

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 maximumrated 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)
TL331, TL331B, TL391B	SOT-23 (5)	2.90mm × 1.60mm

- For all available packages, see the orderable addendum at the end of the data sheet.
- 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

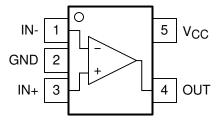


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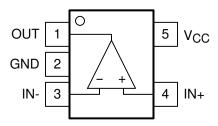


4 Pin Configuration and Functions



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		PIN		
	TL331, TL331B	TL391B	TYPE	DESCRIPTION	
NAME	NO.	NO.			
IN+	3	4	I	Positive Input	
IN-	1	3	I	Negative Input	
OUT	4	1	0	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
VI	Input voltage range (either input)	-0.3	36	V
Vo	Output voltage	0	36	V
Io	Output current	0	20	mA
	Duration of output short-circuit to ground ⁽⁴⁾	Unlir	nited	
I _{IK}	Input current ⁽⁵⁾		-50	mA
TJ	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
VI	Input voltage range (either input)	-0.3	38	V
Vo	Output voltage	-0.3	38	V
Io	Output current		20	mA
	Duration of output short-circuit to ground ⁽⁴⁾	Unlir	nited	
I _{IK}	Input current ⁽⁵⁾		-50	mA
TJ	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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- (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.

Product Folder Links: TL331 TL331B TL391B

5.3 ESD Ratings - TL331B and TL391B

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

- (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	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾	±1000	V
V _(ESD)	Electrostatic discriarge	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
TJ	Junction temperature, TL331	-40	85	°C
T _J	Junction temperature, TL331K	-40	105	°C

5.7 Thermal Information

		TL331x, TL391x	
	Junction-to-ambient thermal resistance	DBV (SOT-23)	UNIT
		5 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	211.7	°C/W
R _{0JC(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
ΨЈВ	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
\/	Innut offset valtage	V _S = 5 to 36V	-2.5	±0.37	2.5	ma\ /
V _{IO}	Input offset voltage	$V_S = 5 \text{ to } 36V, T_A = -40^{\circ}\text{C to } +125^{\circ}\text{C}$	-4		4	mV
1	lanut bigg gurrant			-3.5	-25	nA
I _B	Input bias current	T _A = -40°C to +125°C			-50	nA
loo	lanut affect augrent		-10	±0.5	10	nA
I _{OS}	Input offset current	T _A = -40°C to +125°C	-25		25	nA
V	lanut valtaga ranga	V _S = 3 to 36V	(V-) - 0.1		(V+) - 1.5	V
V _{CM}	Input voltage range	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; $R_L \ge 15k$ to $(V+)$	50	200		V/mV
	Low lovel output Voltage Coving	I _{SINK} ≤ 4mA, V _{ID} = -1V		110	400	mV
V _{OL}	Low level output Voltage {swing from (V–)}	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	$(V+) = V_O = 36V; V_{ID} = 1V; T_A = -40^{\circ}C \text{ to } +125^{\circ}C$			1000	nA
I _{OL}	Low level output current	V _{OL} = 1.5V; V _{ID} = -1V; V _S = 5V	6	18		mA
	Ouiseant surrent	V _S = 5V, no load		210	330	μA
IQ	Quiescent current	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.

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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	Input offset voltage	V _{CC} = 5V to 30V, V _O = 1.4V,	25°C		2	5	mV
V _{IO}	input onset voltage	$V_{IC} = V_{IC(min)}$ Full ran				9	IIIV
	Input offset current	V _O = 1.4V	25°C		5 50		nA
I _{IO}	input onset current	V _O = 1.4V	Full range			250	IIA
	B Input bias current	V _O = 1.4V	25°C		-25	-250	nA
I _{IB}	input bias current	V _O = 1.4V	Full range			-400	IIA
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, $R_{L} \ge$ 15 kΩ to V_{CC}	25°C	50	200		V/mV
	High lovel output ourrent	V _{OH} = 5V, V _{ID} = 1V	25°C		0.1	50	nA
Іон	High-level output current	V _{OH} = 30V, V _{ID} = 1V	Full range			1	μΑ
	Low-level output voltage	I _{OL} = 4mA, V _{ID} = -1V	25°C		150	400	mV
V _{OL}	VOL LOW-level output voltage	10L - 4111A, VID1V	Full range		700		IIIV
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

- All characteristics are measured with zero common-mode input voltage, unless otherwise specified.
- 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 commonmode voltage range is V_{CC+} – 1.5V, but either or both inputs can go to 30V without damage. 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

