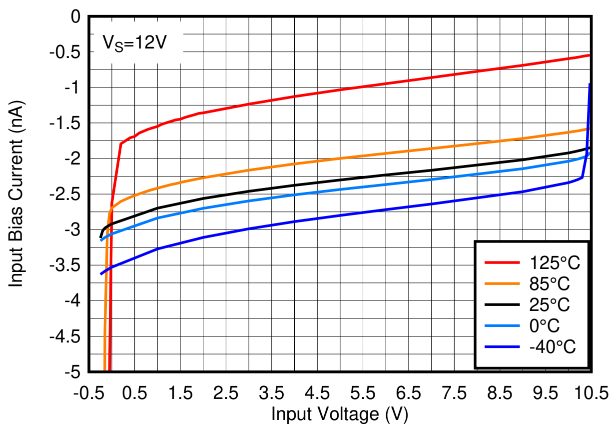


Figure 5-9. Input Bias Current vs. Input Voltage at 12V

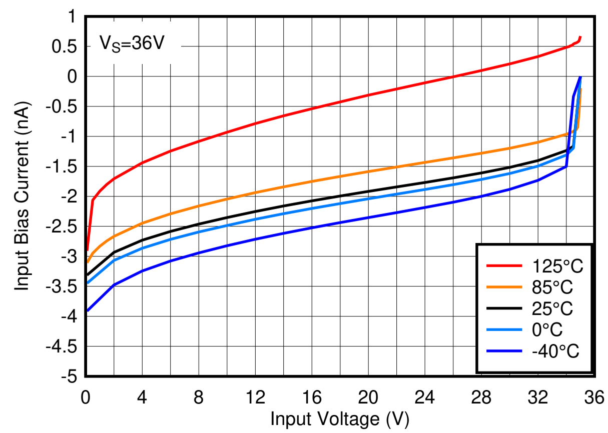


Figure 5-10. Input Bias Current vs. Input Voltage at 36V

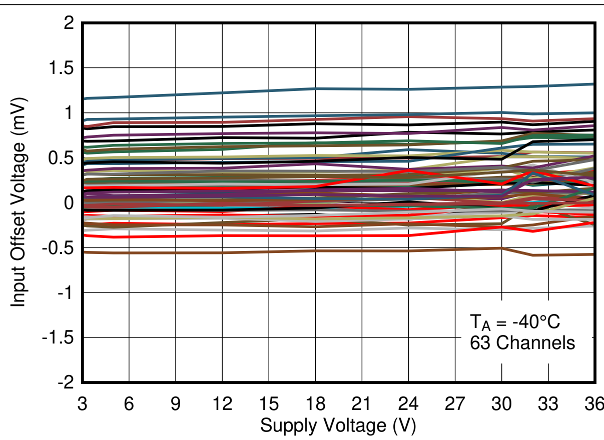


Figure 5-11. Input Offset Voltage vs. Supply Voltage at -40°C

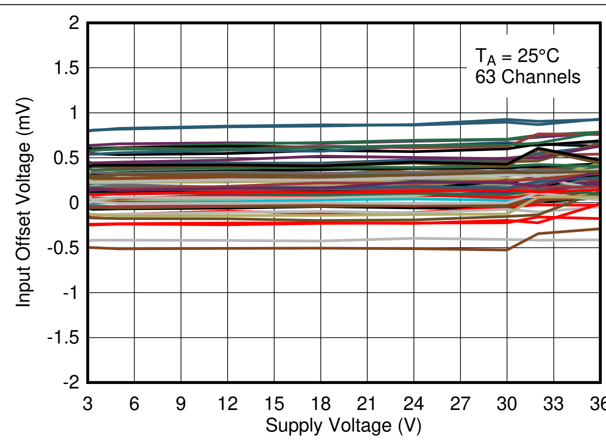


Figure 5-12. Input Offset Voltage vs. Supply Voltage at 25°C

5.12 Typical Characteristics (continued)

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

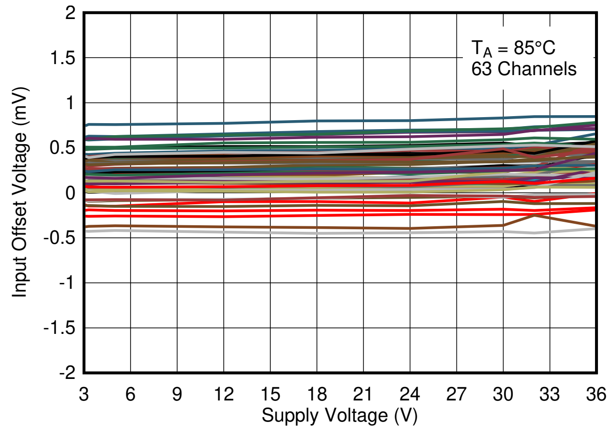


Figure 5-13. Input Offset Voltage vs. Supply Voltage at 85°C

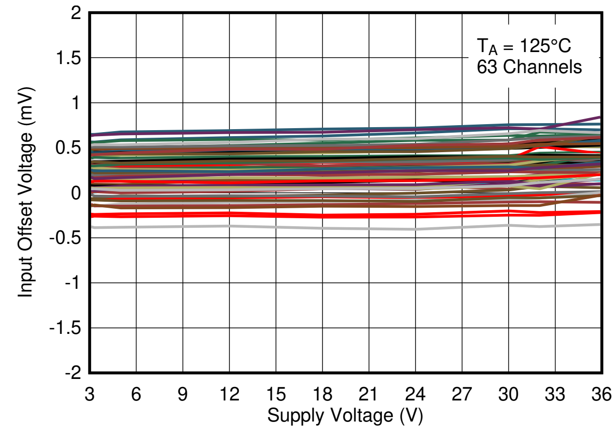


Figure 5-14. Input Offset Voltage vs. Supply Voltage at 125°C

