

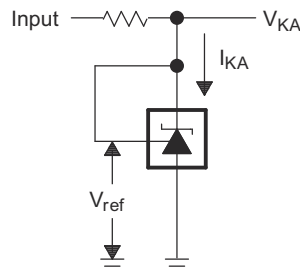
TLA431, TLA432 All-Capacitor Stable Precision Programmable Reference

1 Features

- No output capacitor required
- Stable with all capacitive loads
- Reference voltage tolerance at 25°C
 - 1% (A grade)
- Adjustable output voltage: V_{ref} to 36V
- Operation from –40°C to 125°C
- Typical temperature drift (TLA43xA)
 - 8mV (I temp)
 - 11mV (Q temp)
- Low Output Noise
- 0.2Ω Typical output impedance
- Sink-current capability: 0.2mA to 100mA
- Pin-compatible with industry-standard TL431 and TL432

2 Applications

- [Rack server power](#)
- [Industrial AC/DC](#)
- [AC inverter & VF drives](#)
- [Servo drive control module](#)
- [Notebook PC power adapter design](#)



Simplified Schematic

3 Description

The TLA431 and TLA432 devices are three-terminal adjustable shunt regulators that are stable with all capacitor loads. The devices are pin compatible with the industry standard TL431 and TL432 but with improved stability to support all capacitor loads. The output cathode voltage can be set to any value between V_{ref} (2.495V) and 36V, with two external resistors. These devices have a typical output impedance of 0.2Ω. Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent replacements for Zener diodes in many applications, such as onboard regulation, adjustable power supplies, and switching power supplies. The TLA431 also functions as a comparator for undervoltage monitoring. The internal amplifier and reference of the TLA431 is used as an error amplifier in isolated optocoupler flyback power supplies. The TLA432 device has exactly the same functionality and electrical specifications as the TLA431 device.

The TLA431 and TLA432 devices are specified in two temperature grades, I and Q. In addition, the devices offer good stability reference voltage over the entire temperature range.

Device Information

PART NUMBER ⁽¹⁾	PACKAGE (PIN) ⁽²⁾	BODY SIZE (NOM)
TLA431	SOT23-3	2.90mm × 1.30mm
TLA432	SOT23-3	2.90mm × 1.30mm
TLA431 ⁽³⁾	SOT5X3 (6)	1.20mm × 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.
- (3) *Product Preview*



Table of Contents

1 Features	1	8.4 Device Functional Modes.....	12
2 Applications	1	9 Applications and Implementation	14
3 Description	1	9.1 Application Information.....	14
4 Device Comparison Table	3	9.2 Typical Applications.....	14
5 Pin Configuration and Functions	3	9.3 System Examples.....	19
6 Specifications	4	9.4 Power Supply Recommendations.....	20
6.1 Absolute Maximum Ratings.....	4	9.5 Layout.....	21
6.2 ESD Ratings.....	4	10 Device and Documentation Support	22
6.3 Recommended Operating Conditions.....	4	10.1 Device Nomenclature.....	22
6.4 Thermal Information.....	4	10.2 Related Links.....	22
6.5 Electrical Characteristics.....	5	10.3 Receiving Notification of Documentation Updates..	22
6.6 Typical Characteristics.....	6	10.4 Support Resources.....	22
7 Parameter Measurement Information	9	10.5 Trademarks.....	22
7.1 Temperature Coefficient.....	9	10.6 Electrostatic Discharge Caution.....	22
7.2 Dynamic Impedance.....	10	10.7 Glossary.....	23
8 Detailed Description	11	11 Revision History	23
8.1 Overview.....	11	12 Mechanical, Packaging, and Orderable	
8.2 Functional Block Diagram.....	11	Information	23
8.3 Feature Description.....	12		

4 Device Comparison Table

DEVICE PINOUT	INITIAL ACCURACY	OPERATING FREE-AIR TEMPERATURE (T _A)
TLA431 TLA432	A: 1%	I: -40°C to 85°C Q: -40°C to 125°C

5 Pin Configuration and Functions

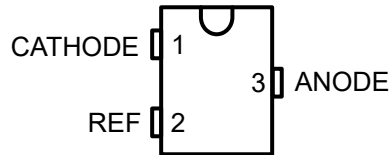


Figure 5-1. DBZ Package, 3-Pin SOT-23, TLA431 (Top View)

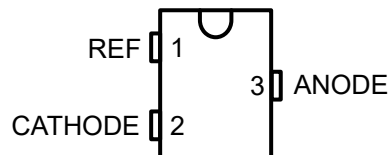


Figure 5-2. DBZ Package, 3-Pin SOT-23, TLA432 (Top View)

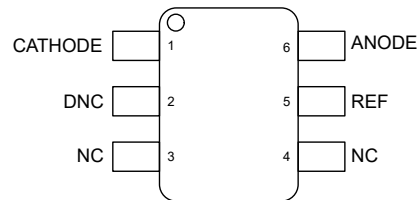


Figure 5-3. DRL Package, 6-Pin SOT-563, TLA431 (Top View) *PRODUCT PREVIEW*

Table 5-1. Pin Functions

NAME	PIN			TYPE	DESCRIPTION
	TLA431		TLA432		
	DBZ	DRL	DBZ		
CATHODE	1	1	2	I/O	Shunt Current/Voltage input
REF	2	5	1	I	Threshold relative to common anode
ANODE	3	6	3	O	Common pin, normally connected to ground
NC	-	3, 4	-	-	No connect
DNC	-	2	-	-	Do not connect

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
V _{KA}	Cathode Voltage ⁽²⁾		37	V
I _{KA}	Continuous Cathode Current Range	-100	150	mA
I _{I(ref)}	Reference Input Current	-0.05	10	mA
T _J	Operating Junction Temperature Range	-40	150	C
T _{stg}	Storage Temperature Range	-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 are with respect to ANODE, unless otherwise noted.

6.2 ESD Ratings

		VALUE	UNIT
V _(ESD)	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001pins ⁽¹⁾	±2000
		Charged-device model (CDM), per JEDEC specification JESD22- ±1000 VC101 ⁽²⁾	±1000

- (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.

6.3 Recommended Operating Conditions

See ⁽¹⁾

		MIN	MAX	UNIT	
V _{KA}	Cathode Voltage	V _{REF}	36	V	
I _{KA}	Continuous Cathode Current Range	0.2	100	mA	
T _A	Operating Free-Air Temperature	TLA43xxI	-40	85	C
		TLA43xxQ	-40	125	C

- (1) Maximum power dissipation is a function of T_{J(max)}, θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is P_D = (T_{J(max)} - T_A)/θ_{JA}. Operating at the absolute maximum T_J of 150°C can affect reliability.

6.4 Thermal Information

THERMAL METRIC ⁽¹⁾		TLA43x	UNIT
		DBZ	
		3 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	218.8	C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	115.8	C/W
R _{θJB}	Junction-to-board thermal resistance	53.1	C/W
ψ _{JT}	Junction-to-top characterization resistance	16.6	C/W
ψ _{JB}	Junction-to-board characterization resistance	52.6	C/W

- (1) For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report, [SPRA953](#).