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

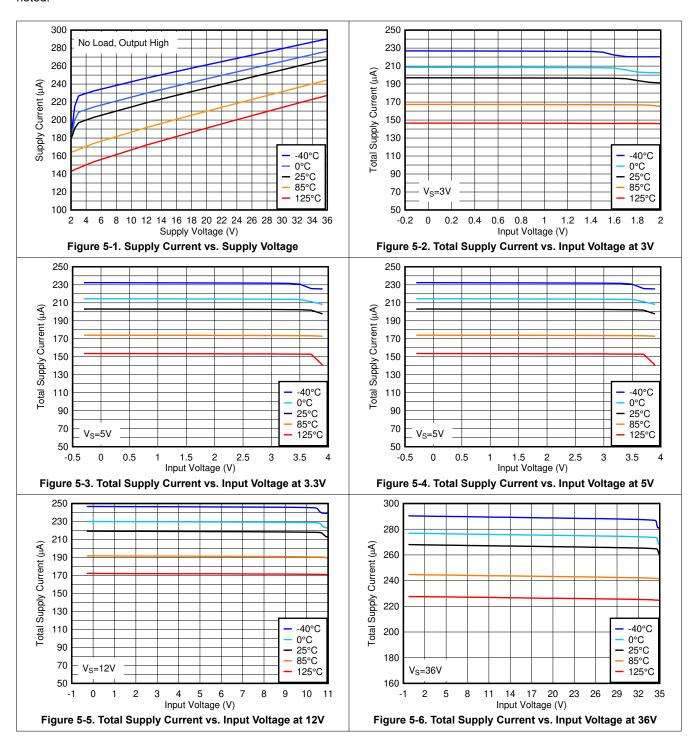
PARAMETER	TEST CONDITION	TYP	UNIT	
Posnonso timo	R_L connected to 5V through 5.1k Ω , C_L = 15pF ⁽¹⁾ (2)	100mV input step with 5mV overdrive	1.3	II.C
Response time	The connected to 57 through 5. This, Ce = 15pr 777	100mV input step with 5mV overdrive 1.3	μδ	

