Description

The TLV431Q is a three-terminal adjustable shunt regulator offering excellent temperature stability and output current handling capability up to 20mA. The output voltage may be set to any chosen voltage between 1.24 and 18 volts by selection of two external divider resistors.

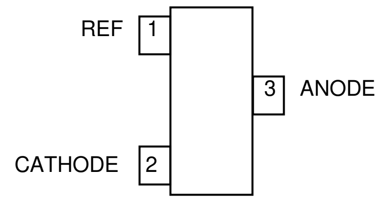
The TLV431Q can be used as a replacement for Zener diodes in many applications requiring an improvement in Zener performance.

The TLV431Q is available in 3 tolerance bands with initial tolerances of 1%, 0.5%, and 0.2% for the A, B and T bands respectively.

The TLV431Q is qualified to AEC-Q100 Grade 1 and is automotive-compliant supporting PPAP documentation.

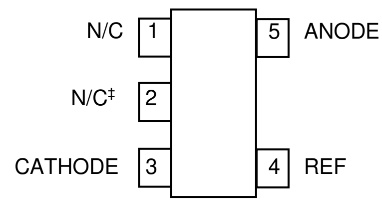
Pin Assignments

(Top View)



SOT23

(Top View)



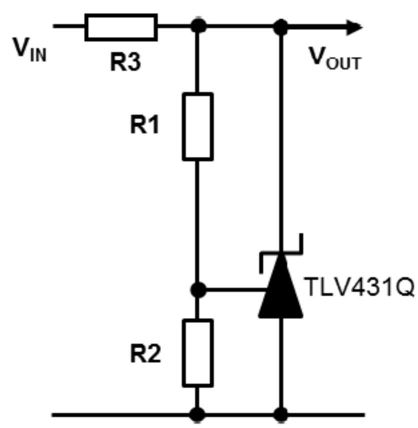
SOT25

‡ Pin should be left floating or connected to anode

Features

- Low Voltage Operation, V_{REF} = 1.24V
- Temperature Range -40°C to +125°C
- Reference Voltage Tolerance at +25°C
  - 0.2% TLV431TQ (End of Life, EOL)
  - 0.5% TLV431BQ
  - 1% TLV431AQ
- Typical V_{REF} Deviation Across Full Temperature Range (Note 1)
  - 4mV (0°C to +70°C)
  - 6mV (-40°C to +85°C)
  - 11mV (-40°C to +125°C)
- 80µA Minimum Cathode Current
- 0.25Ω Typical Output Impedance
- Adjustable Output Voltage V_{REF} to 18V
- **Totally Lead-Free & Fully RoHS Compliant (Notes 2 & 3)**
- **Halogen and Antimony Free. "Green" Device (Note 4)**
- **The TLV431Q is suitable for automotive applications requiring specific change control; this part is AEC-Q100 qualified, PPAP capable, and manufactured in IATF 16949 certified facilities.**
  https://www.diodes.com/quality/product-definitions/

Typical Application Circuit



Adjustable High Accuracy Shunt Reference

Notes:
1. The V_{REF} deviation is defined as the differences between the maximum and minimum values obtained over the specified temperature range.
2. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
3. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
4. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

Absolute Maximum Ratings (Note 5)

Symbol	Parameter	Rating	Unit
V_{KA}	Cathode Voltage	20	V
I_{KA}	Continuous Cathode Current	-20 to 20	mA
I_{REF}	Reference Input Current Range	-0.05 to 3	mA
V_{IN}	Input Supply Voltage (Relative to Ground)	-0.03 to 18	V
T_J	Operating Junction Temperature	-40 to +150	°C
T_S	Storage Temperature	-65 to +150	°C
ESD Susceptibility			
HBM	Human Body Model	4	kV
MM	Machine Model	400	V
CDM	Charged Device Model	1	kV

Notes: 5. a) Stresses beyond those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions is not implied. Exposure to absolute-maximum-rated conditions for extended period can affect device reliability.
Semiconductor devices are ESD sensitive and can be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices.
b) Ratings apply to ambient temperature at +25°C.

Recommended Operating Conditions (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Unit
V_{KA}	Cathode Voltage	V_{REF}	18	V
I_{KA}	Cathode Current	0.1	15	mA
T_A	Operating Ambient Temperature Range	-40	+125	°C

Package Thermal Data

Package	θ_{JA}	P_{DIS} T_A = +25°C, T_J = +150°C
SOT23	380°C/W	330mW
SOT25	250°C/W	500mW

Electrical Characteristics (@T_A = +25°C, I_K = 10mA, unless otherwise specified.)