6.5 Electrical Characteristics

over recommended operating conditions, $T_A = 25^\circ\text{C}$ (unless otherwise noted)

PARAMETER	TEST CIRCUIT	TEST CONDITIONS	MIN	TYP	MAX	UNIT	
V_{ref}	Reference Voltage	See Figure 7-1 $V_{K_A} = V_{\text{ref}}, I_{K_A} = 10\text{mA}$	TLA43xAx devices			2470 2495 2520	mV
$V_{I(\text{dev})}$	Deviation of reference input voltage over full temperature range ⁽¹⁾	See Figure 7-1 $V_{K_A} = V_{\text{ref}}, I_{K_A} = 10\text{mA}, -40^\circ\text{C} < T_J < 85^\circ\text{C}$	TLA43xxI devices			8 17	mV
$V_{I(\text{dev})}$	Deviation of reference input voltage over full temperature range ⁽¹⁾	See Figure 7-1 $V_{K_A} = V_{\text{ref}}, I_{K_A} = 10\text{mA}, -0^\circ\text{C} < T_J < 90^\circ\text{C}$	TLA43xxQ devices			5 13	mV
$V_{I(\text{dev})}$	Deviation of reference input voltage over full temperature range ⁽¹⁾	See Figure 7-1 $V_{K_A} = V_{\text{ref}}, I_{K_A} = 10\text{mA}, -40^\circ\text{C} < T_J < 125^\circ\text{C}$	TLA43xxQ devices			11 20	mV
$\frac{\Delta V_{\text{ref}}}{\Delta V_{K_A}}$	Ratio of change in reference voltage to the change in cathode voltage	See Figure 7-2 $I_{K_A} = 10\text{mA}$	$\Delta V_{K_A} = 10\text{V} - V_{\text{ref}}$		-1.4 -2.7	mV/V	
			$\Delta V_{K_A} = 36\text{V} - 10\text{V}$		-1 -2	mV/V	
I_{ref}	Reference Input Current	See Figure 7-2 $I_{K_A} = 10\text{mA}, R_1 = 10\text{k}\Omega, R_2 = \infty$				2 4	μA
$I_{I(\text{dev})}$	Deviation of reference input current over full temperature range ⁽¹⁾	See Figure 7-2 $I_{K_A} = 10\text{mA}, R_1 = 10\text{k}\Omega, R_2 = \infty$				0.8 2.5	μA
I_{min}	Minimum cathode current for regulation	See Figure 7-1 $V_{K_A} = V_{\text{ref}}$				0.15 0.2	mA
I_{off}	Off-state cathode current	See Figure 7-3 $V_{K_A} = 36\text{V}, V_{\text{ref}} = 0$				0.1 0.5	μA
$ Z_{K_A} $	Dynamic Impedance ⁽²⁾	See Figure 7-1 $V_{K_A} = V_{\text{ref}}, I_{K_A} = 1\text{mA to } 100\text{mA}$				0.2 0.5	Ω

- (1) The deviation parameters $V_{I(\text{dev})}$ and $I_{I(\text{dev})}$ are defined as the differences between the maximum and minimum values obtained over the rated temperature range. For more details on $V_{I(\text{dev})}$ and how it relates to the average temperature coefficient, see [Parameter Measurement Information](#).
- (2) The dynamic impedance is defined by $|Z_{K_A}| = \Delta V_{K_A} / \Delta I_{K_A}$. For more details on $|Z_{K_A}|$ and how it relates to V_{K_A} , see [Parameter Measurement Information](#).

6.6 Typical Characteristics

Data at high and low temperatures are applicable only within the recommended operating free-air temperature ranges of the various devices.

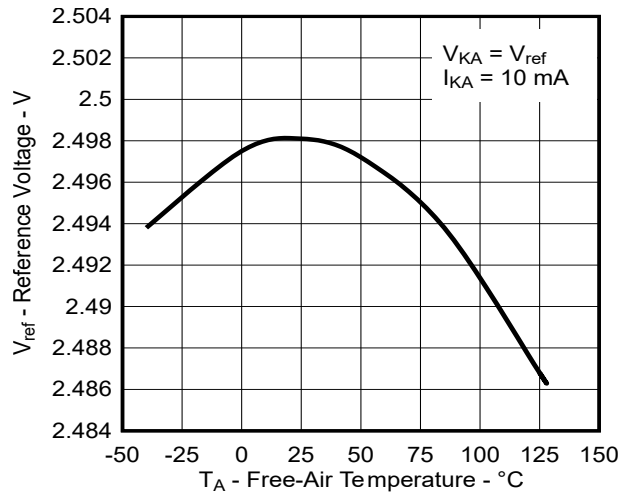


Figure 6-1. Reference Voltage vs Free-Air Temperature

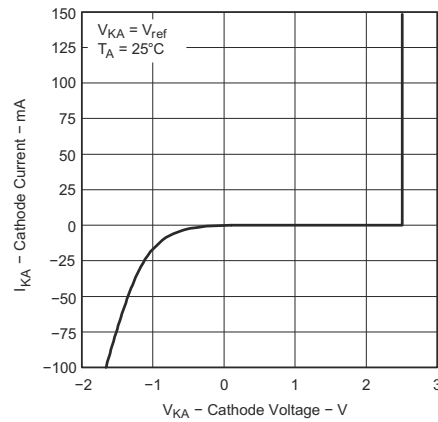


Figure 6-2. Cathode Current vs Cathode Voltage

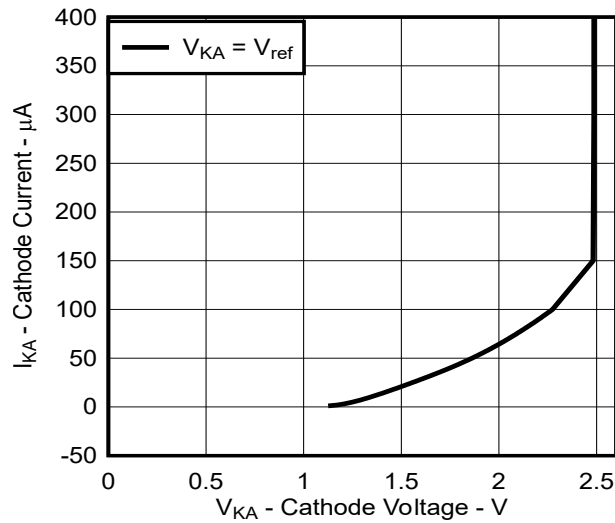


Figure 6-3. Cathode Current vs Cathode Voltage

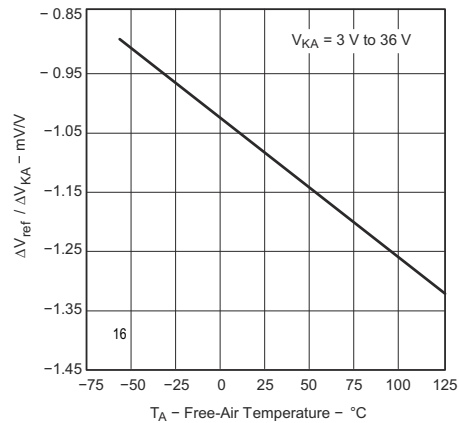


Figure 6-4. Ratio of Delta Reference Voltage to Delta Cathode Voltage vs Free-Air Temperature