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



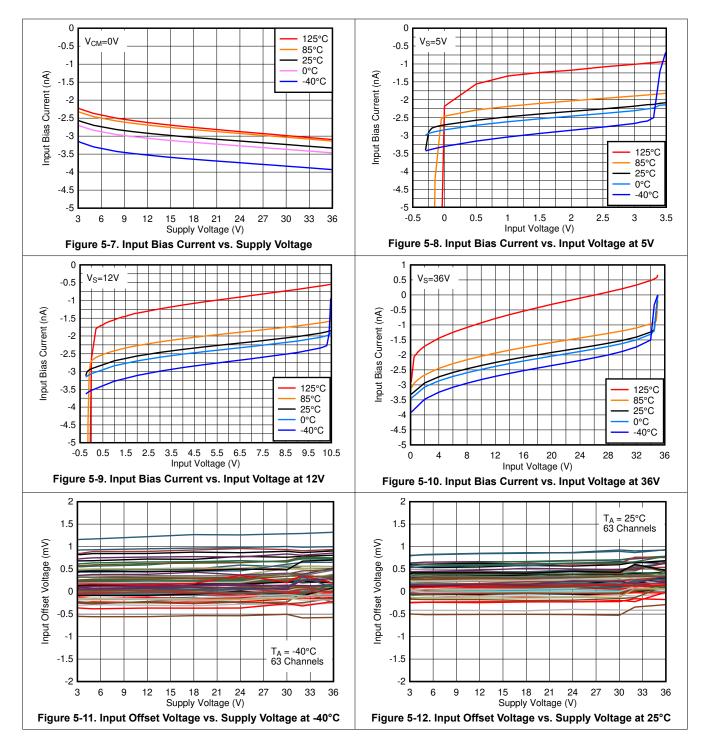
5.12 Typical Characteristics

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



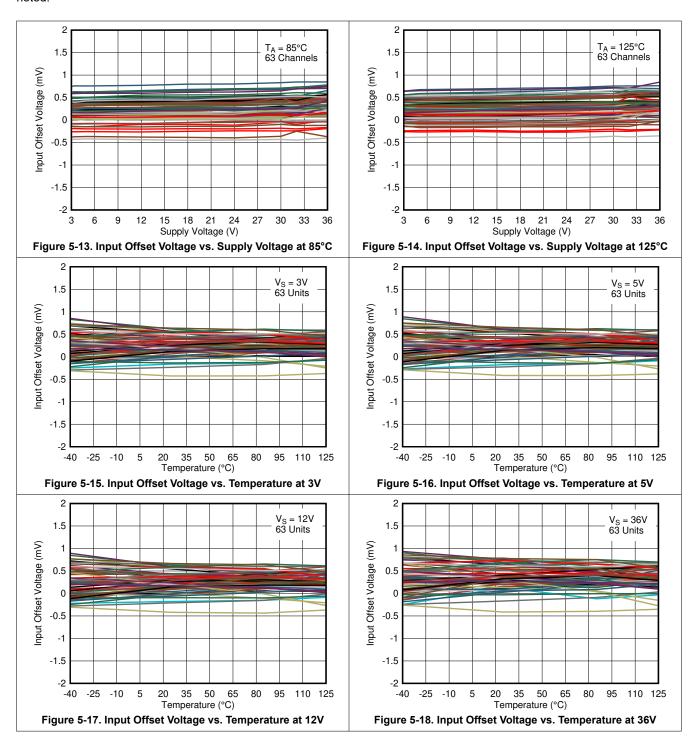


 $T_A = 25$ °C, $V_S = 5$ V, $R_{PULLUP} = 5.1$ k, $C_L = 15$ pF, $V_{CM} = 0$ V, $V_{UNDERDRIVE} = 100$ mV, $V_{OVERDRIVE} = 100$ mV unless otherwise noted.





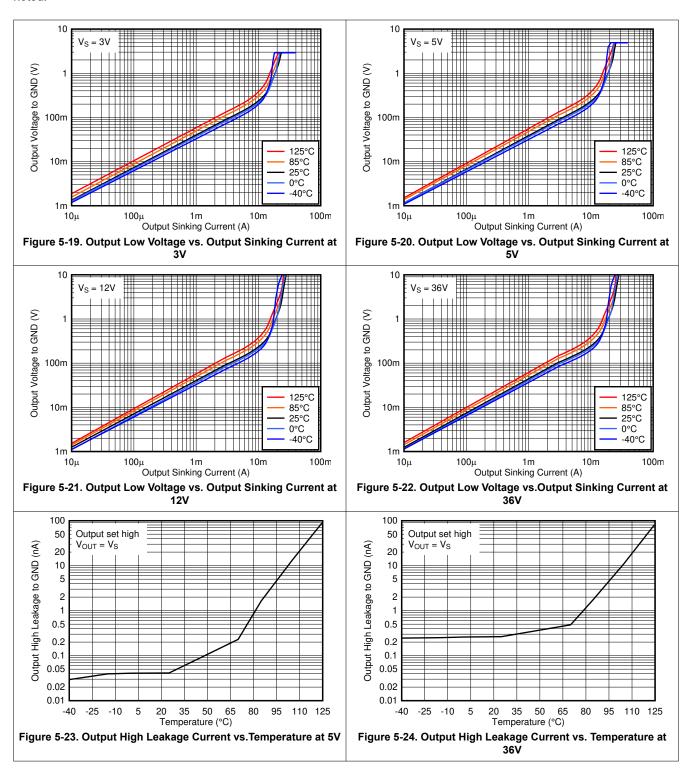
 $T_A = 25$ °C, $V_S = 5$ V, $R_{PULLUP} = 5.1$ k, $C_L = 15$ pF, $V_{CM} = 0$ V, $V_{UNDERDRIVE} = 100$ mV, $V_{OVERDRIVE} = 100$ mV unless otherwise noted.



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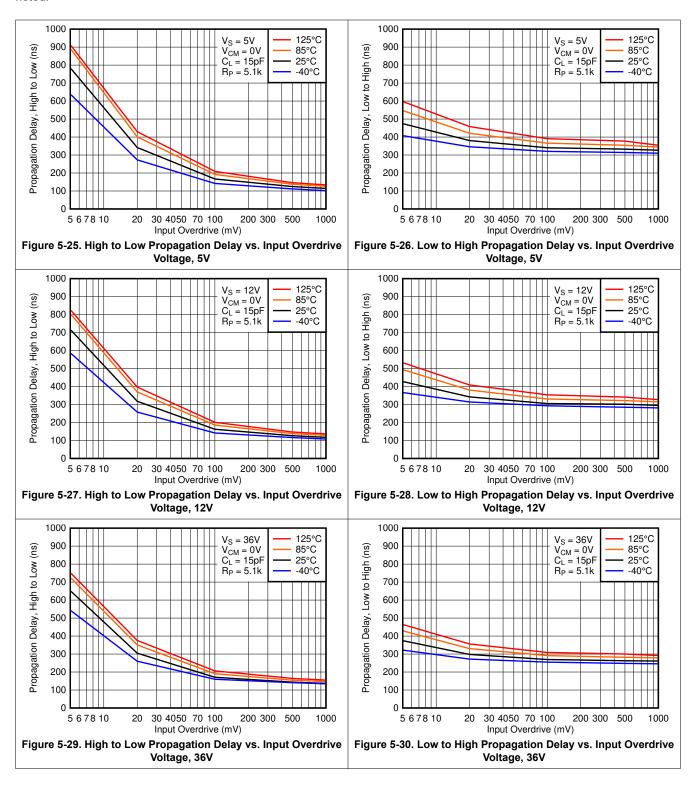
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 $T_A = 25$ °C, $V_S = 5$ V, $R_{PULLUP} = 5.1$ k, $C_L = 15$ pF, $V_{CM} = 0$ V, $V_{UNDERDRIVE} = 100$ mV, $V_{OVERDRIVE} = 100$ mV unless otherwise noted.