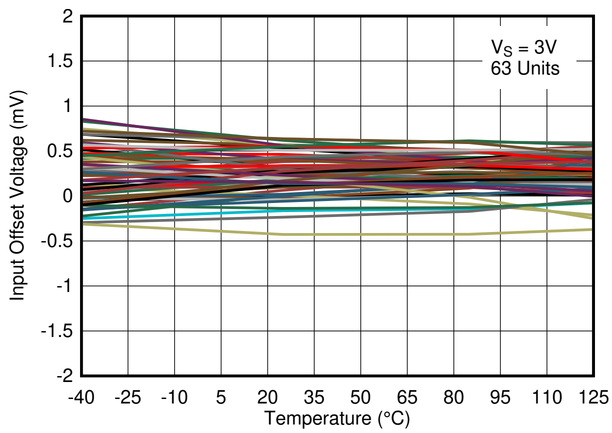


Figure 5-15. Input Offset Voltage vs. Temperature at 3V

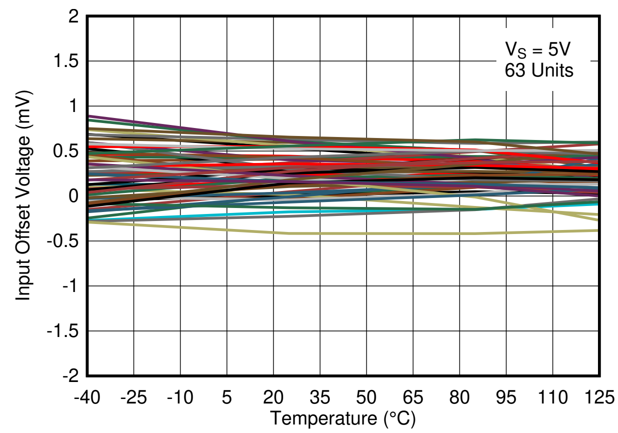


Figure 5-16. Input Offset Voltage vs. Temperature at 5V

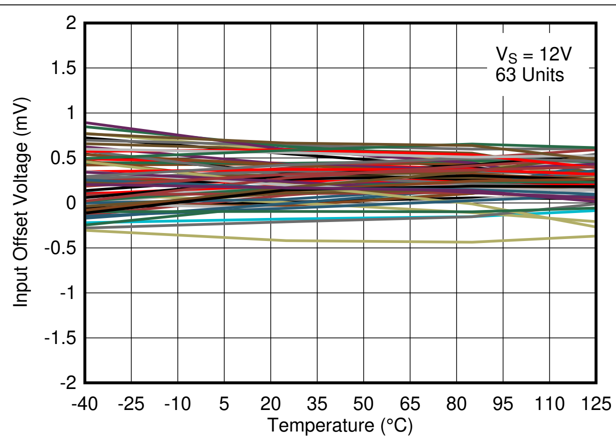


Figure 5-17. Input Offset Voltage vs. Temperature at 12V

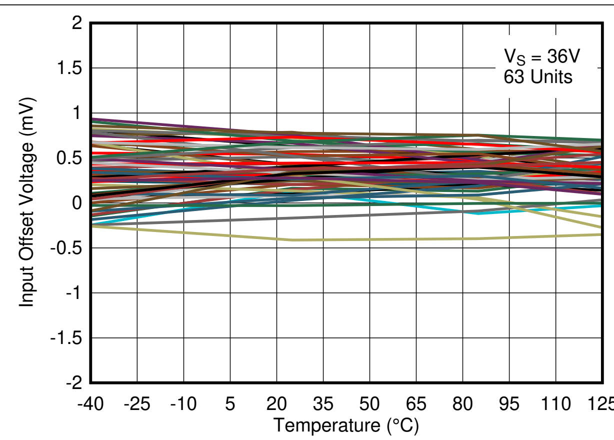


Figure 5-18. Input Offset Voltage vs. Temperature at 36V

5.12 Typical Characteristics (continued)

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

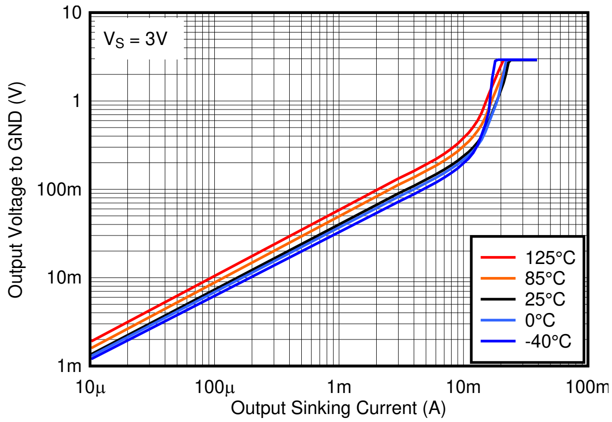


Figure 5-19. Output Low Voltage vs. Output Sinking Current at 3V

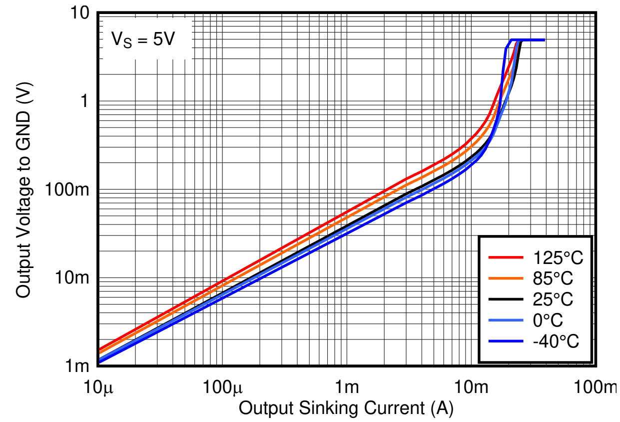


Figure 5-20. Output Low Voltage vs. Output Sinking Current at 5V

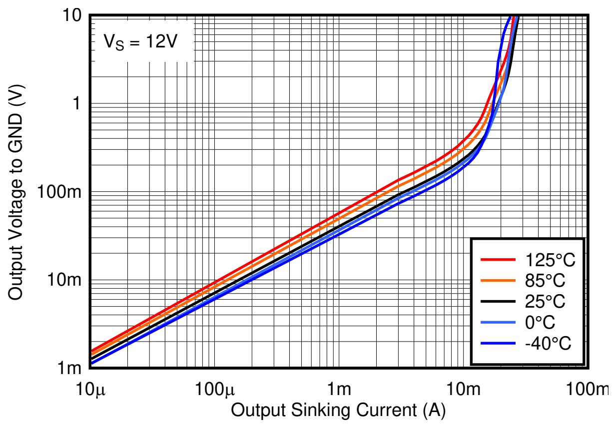