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
V_{REF}	Reference Voltage	V_{KA} = V_{REF}, T_A = +25°C	TLV431AQ	1.228	1.24	1.252	V
			TLV431BQ	1.234	1.24	1.246	
			TLV431TQ	1.2375	1.24	1.2425	
		V_{KA} = V_{REF}, T_A = 0°C to +70°C	TLV431AQ	1.221	—	1.259	
			TLV431BQ	1.227	—	1.253	
			TLV431TQ	1.230	—	1.250	
		V_{KA} = V_{REF}, T_A = -40°C to +85°C	TLV431AQ	1.215	—	1.265	
			TLV431BQ	1.224	—	1.259	
			TLV431TQ	1.228	—	1.252	
		V_{KA} = V_{REF}, T_A = -40°C to +125°C	TLV431AQ	1.209	—	1.271	
			TLV431BQ	1.221	—	1.265	
			TLV431TQ	1.224	—	1.255	
$V_{REF(DEV)}$ (Note 6)	Deviation of Reference Voltage Over Full Temperature Range	V_{KA} = V_{REF}	T_A = 0°C to +70°C	—	4	12	mV
			T_A = -40°C to +85°C	—	6	20	
			T_A = -40°C to +125°C	—	11	31	
$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	Ratio of Change in Reference Voltage to the Change in Cathode Voltage	V_{KA} for V_{REF} to	6V	—	-1.5	-2.7	mV/V
			18V	—	-1.5	-2.7	
I_{REF}	Reference Input Current	R_1 = 10kΩ, R_2 = OC		—	0.15	0.5	µA
$I_{REF(DEV)}$ (Note 6)	I_{REF} Deviation Over Full Temperature Range	R_1 = 10kΩ, R_2 = OC	T_A = 0°C to +70°C	—	0.05	0.3	µA
			T_A = -40°C to +85°C	—	0.1	0.4	
			T_A = -40°C to +125°C	—	0.15	0.5	
I_{KMIN}	Minimum Cathode Current for Regulation	V_{KA} = V_{REF}	T_A = 0°C to +70°C	—	55	80	µA
			T_A = -40°C to +85°C	—	55	80	
			T_A = -40°C to +125°C	—	55	100	
$I_{K(OFF)}$	Off-State Current	V_{KA} = 18V, V_{REF} = 0V		—	0.001	0.1	µA
Z_{KA} (Note 7)	Dynamic Output Impedance	V_{KA} = V_{REF}, f = <1kHz, I_K = 0.1 to 15mA		—	0.25	0.4	Ω

Notes:

6. The deviation parameters $V_{REF(DEV)}$ and $I_{REF(DEV)}$ are defined as the differences between the maximum and minimum values across the specified temperature range. The average full-range temperature coefficient of the reference input voltage, dV_{REF}/dT, is defined as:

$$\left|\frac{dV_{REF}}{dT}\right|\left(\frac{ppm}{^\circ C}\right)=\frac{\left(\frac{V_{REF(DEV)}}{V_{REF}(T_A=25^\circ C)}\right)\times 10^6}{\Delta T_A}$$

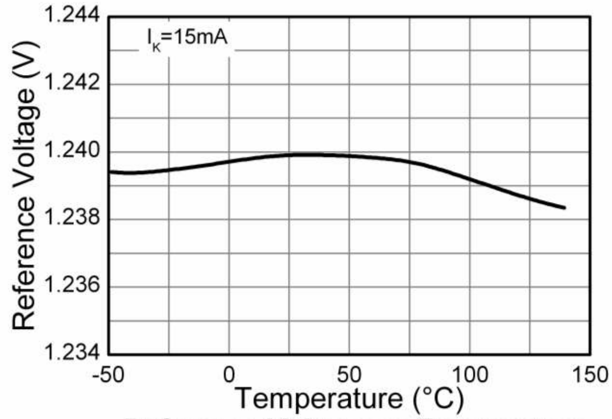
where ΔT_A is the rated operating free-air temperature range of the device.
dV_{REF}/dT can be positive or negative, depending on whether minimum V_{REF} or maximum V_{REF}, respectively, occurs at the lower temperature.

7. The dynamic impedance is defined as:

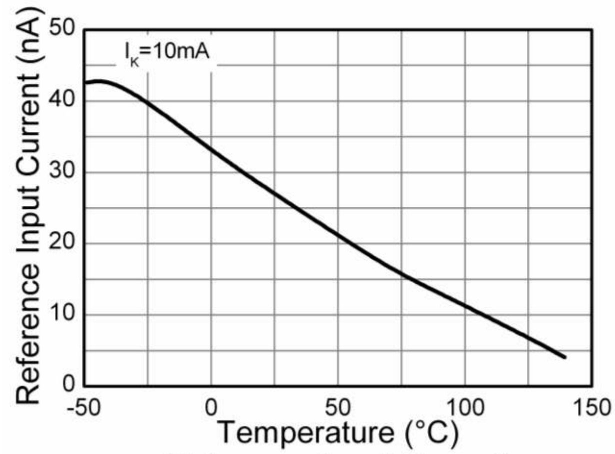
$$|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_{KA}}$$

When the device is operating with two external resistors (see *Typical Application Circuit* Figure 1), the total dynamic impedance of the circuit is increased by a factor of $\left(1+ {}^{R1}/_{R2}\right)$.