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



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 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.

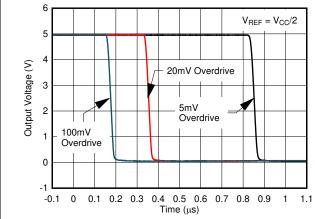


Figure 5-31. Response Time for Various Overdrives, High-to-Low Transition

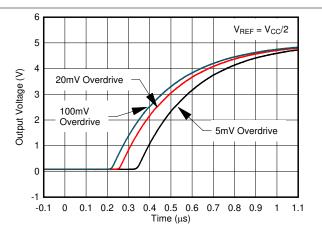


Figure 5-32. Response Time for Various Overdrives, Low-to-High Transition

6 Detailed Description

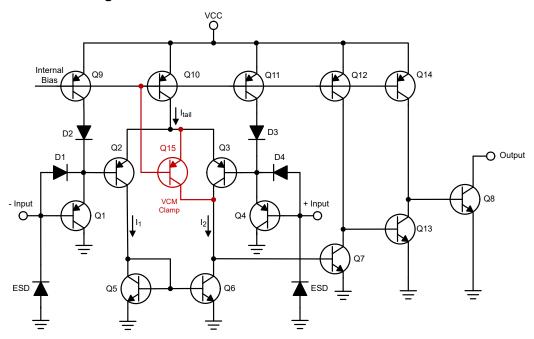
6.1 Overview

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.

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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

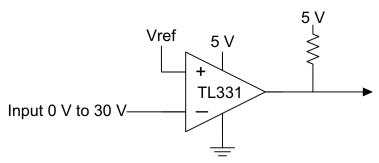


Figure 7-1. Typical Application Schematic

7.2.1 Design Requirements

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

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 1µA to 4mA Output Current (V_{LOGIC}/R_{PULLUP}) Input Overdrive Voltage 100mV Reference Voltage 2.5V Load Capacitance (C₁) 15pF

Table 7-1. Design Parameters

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 <u>Section 7.2.3</u> 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 τ_R ~ R_{PULLUP} × C_L
- The fall time (τ_F) is approximately τ_F ~ R_{CF} × C_I
 - 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}

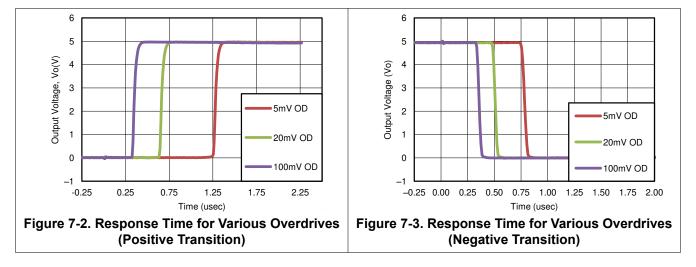
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7.2.3 Application Curves

The following curves were generated with 5V on V_{CC} and V_{Logic} , R_{PULLUP} = 5.1k Ω , 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

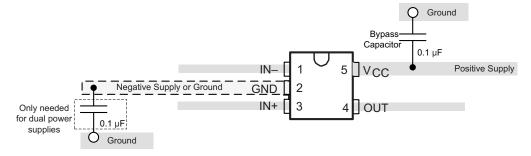


Figure 7-4. TL331 Layout Example

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 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

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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	
Updated Functional Block Diagram and text	
Changes from Revision J (November 2020) to Revision K (September 2023)	
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 	
Changed text from: open-drain output to: open-collector output	
 Removed sentence: This is enables much head room for modern day supplies of 3.3V and 5.0V 	
 Removed sentence: This is enables much head room for modern day supplies of 3.3V and 5.0V. 	
Changed Output Current specifications from: to: in Design Parameters	
Changed first paragraph of the Response Time section	
 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.

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PACKAGING INFORMATION

Orderable part number	Status (1)	Material type	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material	MSL rating/ Peak reflow	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)
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.

PACKAGE OPTION ADDENDUM

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(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



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TAPE AND REEL INFORMATION





A0	Dimension designed to accommodate the component width
В0	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

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing		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
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



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*All dimensions are nominal

All difficultions are norminal							
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
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



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.



SMALL OUTLINE TRANSISTOR



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.



SMALL OUTLINE TRANSISTOR



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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Last updated 10/2025