Figure 5-21. Output Low Voltage vs. Output Sinking Current at 12V

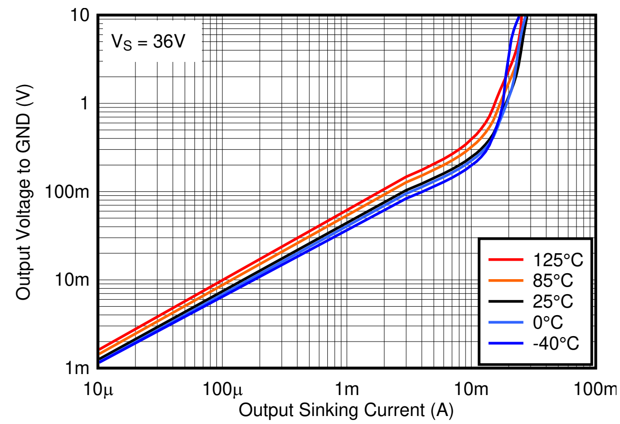


Figure 5-22. Output Low Voltage vs.Output Sinking Current at 36V

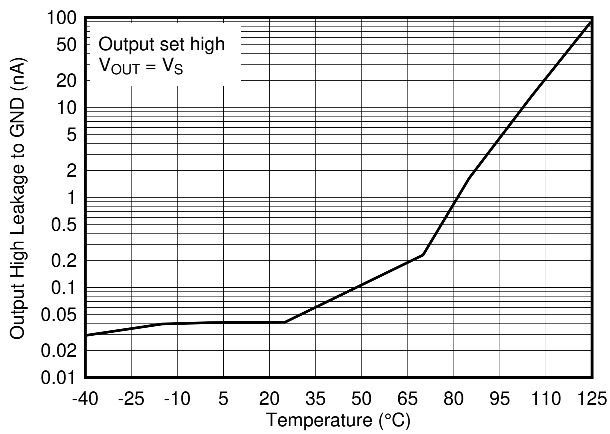


Figure 5-23. Output High Leakage Current vs.Temperature at 5V

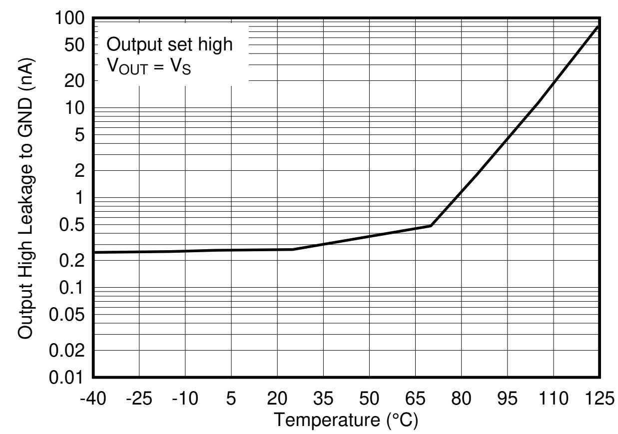


Figure 5-24. Output High Leakage Current vs. Temperature at 36V

5.12 Typical Characteristics (continued)

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

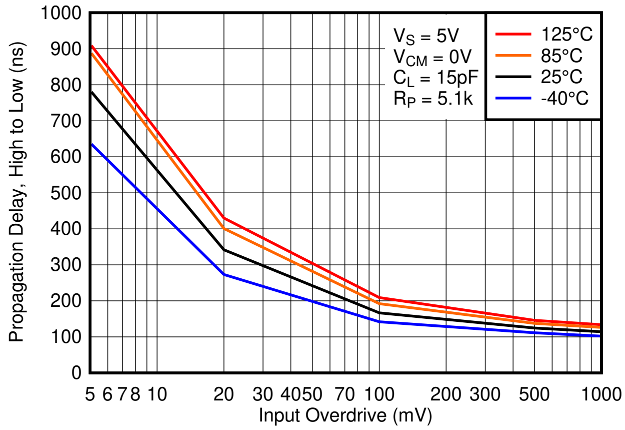


Figure 5-25. High to Low Propagation Delay vs. Input Overdrive Voltage, 5V

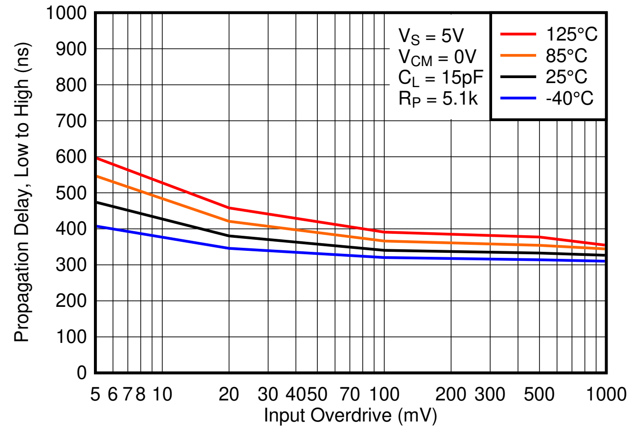


Figure 5-26. Low to High Propagation Delay vs. Input Overdrive Voltage, 5V