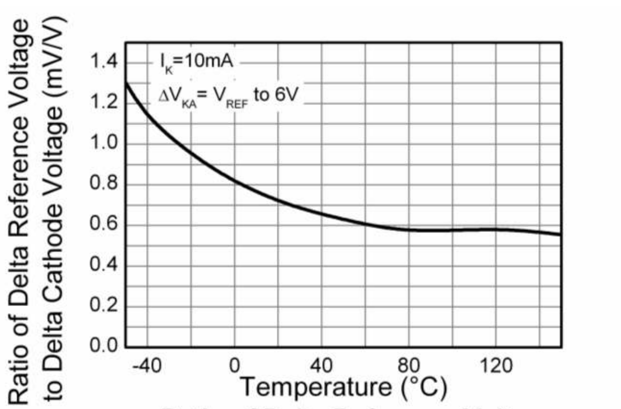
Typical Characteristics



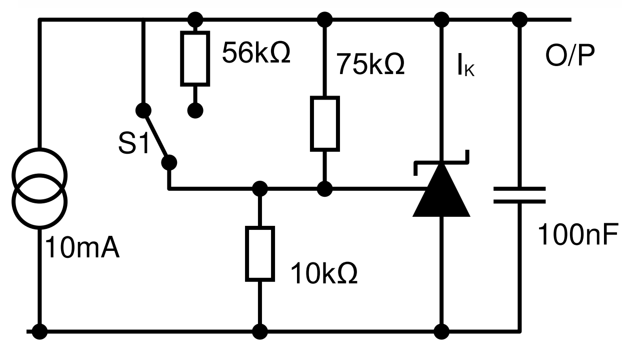
Reference Voltage vs Temperature



Reference Input Current
vs Temperature

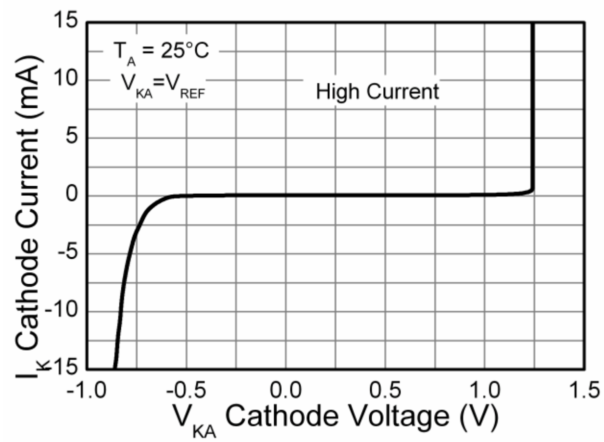


Ratio of Delta Reference Voltage
to Delta Cathode Voltage vs Temperature

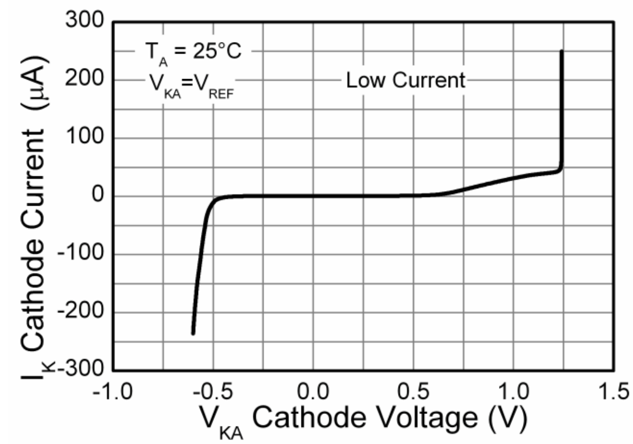


Test Circuit for V_{REF} Measurement

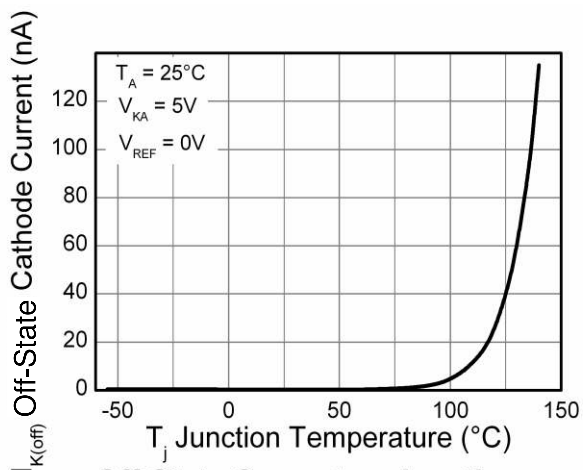
Typical Characteristics (continued)