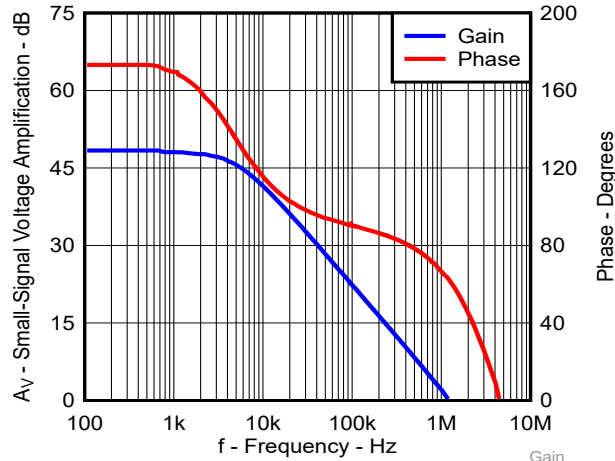


Figure 6-5. Small-Signal Voltage Amplification vs Frequency

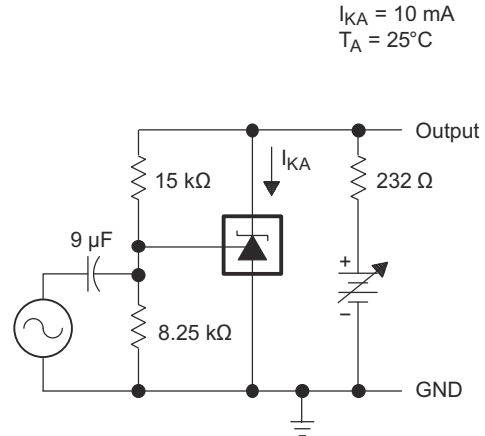


Figure 6-6. Test Circuit for Voltage Amplification

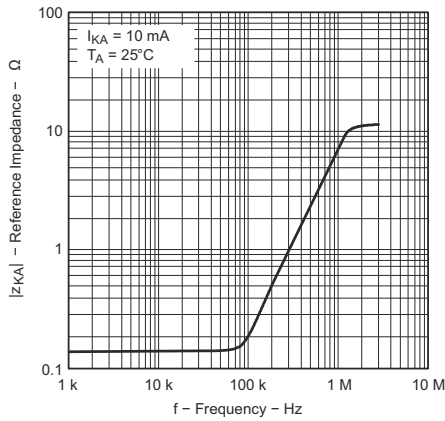


Figure 6-7. Reference Impedance vs Frequency

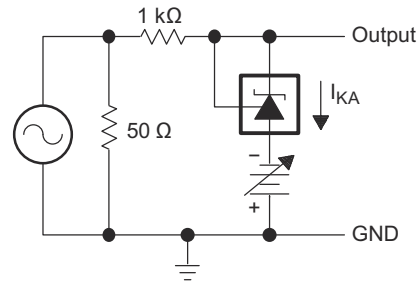


Figure 6-8. Test Circuit for Reference Impedance

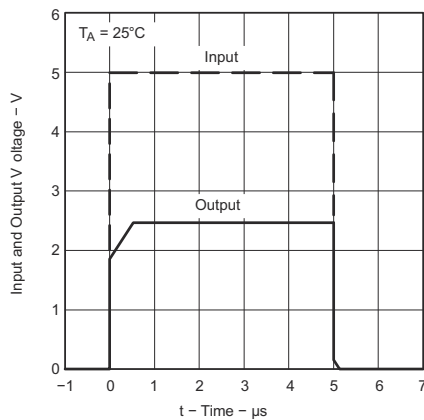


Figure 6-9. Pulse Response

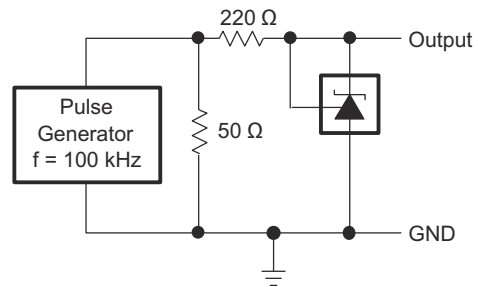


Figure 6-10. Test Circuit for Pulse Response

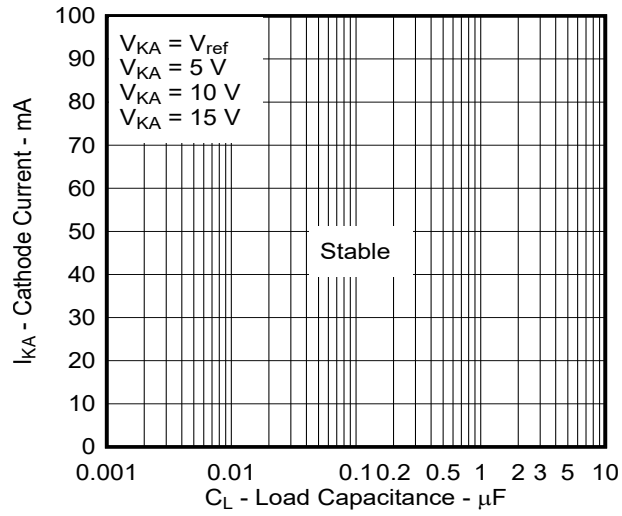


Figure 6-11. Stability Boundary Conditions

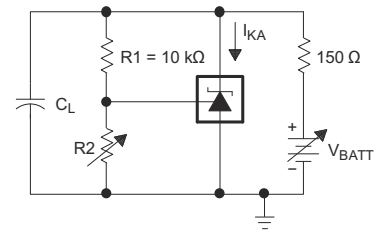
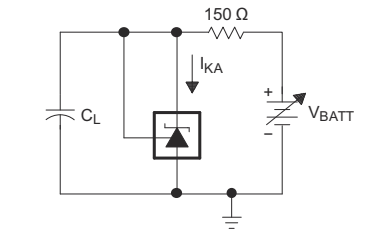