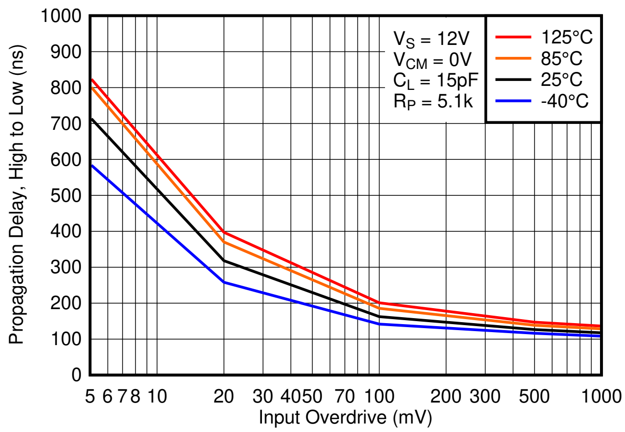


Figure 5-27. High to Low Propagation Delay vs. Input Overdrive Voltage, 12V

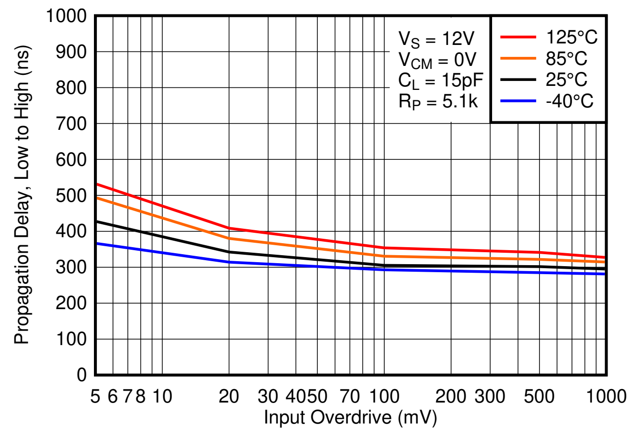


Figure 5-28. Low to High Propagation Delay vs. Input Overdrive Voltage, 12V

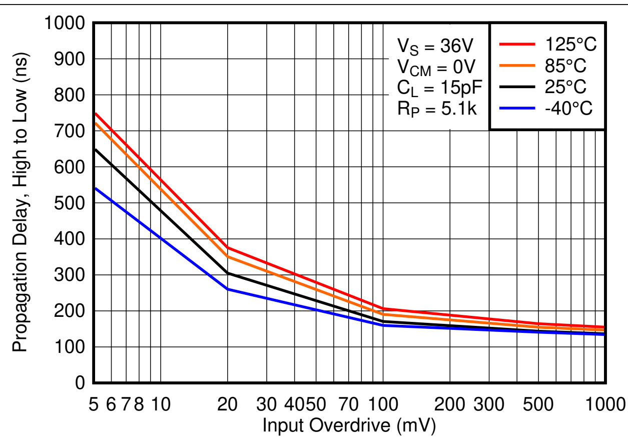


Figure 5-29. High to Low Propagation Delay vs. Input Overdrive Voltage, 36V

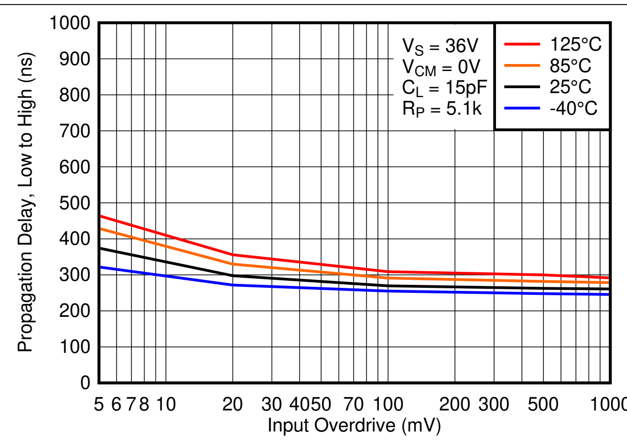


Figure 5-30. Low to High Propagation Delay vs. Input Overdrive Voltage, 36V

5.12 Typical Characteristics (continued)

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

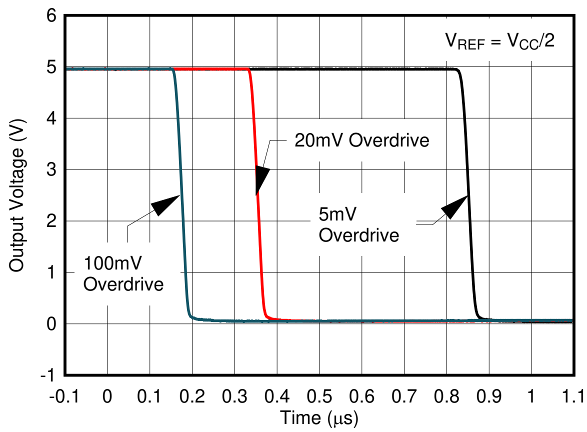


Figure 5-31. Response Time for Various Overdrives, High-to-Low Transition