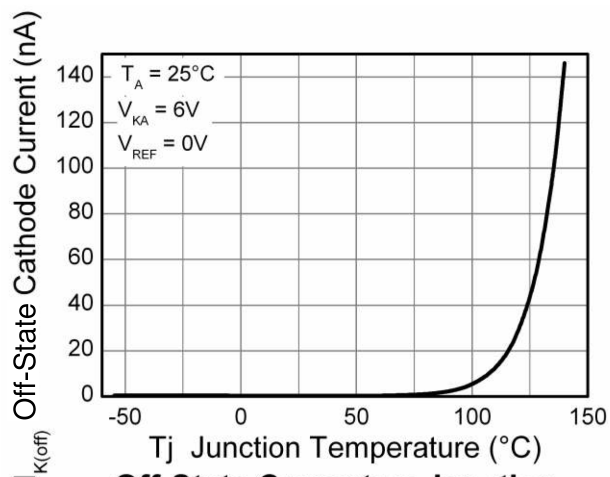
Cathode Current vs Voltage



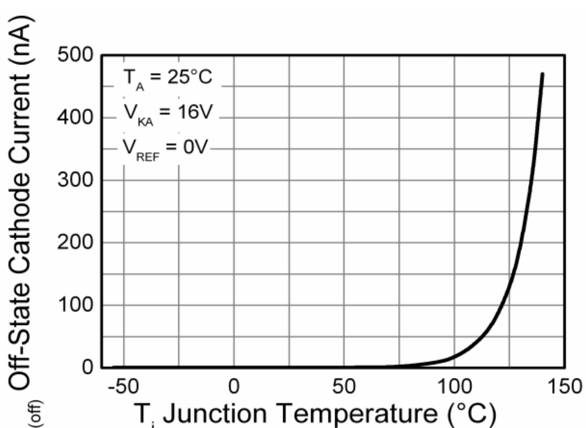
Cathode Current vs Voltage



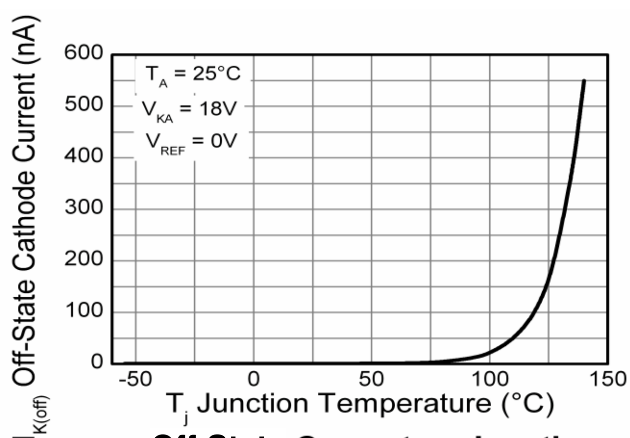
Off-State Current vs Junction Temperature



Off-State Current vs Junction Temperature

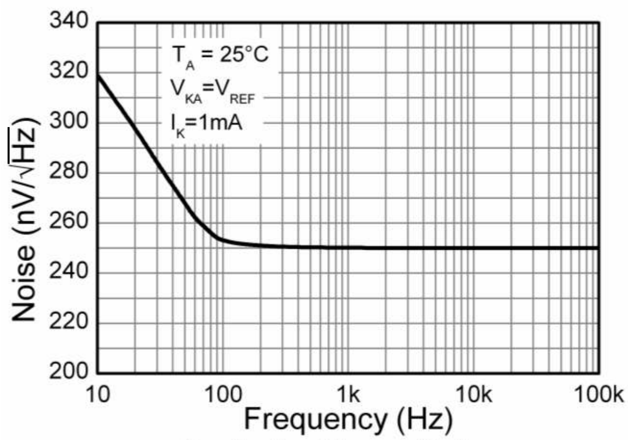


Off-State Current vs Junction Temperature

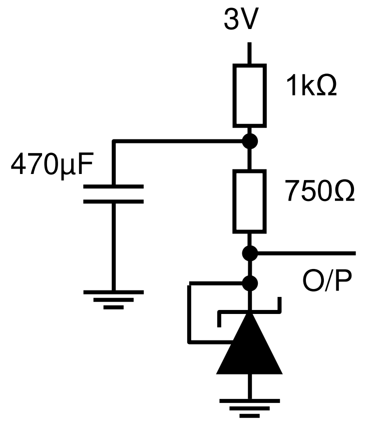


Off-State Current vs Junction Temperature

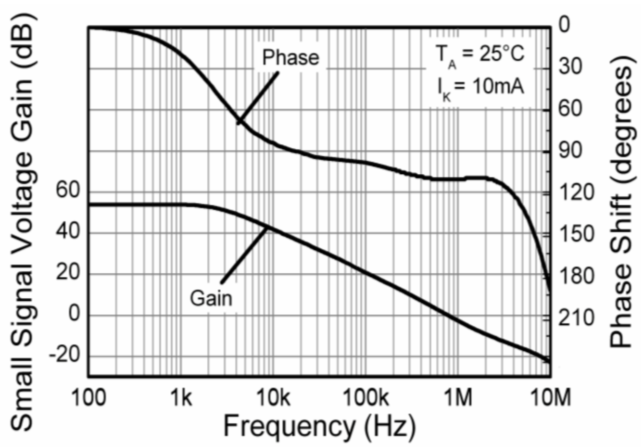
Typical Characteristics (continued)



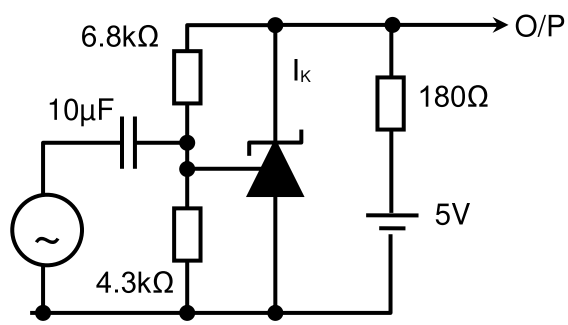
Equivalent Input Noise Voltage vs Frequency