Figure 6-12. Test Circuit for Stability Boundary Conditions

7 Parameter Measurement Information

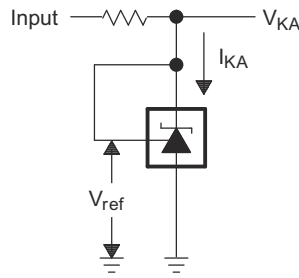


Figure 7-1. Test Circuit for $V_{KA} = V_{ref}$

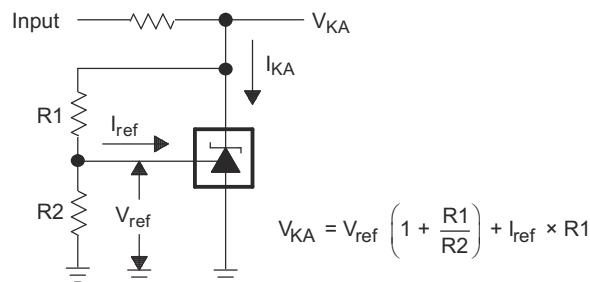


Figure 7-2. Test Circuit for $V_{KA} > V_{ref}$

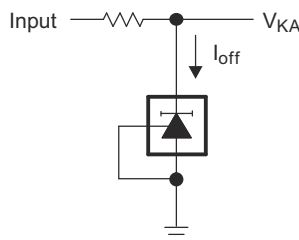


Figure 7-3. Test Circuit for I_{off}

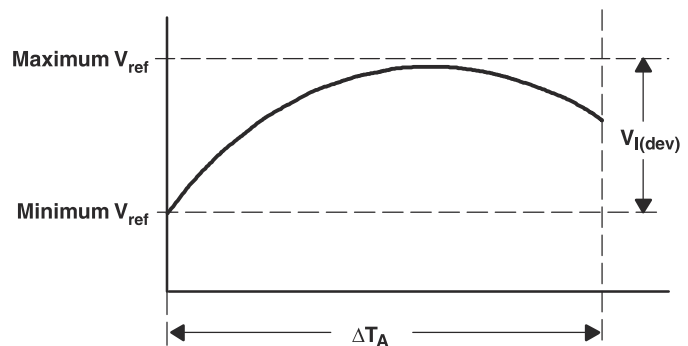
7.1 Temperature Coefficient

The deviation of the reference voltage, V_{ref} , over the full temperature range is known as $V_{I(dev)}$. The parameter of $V_{I(dev)}$ can be used to find the temperature coefficient of the device. The average full-range temperature coefficient of the reference input voltage, $\alpha_{V_{ref}}$, is defined as:

$$|\alpha_{V_{ref}}| \left(\frac{\text{ppm}}{^{\circ}\text{C}} \right) = \frac{\left(\frac{V_{I(dev)}}{V_{ref \text{ at } 25^{\circ}\text{C}}} \right) \times 10^6}{\Delta T_A}$$

where:

ΔT_A is the rated operating temperature range of the device.



$\alpha_{V_{ref}}$ is positive or negative, depending on whether minimum V_{ref} or maximum V_{ref} , respectively, occurs at the lower temperature. The full-range temperature coefficient is an average and therefore any subsection of the rated operating temperature range can yield a value that is greater or less than the average. For more details on temperature coefficient, refer to the [Voltage Reference Selection Basics White Paper](#).

7.2 Dynamic Impedance

The dynamic impedance is defined as $|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_{KA}}$. When the device is operating with two external resistors (see Figure 6-8), the total dynamic impedance of the circuit is given by $|z'| = \frac{\Delta V}{\Delta I}$, which is approximately equal to $|Z_{KA}| \left(1 + \frac{R1}{R2}\right)$.

The V_{KA} of the device can be affected by the dynamic impedance. The device test current I_{test} for V_{KA} is specified in the *Electrical Characteristics*. Any deviation from I_{test} can cause deviation on the output V_{KA} . Figure 7-4 shows the effect of the dynamic impedance on the V_{KA} .

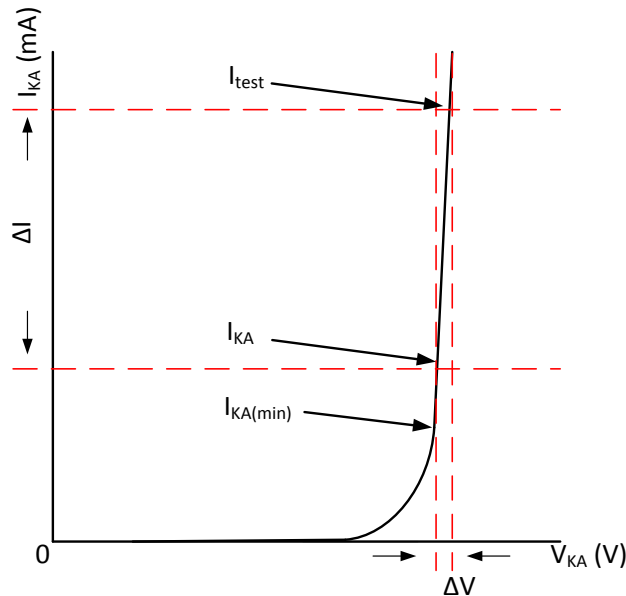


Figure 7-4. Dynamic Impedance

8 Detailed Description

8.1 Overview

The TLA431 and TLA432 devices are three-terminal adjustable shunt regulators that are stable with all capacitor loads. This standard device has proven ubiquity and versatility across a wide range of applications, ranging from power to signal path. This device is pin compatible with the industry standard TL431. The TLA431 contains an accurate voltage reference & op amp, which are very fundamental analog building blocks. TLA431 has improved the stability for capacitive loads. TLA431 is used in conjunction with external components to behave as a single voltage reference, error amplifier, current sink, voltage clamp or comparator with an integrated reference.

TLA431 can be operated and adjusted to cathode voltages from 2.495V to 36V, making this part optimum for a wide range of end equipment in industrial, auto, telecom & computing. For this device to behave as a shunt regulator or error amplifier, $>0.2\text{mA}$ ($I_{\text{min(max)}}$) must be supplied in to the cathode pin. Under this condition, feedback can be applied from the Cathode and Ref pins to create a replica of the internal reference voltage.

The TLA432 device has exactly the same functionality and electrical specifications as the TLA431 device. The TLA43xAI devices are characterized for operation from -40°C to 85°C , and the TLA43xAQ devices are characterized for operation from -40°C to 125°C .

8.2 Functional Block Diagram

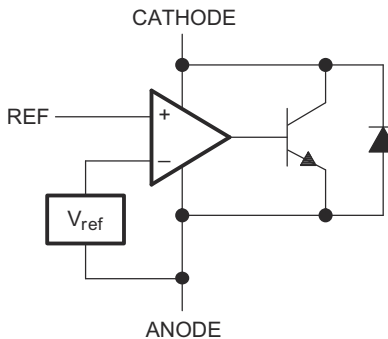


Figure 8-1. Equivalent Schematic

8.3 Feature Description

TLA431 consists of an internal reference and amplifier that outputs a sink current base on the difference between the reference pin and the virtual internal pin. The sink current is produced by the internal Darlington pair. A Darlington pair is used for this device to be able to sink a maximum current of 100mA.

When operated with enough voltage headroom ($\geq 2.495\text{V}$) and cathode current (I_{KA}), TLA431 forces the reference pin to 2.495V. However, the reference pin can not be left floating, as the reference pin needs $I_{REF} \geq 4\mu\text{A}$ (please see [Electrical Characteristics](#)). This is because the reference pin is driven into an npn, which needs base current in order operate properly.

When feedback is applied from the Cathode and Reference pins, TLA431 behaves as a Zener diode, regulating to a constant voltage dependent on current being supplied into the cathode. This is due to the internal amplifier and reference entering the proper operating regions. The same amount of current needed in the above feedback situation must be applied to this device in open loop, servo or error amplifying implementations for the TLA431 to be in the proper linear region giving the TLA431 enough gain.

TLA431 is internally compensated to be stable without an output capacitor between the cathode and anode.

8.4 Device Functional Modes

8.4.1 Closed Loop

When the cathode/output voltage or current of TLA431 is being fed back to the reference/input pin in any form, this device is operating in closed loop. The majority of applications involving TLA431 use the TLA431 in this manner to regulate a fixed voltage or current. The feedback enables this device to behave as an error amplifier, computing a portion of the output voltage and adjusting the cathode to maintain the desired regulation. This is done by relating the output voltage back to the reference pin in a manner to make the reference pin equal to the internal reference voltage, which can be accomplished via resistive or direct feedback.