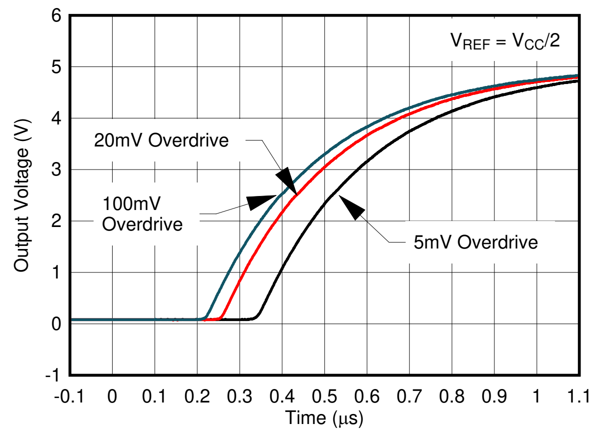


Figure 5-32. Response Time for Various Overdrives, Low-to-High Transition

6 Detailed Description

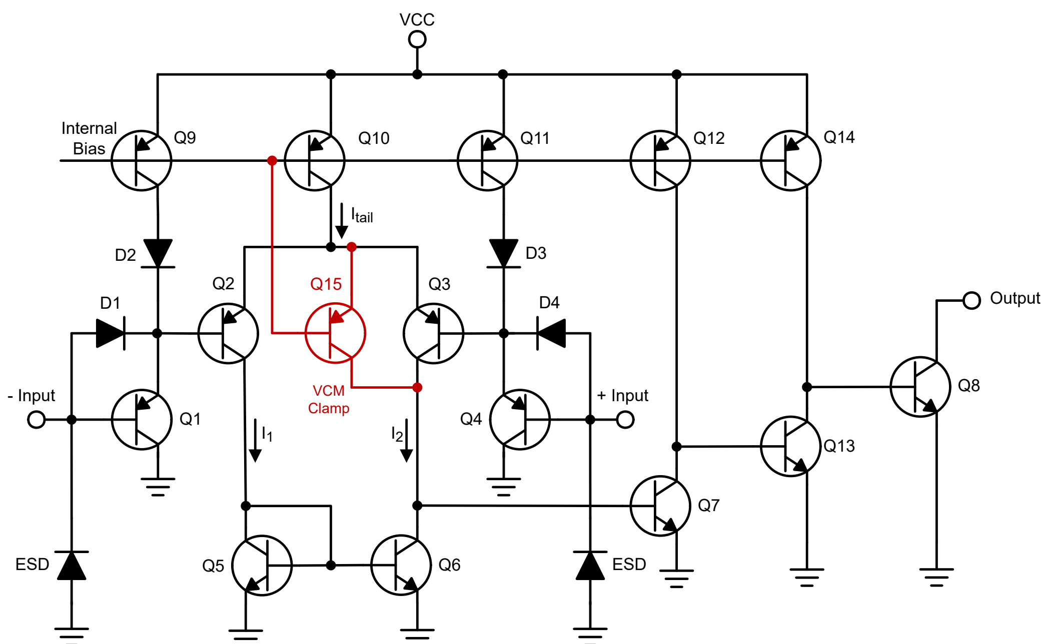
6.1 Overview

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 Iq, 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 VOL 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

Note

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

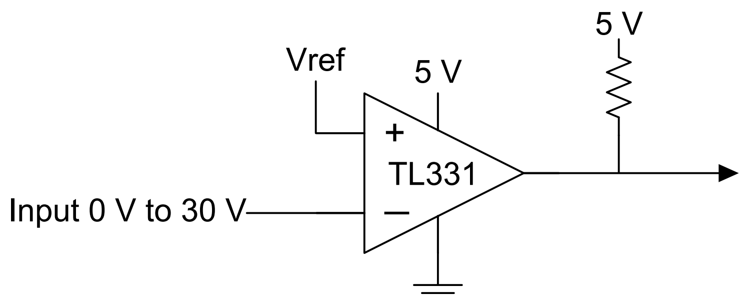


Figure 7-1. Typical Application Schematic

7.2.1 Design Requirements

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

Table 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})	1µA 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} = 5.1kΩ, and 50pF scope probe.