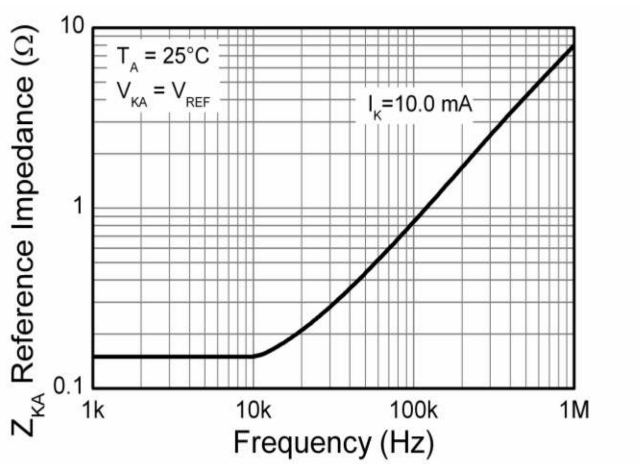
Test Circuit for Input Noise Voltage



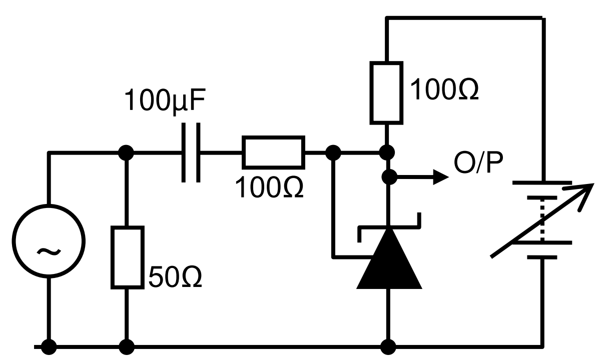
Phase Shift and Gain vs Frequency



Test Circuit for Phase Shift and Gain

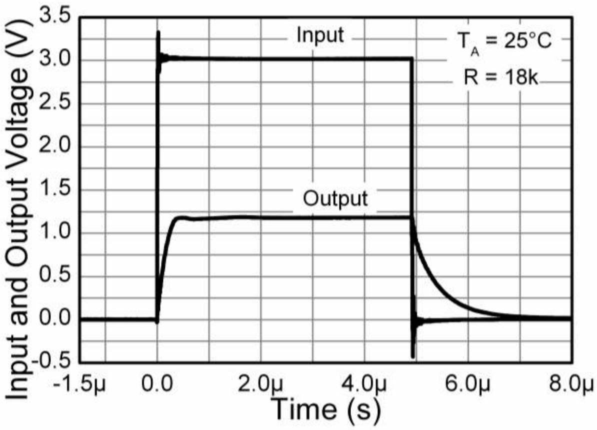


Reference Impedance vs Frequency

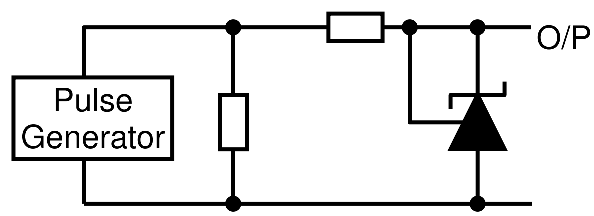


Test Circuit for Reference Impedance

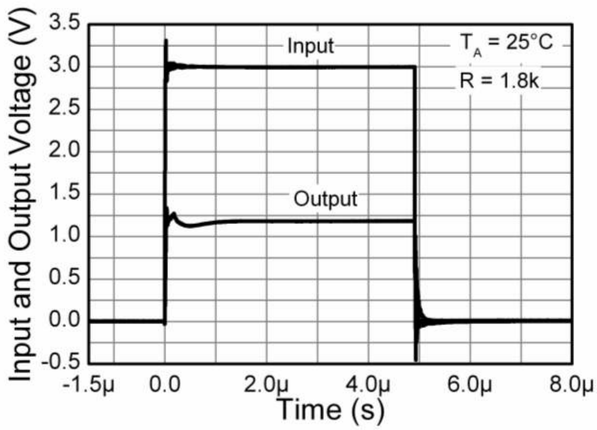
Typical Characteristics (continued)



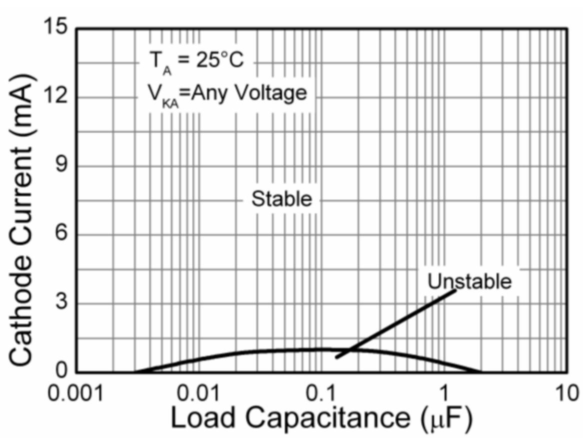
Pulse Response



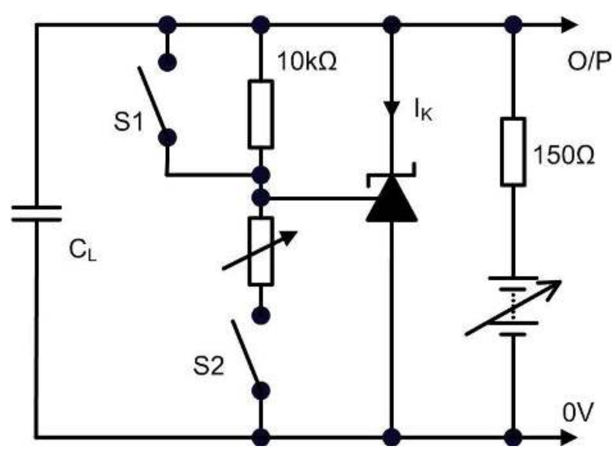
Test Circuit for Pulse Response



Pulse Response



Stability Boundary Condition



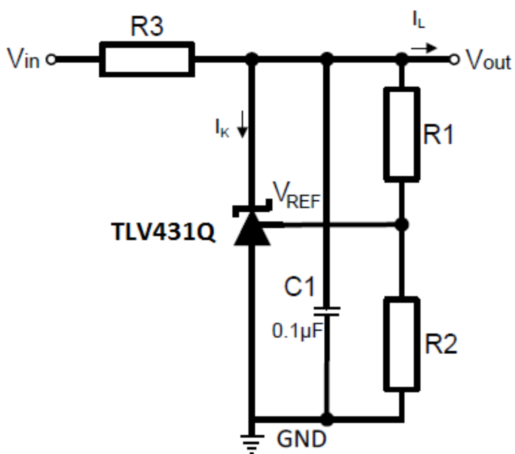
Test Circuit for Stability Boundary

Application Notes

In a conventional shunt regulator application (Figure 1), an external series resistor (R3) is connected between the supply voltage, V_{IN}, and the TLV431Q. The 0.5% and 0.2% tolerance versions allow the creation of a high-accuracy adjustable shunt reference.