8.4.1.1 Stability (Closed Loop)

TLA431 is internally compensated to be stable without an output capacitor between the cathode and anode as shown in [Figure 8-2](#). The TLA431 is also stable across all capacitive loads from cathode to anode. This includes the popular $0.1\mu\text{F}$ capacitor load. The TLA431 has been tested to have stable operation with no capacitive loads up to capacitors larger than $10\mu\text{F}$. See [Figure 6-11](#) for stability chart and test setup.

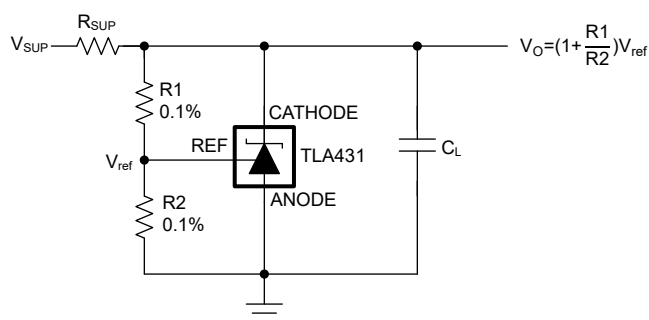


Figure 8-2. TLA431 with load capacitor

The TLA431 is sensitive to capacitance on the REF pin when the REF is isolated from cathode. For stable voltage regulation, do not add capacitance to the REF pin as shown in [Figure 8-3](#).

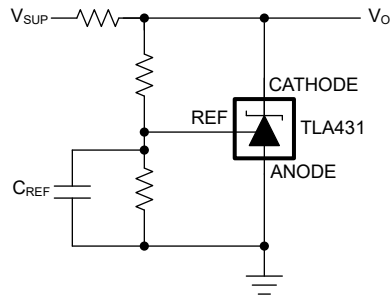


Figure 8-3. TLA431 with capacitor on REF pin

8.4.2 Open Loop (Comparator)

When the cathode/output voltage or current of TLA431 is not being fed back to the reference/input pin in any form, this device is operating in open loop. With proper cathode current (I_{ka}) applied to this device, TLA431 has the characteristics shown in [Figure 9-4](#). With such high gain in this configuration, TLA431 is typically used as a comparator. With the reference integrated makes TLA431 the preferred choice when users are trying to monitor a certain level of a single signal.

9 Applications 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.

9.1 Application Information

As this device has many applications and setups, there are many situations that this data sheet can not characterize in detail.

Application note [Setting the Shunt Voltage on an Adjustable Shunt Regulator](#) (SLVA445) assists designers in setting the shunt voltage to achieve optimum accuracy for this device.

9.2 Typical Applications

9.2.1 Shunt Regulator/Reference

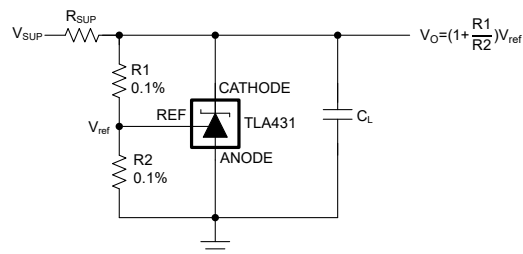


Figure 9-1. Shunt Regulator Schematic

9.2.1.1 Design Requirements

For this design example, use the parameters listed in [Table 9-2](#) as the input parameters.

Table 9-1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Reference Initial Accuracy	1.0%
Supply Voltage	24V
Cathode Current (I _k)	5mA
Output Voltage Level	2.5V - 36V
Load Capacitance	0.1μF
Feedback Resistor Values and Accuracy (R1 & R2)	10kΩ

9.2.1.2 Detailed Design Procedure

When using TLA431 as a Shunt Regulator, determine the following:

- Input Voltage Range
- Temperature Range
- Total Accuracy
- Cathode Current
- Reference Initial Accuracy
- Output Capacitance

9.2.1.2.1 Programming Output/Cathode Voltage

To program the cathode voltage to a regulated voltage a resistive bridge must be shunted between the cathode and anode pins with the mid point tied to the reference pin. This can be seen in [Figure 9-1](#), with R1 & R2 being

the resistive bridge. The cathode/output voltage in the shunt regulator configuration can be approximated by the equation shown in [Figure 9-1](#). The cathode voltage can be more accurately determined by taking in to account the cathode current:

$$V_o = (1 + R_1/R_2) \cdot V_{REF} - I_{REF} \cdot R_1$$

For this equation to be valid, TLA431 must be fully biased so that the TLA431 has enough open loop gain to mitigate any gain error. This can be done by meeting the I_{min} spec denoted in [Electrical Characteristics](#).

9.2.1.2.2 Total Accuracy

When programming the output above unity gain ($V_{KA} = V_{REF}$), TLA431 is susceptible to other errors that can effect the overall accuracy beyond V_{REF} . These errors include:

- R_1 and R_2 accuracies
- $V_{I(dev)}$ - Change in reference voltage over temperature
- $\Delta V_{REF} / \Delta V_{KA}$ - Change in reference voltage to the change in cathode voltage
- $|Z_{KA}|$ - Dynamic impedance, causing a change in cathode voltage with cathode current

Worst case cathode voltage can be determined taking all of the variables in to account. Application note [Setting the Shunt Voltage on an Adjustable Shunt Regulator](#) (SLVA445) assists designers in setting the shunt voltage to achieve optimum accuracy for this device.

9.2.1.2.3 Start-Up Time

As shown in [Figure 9-2](#), TLA431 has a fast response up to about 2V and then slowly charges to the programmed value.

9.2.1.3 Application Curve

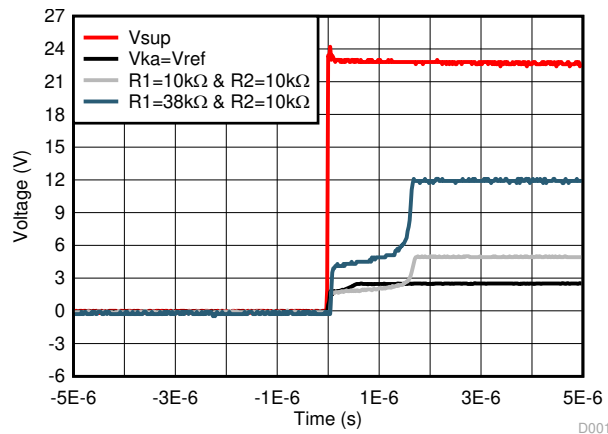


Figure 9-2. TLA431 Start-Up Response

9.2.2 Comparator With Integrated Reference

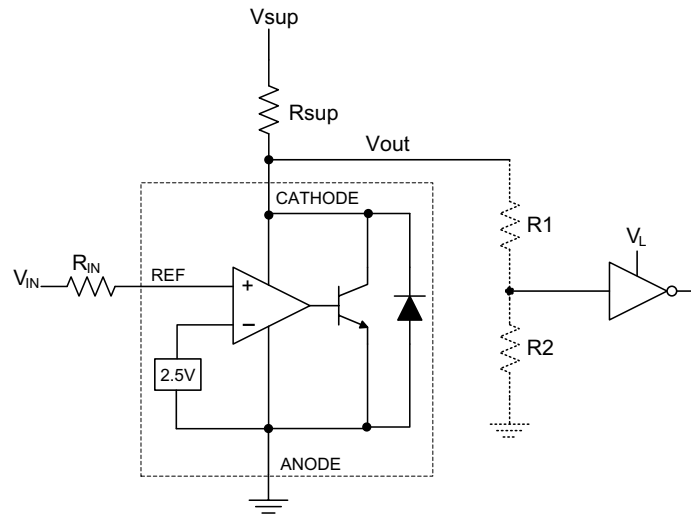


Figure 9-3. Comparator Application Schematic

9.2.2.1 Design Requirements

For this design example, use the parameters listed in [Table 9-2](#) as the input parameters.