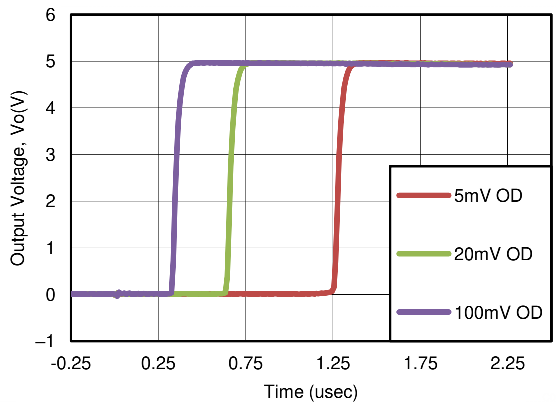


Figure 7-2. Response Time for Various Overdrives (Positive Transition)

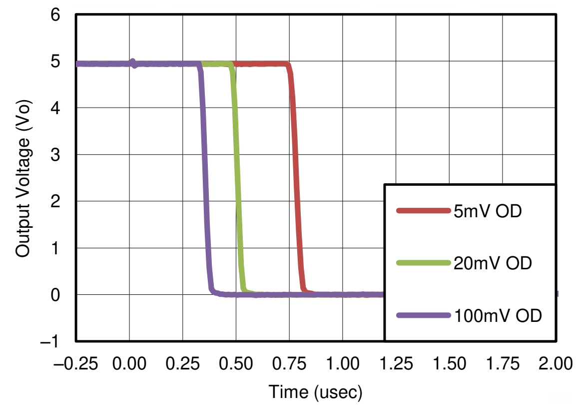


Figure 7-3. Response Time for Various Overdrives (Negative Transition)

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

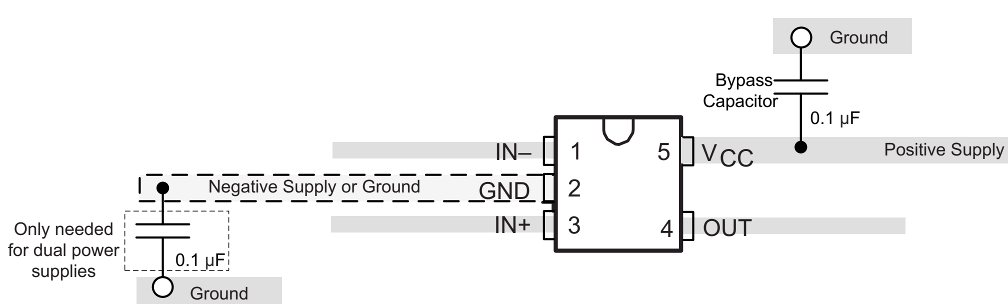


Figure 7-4. TL331 Layout Example

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 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

8.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.
All trademarks are the property of their respective owners.

8.5 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

8.6 Glossary

TI Glossary	This glossary lists and explains terms, acronyms, and definitions.

9 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

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
• Corrected Family Comparison Table supply voltages for "B", "K" and "I" versions	1

Changes from Revision H (April 2020) to Revision I (August 2020)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document	1
• Added "B" device Typical Char graphs	8

Changes from Revision G (January 2015) to Revision H (April 2020)	Page
• Added TL331B and TL391B tables and pinouts, Updated front page for new B devices for APL	1
• Added Input current, I_{IK} in *Absolute Maximum Ratings*	4
• Changed incorrect TL331 and TL331K Temp Ranges in *Recommended Operating Conditions*	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 *Design Parameters*	15
• Changed first paragraph of the *Response Time* section	16
• Added *Receiving Notification of Documentation Updates* section and *Community Resources* 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.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TL331BIDBVR	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	331B	Samples
TL331IDBVR	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 85	(T1I8, T1IG, T1IL, T1IS)	Samples
TL331IDBVT	ACTIVE	SOT-23	DBV	5	250	RoHS & Green	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 85	(T1I8, T1IG, T1IL, T1IU)	Samples
TL331KDBVR	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 105	(T1K8, T1KG, T1KJ, T1KL)	Samples
TL331KDBVRG4	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 105	(T1K8, T1KG, T1KL)	Samples
TL331KDBVT	ACTIVE	SOT-23	DBV	5	250	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 105	(T1K8, T1KG, T1KJ, T1KL)	Samples
TL391BIDBVR	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 125	391B	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

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

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

(6) Lead finish/Ball material - Orderable Devices 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.

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

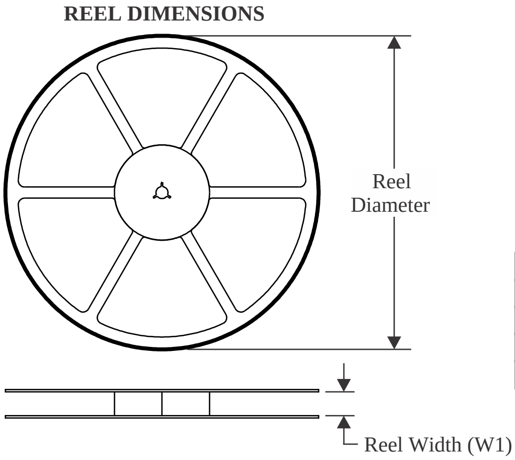
OTHER QUALIFIED VERSIONS OF TL331, TL331B, TL391B :

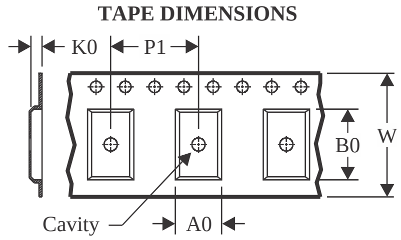
- Automotive : TL331-Q1, TL331B-Q1, TL391B-Q1
- Enhanced Product : TL331-EP

NOTE: Qualified Version Definitions:

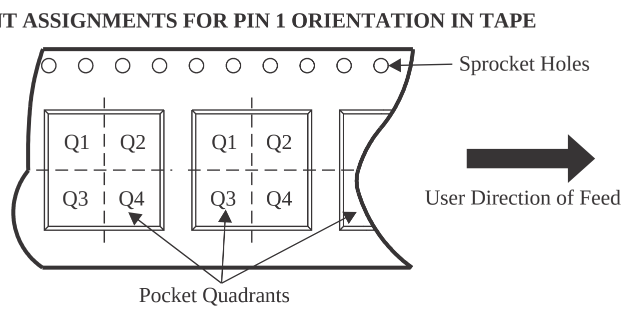
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