R3 determines the current that flows through the load (I_L) and the TLV431Q (I_K). The TLV431Q will adjust how much current it sinks or "shunts" to maintain a voltage equal to V_{REF} across its feedback pin. Since load current and supply voltage may vary, R3 should be small enough to supply at least the minimum acceptable I_{KMIN} to the TLV431Q even when the supply voltage is at its minimum and the load current is at its maximum value. When the supply voltage is at its maximum and I_L is at its minimum, R3 should be large enough so that the current flowing through the TLV431Q is less than 15mA.

R3 is determined by the supply voltage, (V_{IN}), the load and operating current, (I_L and I_K), and the TLV431Q's reverse breakdown voltage, V_{KA}.



$$R_3 = \frac{V_{IN} - V_{KA}}{I_L + I_K}$$

where

$$V_{KA} = V_{REF} \times \left(1 + \frac{R_1}{R_2}\right)$$

and $V_{KA} = V_{OUT}$

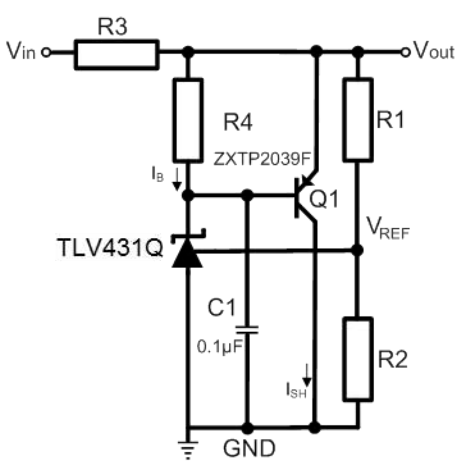
Figure 1. Adjustable Low Voltage Reference

The values of R1 and R2 should be large enough so that the current flowing through them is much smaller than the current through R3 yet not too large so that the voltage drop across them caused by I_{REF} affects the reference accuracy.

Printed Circuit Board Layout Considerations

The TLV431Q in the SOT25 package has the die attached to pin 2, which results in an electrical contact between pin 2 and pin 5. Therefore, pin 2 of the SOT25 package must be left floating or connected to pin 5.

Other Applications of the TLV431Q



$$V_{OUT} = V_{REF}\left(1 + \frac{R1}{R2}\right)$$

$$R3 = \frac{V_{IN} - V_{OUT}}{I_{SH} + I_B}$$

$$R4 = \frac{V_{BE}}{I_B}$$

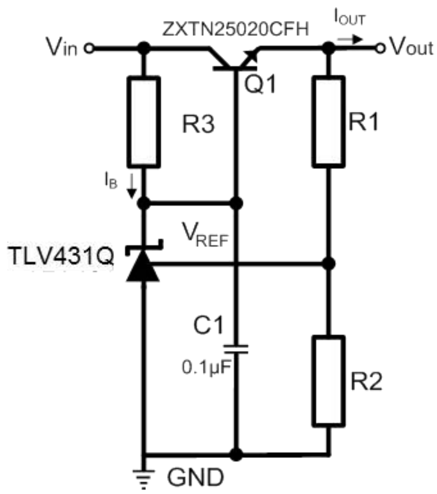
$$\left(\frac{I_{SH}}{h_{FE(min)}}\right) < I_B \le 15mA$$

Figure 2. High Current Shunt Regulator

It may at times be required to shunt-regulate more current than the 15mA that the TLV431Q is capable of.

Figure 2 shows how this can be done using transistor Q1 to amplify the TLV431Q's current. Care needs to be taken that the power dissipation and/or SOA requirements of the transistor is not exceeded.

Application Notes (continued)



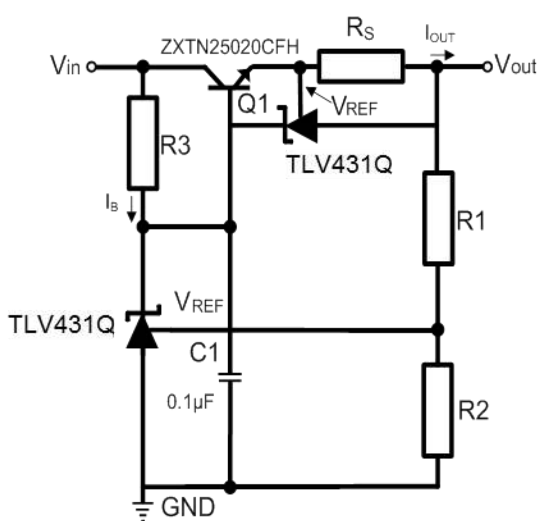
$$V_{OUT} = V_{REF}\left(1+\frac{R1}{R2}\right)$$

$$R3 = \frac{V_{IN} - (V_{OUT} + V_{BE})}{I_B}$$

$$\left(\frac{I_{OUT(max)}}{h_{FE(min)}}\right) < I_B \leq 15mA$$

Figure 3. Basic Series Regulator

A very effective and simple series regulator can be implemented as shown in Figure 3 above. This may be preferable if the load requires more current than can be provided by the TLV431Q alone and there is a need to conserve power when the load is not being powered. This circuit also uses one component less than the shunt circuit shown in Figure 3 above.