Table 9-2. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Input Voltage Range	0V to 5V
Input Resistance	10kΩ
Supply Voltage	24V
Cathode Current (I _K)	5mA
Output Voltage Level	2V – V _{SUP}
Logic Input Thresholds V _{IH} /V _{IL}	V _L

9.2.2.2 Detailed Design Procedure

When using TLA431 as a comparator with reference, determine the following:

- Input Voltage Range
- Reference Voltage Accuracy
- Output logic input high and low level thresholds
- Current Source resistance

9.2.2.2.1 Basic Operation

In the configuration shown in [Figure 9-3](#) TLA431 behaves as a comparator, comparing the V_{REF} pin voltage to the internal virtual reference voltage. When provided a proper cathode current (I_K), TLA431 has enough open loop gain to provide a quick response. This can be seen in [Figure 9-4](#), where the R_{SUP}=10kΩ (I_{KA}=500μA) situation responds much slower than R_{SUP}=1kΩ (I_{KA}=5mA). Operation near and below I_{min} can result in low gain, leading to a slow response.

9.2.2.2.1.1 Overdrive

Slow or inaccurate responses can also occur when the reference pin is not provided enough overdrive voltage. This is the amount of voltage that is higher than the internal virtual reference. The more overdrive voltage provided, the faster the TLA431 response.

For applications where TLA431 is being used as a comparator, good design practice is to set the trip point to greater than the positive expected error (i.e. +1.0% for the A version). For fast response, setting the trip point to >10% of the internal V_{REF} can suffice.

For minimal voltage drop or difference from Vin to the ref pin, use an input resistor <10kΩ to provide I_{ref}.

9.2.2.2.2 Output Voltage and Logic Input Level

For the TLA431 to properly be used as a comparator, the logic output must be readable by the receiving logic device. This is accomplished by knowing the input high and low level threshold voltage levels, typically denoted by V_{IH} & V_{IL} .

As seen in [Figure 9-4](#), TLA431's output low level voltage in open-loop/comparator mode is approximately 2V, which is typically sufficient for 5V supplied logic. However, 5V does not work for 3.3V & 1.8V supplied logic. To accommodate this a resistive divider can be tied to the output to attenuate the output voltage to a voltage legible to the receiving low voltage logic device.

TLA431's output high voltage is equal to V_{SUP} due to TLA431 being open-collector. If V_{SUP} is much higher than the receiving logic's maximum input voltage tolerance, the output must be attenuated to accommodate the outgoing logic's reliability.

When using a resistive divider on the output, be sure to make the sum of the resistive divider ($R1$ & $R2$ in [Figure 9-3](#)) is much greater than R_{SUP} to not interfere with TLA431's ability to pull close to V_{SUP} when turning off.

9.2.2.2.1 Input Resistance

TLA431 requires an input resistance in this application to source the reference current (I_{REF}) needed from this device to be in the proper operating regions while turning on. The actual voltage seen at the ref pin is $V_{REF} = V_{IN} - I_{REF} * R_{IN}$. Since I_{REF} can be as high as $4\mu A$, the recommendation is to use a resistance small enough that mitigate the error that I_{REF} creates from V_{IN} .

9.2.2.3 Application Curve

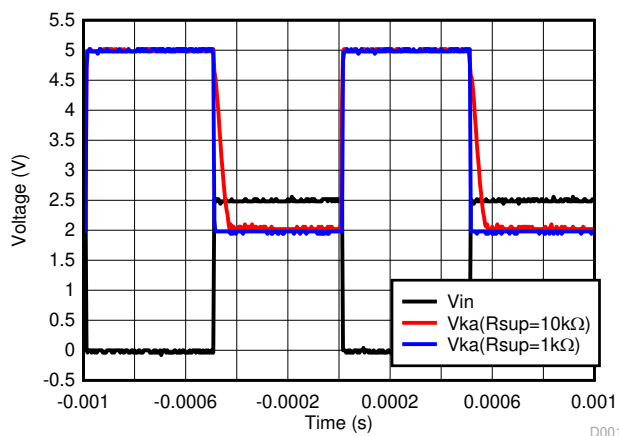
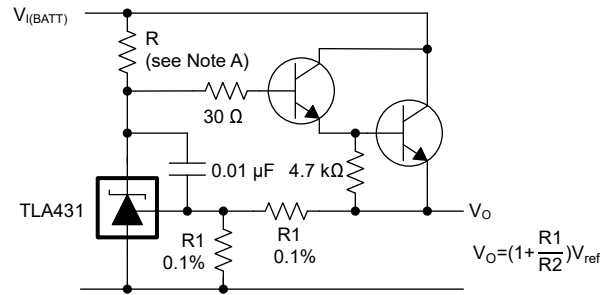


Figure 9-4. Output Response With Various Cathode Currents

9.3 System Examples



A. R is designed to provide cathode current $\geq 0.2\text{mA}$ to the TLA431 at minimum $V_{(BATT)}$.

Figure 9-5. Precision High-Current Series Regulator

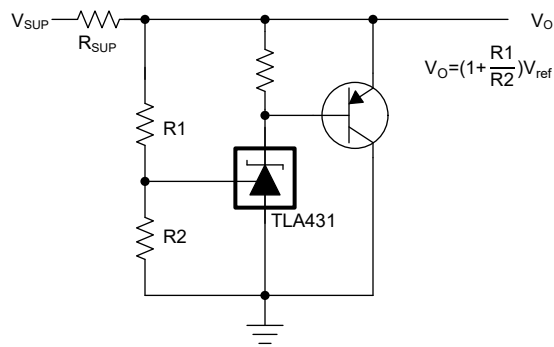
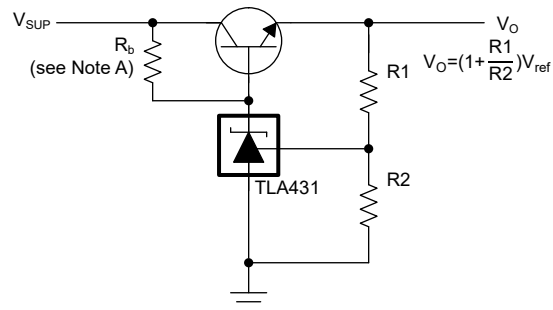
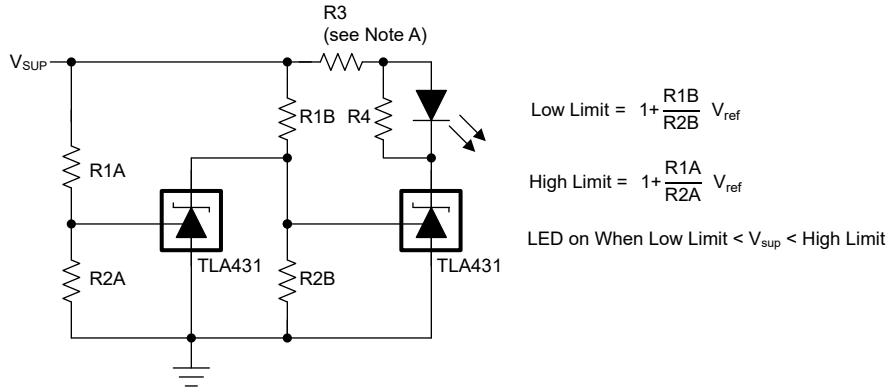