TAPE AND REEL INFORMATION





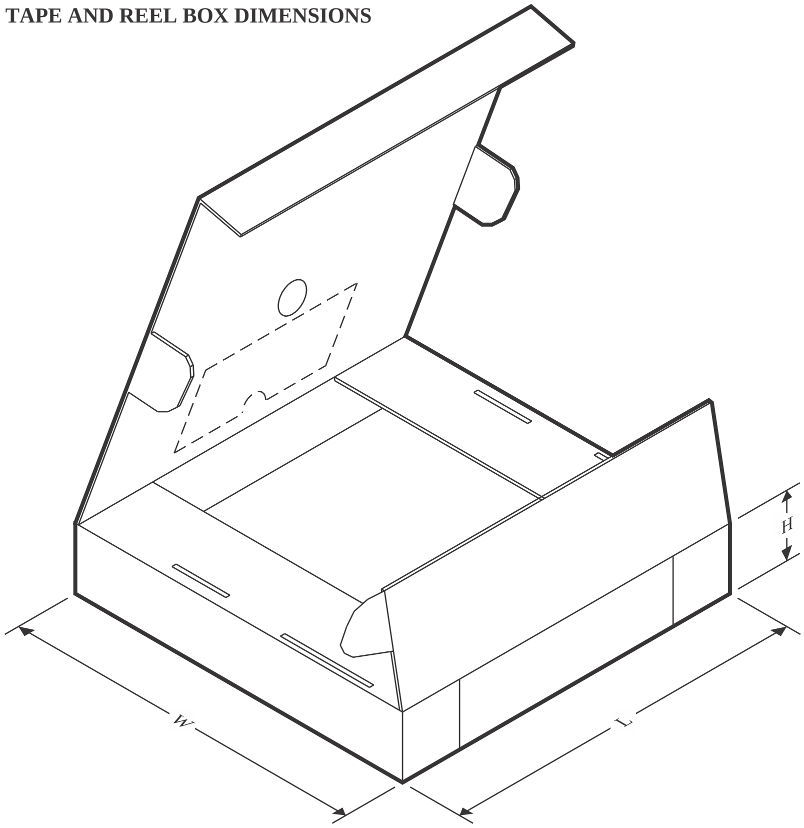
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers



*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	180.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TL331BIDBVR	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
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
TL331KDBVRG4	SOT-23	DBV	5	3000	178.0	9.0	3.23	3.17	1.37	4.0	8.0	Q3
TL331KDBVRG4	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	180.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

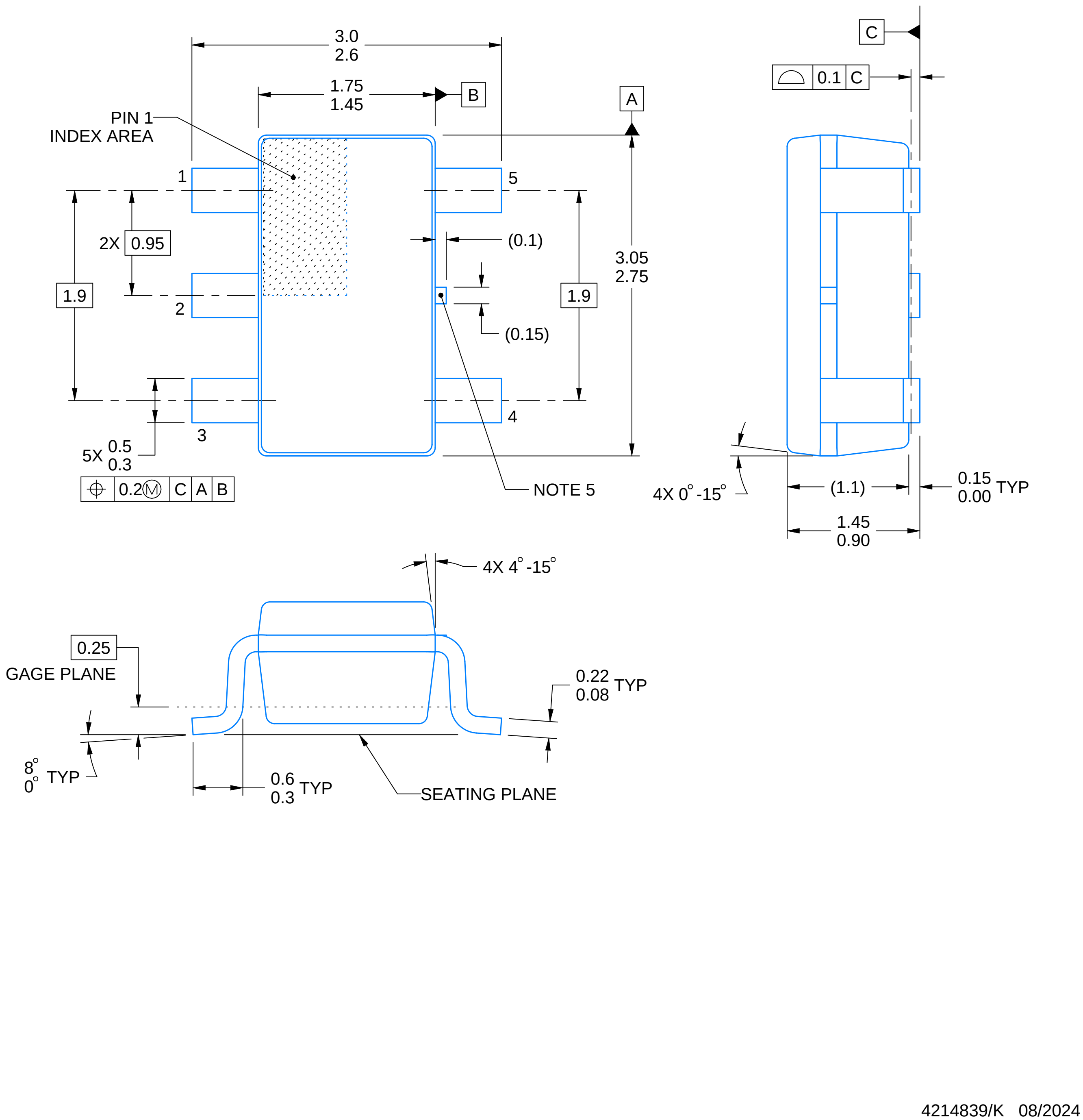
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TL331BIDBVR	SOT-23	DBV	5	3000	210.0	185.0	35.0
TL331BIDBVR	SOT-23	DBV	5	3000	210.0	185.0	35.0
TL331IDBVR	SOT-23	DBV	5	3000	210.0	185.0	35.0
TL331IDBVR	SOT-23	DBV	5	3000	210.0	185.0	35.0
TL331IDBVT	SOT-23	DBV	5	250	210.0	185.0	35.0
TL331KDBVR	SOT-23	DBV	5	3000	210.0	185.0	35.0
TL331KDBVR	SOT-23	DBV	5	3000	210.0	185.0	35.0
TL331KDBVRG4	SOT-23	DBV	5	3000	180.0	180.0	18.0
TL331KDBVRG4	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	210.0	185.0	35.0