$$V_{OUT} = V_{REF}\left(1+\frac{R1}{R2}\right)$$

$$R3 = \frac{V_{IN} - (V_{OUT} + V_{BE})}{I_B}$$

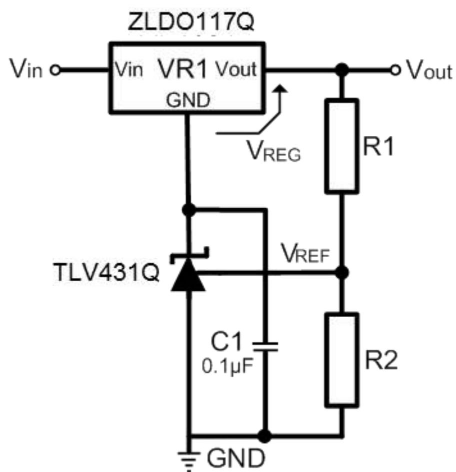
$$\left(\frac{I_{OUT(max)}}{h_{FE(min)}}\right) < I_B \leq 18mA$$

$$R_S = \frac{V_{REF}}{I_{OUT(max)}}$$

Figure 4. Series Regulator with Current Limit

Figure 4 adds current limit to the series regulator in Figure 3 using a second TLV431Q. For currents below the limit, the circuit works normally supplying the required load current at the design voltage. However, should attempts be made to exceed the design current set by the second TLV431Q, the device begins to shunt current away from the base of Q1. This begins to reduce the output voltage and thus ensuring that the output current is clamped at the design value. Subject only to Q1's ability to withstand the resulting power dissipation, the circuit can withstand either a brief or indefinite short circuit.

Application Notes (continued)



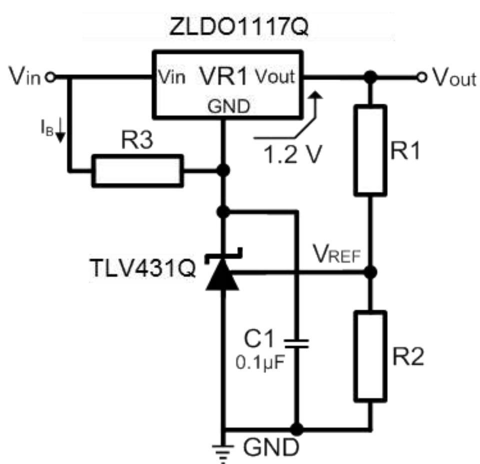
$$V_{OUT} = V_{REF}\left(1 + \frac{R1}{R2}\right)$$

$$V_{OUT} \geq (V_{REG} + V_{REF})$$

(All features of the regulator such as short circuit protection, thermal shutdown, etc, are maintained.)

Figure 5. Increasing Output Voltage of a Fixed Linear Regulator

One of the useful applications of the TLV431Q is in using it to improve the accuracy and/or extend the range and flexibility of fixed voltage regulators. In the circuit in Figure 5 above both the output voltage and its accuracy are entirely determined by the TLV431Q, R1 and R2. However, the rest of the features of the regulator (up to 1A output current, output current limiting and thermal shutdown) are all still available.



$$V_{OUT} = V_{REF}\left(1 + \frac{R1}{R2}\right)$$

$$V_{OUT} \geq (V_{REG} + V_{REF})$$

$$R3 = \frac{V_{IN} - (V_{OUT} - V_{REG})}{I_B}$$

$$0.1mA \leq I_B \leq 18mA$$

(All features of the regulator such as short circuit protection, thermal shutdown, etc, are maintained.)

Figure 6. Adjustable Linear Voltage Regulator

Figure 6 is similar to Figure 5 with adjustability added. Note the addition of R3, This is added to provide sufficient bias current for the TLV431Q.

Ordering Information

TLV431 X Q (X) X TA

Tolerance	Qualification	Package	Packing
A : ±1.0% B : ±0.5% T : ±0.2%	Q : Automotive Compliant	E5 : SOT25 F : SOT23	TA : 7" Tape & Reel

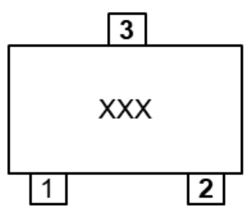
Tolerance	Part Number	Package (Note 8)	Identification Code	Reel Size	Tape Width	Packing		Status
						Qty.	Carrier	
1%	TLV431AQE5TA	SOT25	V1A	7", 180mm	8mm	3000	7" Tape & Reel	RTM
	TLV431AQFTA	SOT23	V1A	7", 180mm	8mm	3000	7" Tape & Reel	RTM
0.5%	TLV431BQE5TA	SOT25	V1B	7", 180mm	8mm	3000	7" Tape & Reel	RTM
	TLV431BQFTA	SOT23	V1B	7", 180mm	8mm	3000	7" Tape & Reel	RTM
0.2%	TLV431TQFTA	SOT23	V1T	7", 180mm	8mm	3000	7" Tape & Reel	EOL

Note: 8. For packaging details, go to our website at https://www.diodes.com/design/support/packaging/diodes-packaging/.