Figure 9-6. High-Current Shunt Regulator



A. R_b is designed to provide cathode current $\geq 0.2\text{mA}$ to the TLA431.

Figure 9-7. Efficient Precision Regulator



A. Select R3 and R4 to provide the desired LED intensity and cathode current $\geq 0.2\text{mA}$ to the TLA431 at the available V_{SUP} .

Figure 9-8. Voltage Monitor

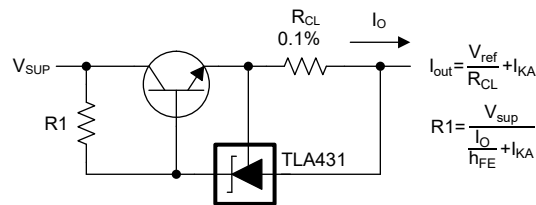


Figure 9-9. Precision Current Limiter

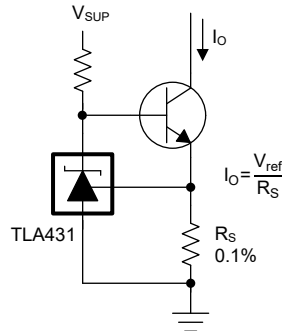


Figure 9-10. Precision Constant-Current Sink

9.4 Power Supply Recommendations

When using TLA431 as a Linear Regulator to supply a load, designers typically use a bypass capacitor on the output/cathode pin. The TLA431 is stable with all capacitive loads.

To not exceed the maximum cathode current, be sure that the supply voltage is current limited. Also, be sure to limit the current being driven into the Ref pin, as not to exceed the absolute maximum rating.

For applications shunting high currents, pay attention to the cathode and anode trace lengths, adjusting the width of the traces to have the proper current density.

9.5 Layout

9.5.1 Layout Guidelines

Bypass capacitors need to be placed as close to the part as possible to limit ESR. Current-carrying traces need to have widths appropriate for the amount of current the traces are carrying; in the case of the TLA431, the currents are be low.

9.5.2 Layout Example

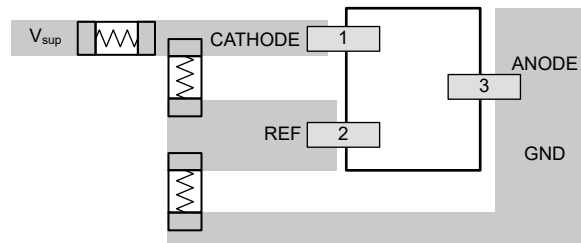
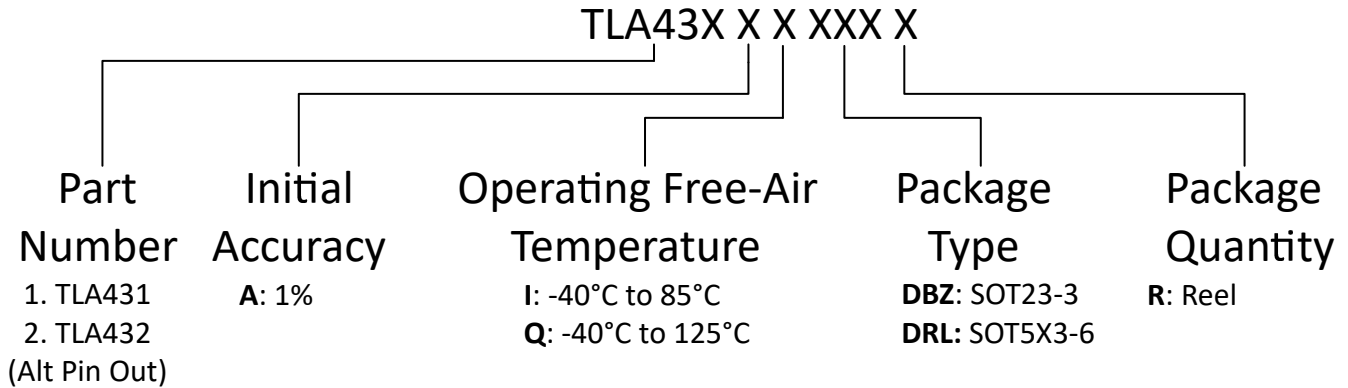


Figure 9-11. TLA431 DBZ Layout Example

10 Device and Documentation Support

10.1 Device Nomenclature

TI assigns suffixes and prefixes to differentiate all the combinations of the TLA43x family. The Eco Plan designator is a legacy designator that was used to differentiate Pb-free and Green devices. More details and possible orderable combinations are located on the Package Option Addendum in [Mechanical](#), [Packaging](#), and [Orderable Information](#).



10.2 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 10-1. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
TLA431	Click here	Click here	Click here	Click here	Click here
TLA432	Click here	Click here	Click here	Click here	Click here

10.3 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](#). Click on *Notifications* 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.

10.4 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](#).

10.5 Trademarks

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

10.6 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.

10.7 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

11 Revision History

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

Changes from Revision * (July 2024) to Revision A (October 2024)	Page
• Production Data Release.....	1

12 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
PTLA431AIDBZR	ACTIVE	SOT-23	DBZ	3	3000	TBD	Call TI	Call TI	-40 to 85		Samples
PTLA431AQDBZR	ACTIVE	SOT-23	DBZ	3	3000	TBD	Call TI	Call TI	-40 to 125		Samples
PTLA432AIDBZR	ACTIVE	SOT-23	DBZ	3	3000	TBD	Call TI	Call TI	-40 to 85		Samples
PTLA432AQDBZR	ACTIVE	SOT-23	DBZ	3	3000	TBD	Call TI	Call TI	-40 to 125		Samples
TLA431AIDBZR	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	3KVF	Samples
TLA431AQDBZR	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	3KWF	Samples
TLA432AIDBZR	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	3KXF	Samples
TLA432AQDBZR	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	3KZF	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.

OBSELETE: 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.

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

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.

TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

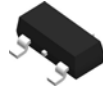
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TLA431AIDBZR	SOT-23	DBZ	3	3000	180.0	8.4	2.9	3.35	1.35	4.0	8.0	Q3
TLA431AQDBZR	SOT-23	DBZ	3	3000	180.0	8.4	2.9	3.35	1.35	4.0	8.0	Q3
TLA432AIDBZR	SOT-23	DBZ	3	3000	180.0	8.4	2.9	3.35	1.35	4.0	8.0	Q3
TLA432AQDBZR	SOT-23	DBZ	3	3000	180.0	8.4	2.9	3.35	1.35	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)
TLA431AIDBZR	SOT-23	DBZ	3	3000	210.0	185.0	35.0
TLA431AQDBZR	SOT-23	DBZ	3	3000	210.0	185.0	35.0
TLA432AIDBZR	SOT-23	DBZ	3	3000	210.0	185.0	35.0
TLA432AQDBZR	SOT-23	DBZ	3	3000	210.0	185.0	35.0

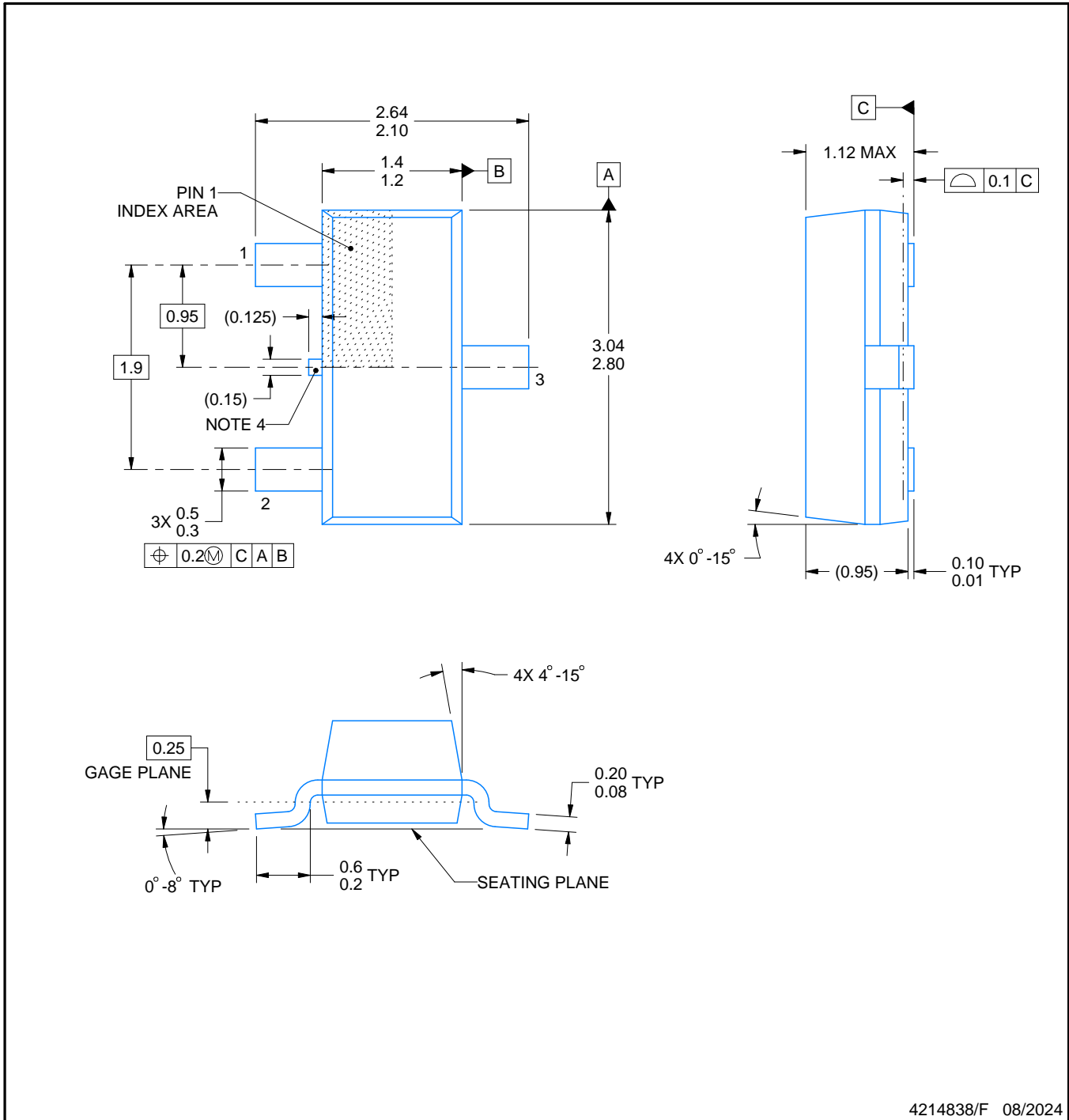
DBZ0003A



PACKAGE OUTLINE

SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR



NOTES:

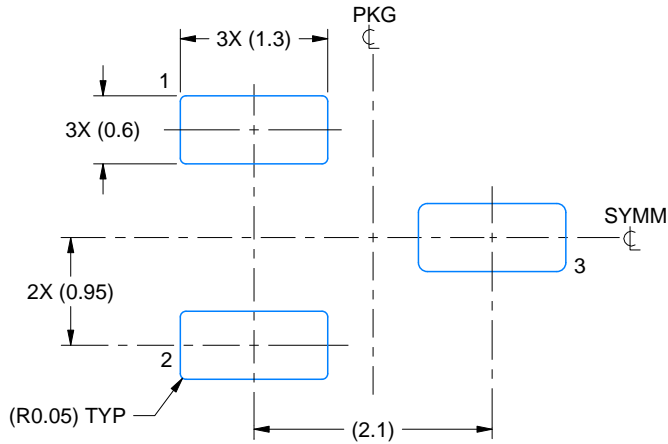
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC registration TO-236, except minimum foot length.
4. Support pin may differ or may not be present.
5. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25mm per side

EXAMPLE BOARD LAYOUT

DBZ0003A

SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE
SCALE:15X



SOLDER MASK DETAILS

4214838/F 08/2024

NOTES: (continued)

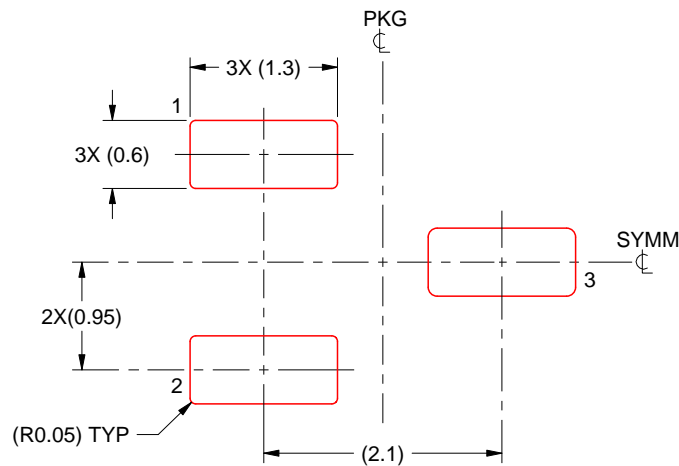
5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DBZ0003A

SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR



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

4214838/F 08/2024

NOTES: (continued)

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

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2024, Texas Instruments Incorporated