PACKAGE OUTLINE

DBV0005A

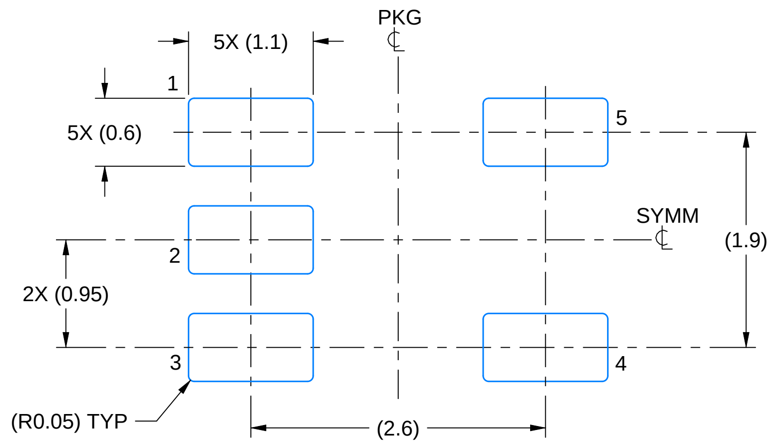
SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR

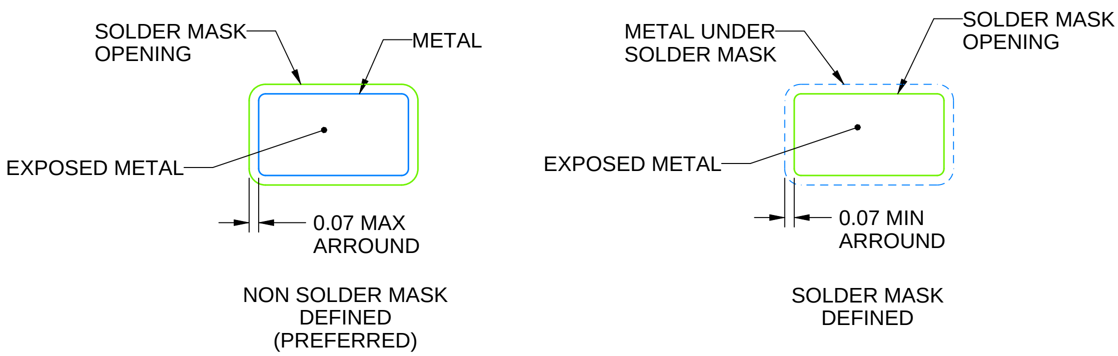


NOTES:

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. Refernce 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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X

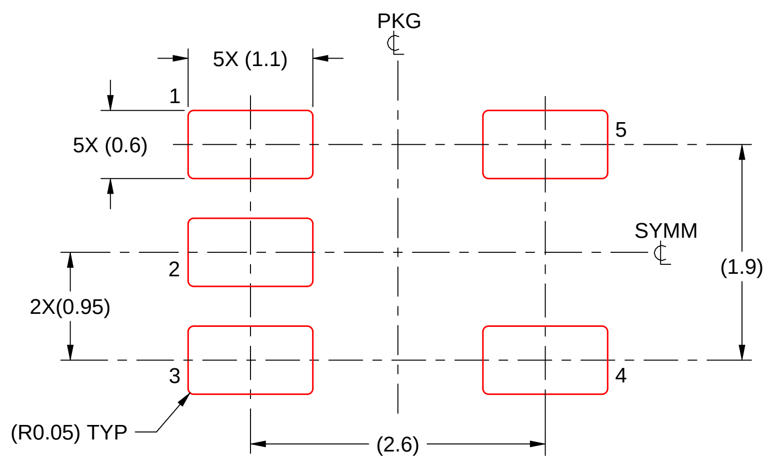


SOLDER MASK DETAILS

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.



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.