Marking Information

(1) SOT23

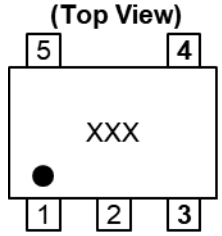
(Top View)



XXX : Identification code

(2) SOT25

(Top View)

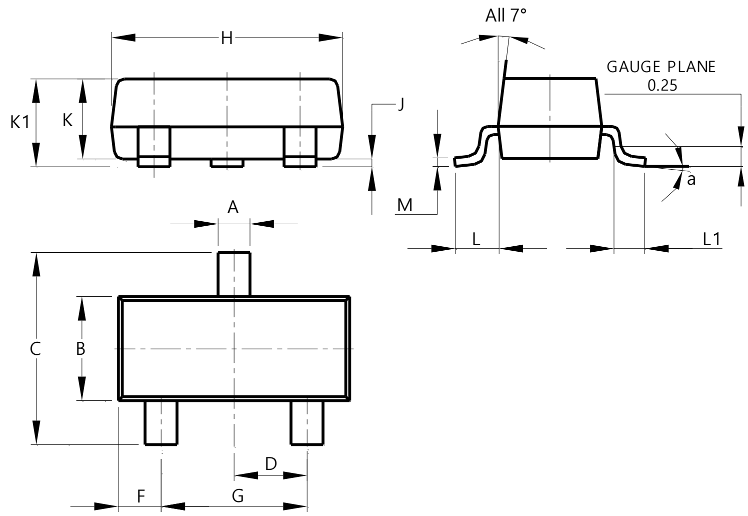


XXX : Identification code

Package Outline Dimensions

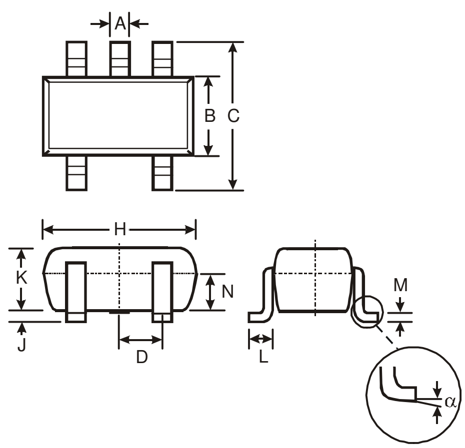
Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) Package Type: SOT23



SOT23			
Dim	**Min**	**Max**	**Typ**
A	0.37	0.51	0.40
B	1.20	1.40	1.30
C	2.30	2.50	2.40
D	0.89	1.03	0.915
F	0.45	0.60	0.535
G	1.78	2.05	1.83
H	2.80	3.00	2.90
J	0.013	0.10	0.05
K	0.890	1.00	0.975
K1	0.903	1.10	1.025
L	0.45	0.61	0.55
L1	0.25	0.55	0.40
M	0.085	0.150	0.110
a	0°	8°	--
All Dimensions in mm			

(2) Package Type: SOT25

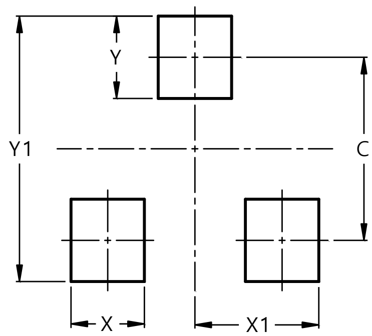


SOT25			
Dim	**Min**	**Max**	**Typ**
A	0.35	0.50	0.38
B	1.50	1.70	1.60
C	2.70	3.00	2.80
D	-	-	0.95
H	2.90	3.10	3.00
J	0.013	0.10	0.05
K	1.00	1.30	1.10
L	0.35	0.55	0.40
M	0.10	0.20	0.15
N	0.70	0.80	0.75
α	0°	8°	-
All Dimensions in mm			

Suggested Pad Layout

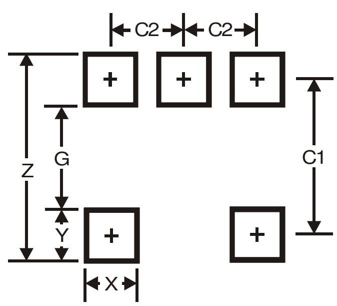
Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) Package Type: SOT23



Dimensions	Value (in mm)
C	2.0
X	0.8
X1	1.35
Y	0.9
Y1	2.9

(2) Package Type: SOT25



Dimensions	Value
Z	3.20
G	1.60
X	0.55
Y	0.80
C1	2.40
C2	0.95

Note: The suggested land pattern dimensions have been provided for reference only, as actual pad layouts may vary depending on application. These dimensions may be modified based on user equipment capability or fabrication criteria. A more robust pattern may be desired for wave soldering and is calculated by adding 0.2 mm to the 'Z' dimension. For further information, please reference document IPC-7351A, Naming Convention for Standard SMT Land Patterns, and for International grid details, please see document IEC, Publication 97.

Note: For high voltage applications, the appropriate industry sector guidelines should be considered with regards to creepage and clearance distances between device Terminals and PCB tracking.

Mechanical Data

(1) SOT23

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish – Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208 (e3)
- Weight: 0.009 grams (Approximate)

(2) SOT25

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish – Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208 (e3)
- Weight: 0.016 grams (Approximate)

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