AUTOMOTIVE COMPLIANT ADJUSTABLE PRECISION SHUNT REGULATOR

Description

The ZTL431AQ, ZTL431BQ, ZTL432AQ and ZTL432BQ are three terminal adjustable shunt regulators offering excellent temperature stability and output current handling capability up to 100mA. The output voltage may be set to any chosen voltage between 2.5 and 20 volts by selection of two external divider resistors.

The ZTL432AQ, ZTL432BQ has the same electrical specifications as the ZTL431AQ, ZTL431BQ but has a different pin out in SOT23 (F-suffix) and SOT23F (FF-suffix).

The ZTL431AQ, ZTL431BQ, ZTL432AQ and ZTL432BQ are available in 2 grades with initial tolerances of 1% and 0.5% for the A and B grades respectively.

These are functionally equivalent to the TL431/TL432 except for maximum operation voltage, and have an ambient temperature range of -40°C to +125°C as standard.

The ZTL431AQ, ZTL431BQ, ZTL432AQ and ZTL432BQ are qualified to AEC-Q100 Grade 1 and are Automotive Compliant supporting PPAPs.

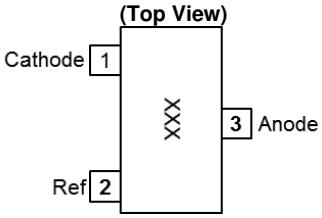
Features

- Temperature Range: -40°C to +125°C
- Reference Voltage Tolerance at +25°C
  - 0.5%: B grade
  - 1%: A grade
- 0.2Ω Typical Output Impedance
- Sink Current Capability: 1mA to 100mA
- Adjustable Output Voltage: V_{REF} to 20V
- Green Molding in SOT23, SOT23F and SOT25
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **Qualified to AEC-Q100 Standards for High Reliability**
  - **AEC-Q100 Grade 1**
- **PPAP Capable (Note 4)**

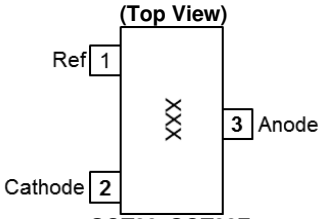
Applications

- Opto-Coupler Linearization
- Linear Regulators
- Improved Zener
- Variable Reference

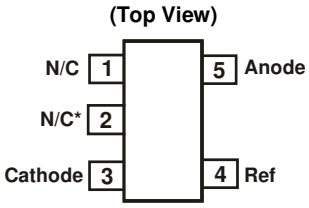
Pin Assignments



SOT23, SOT23F
(ZTL431AQ, ZTL431BQ)



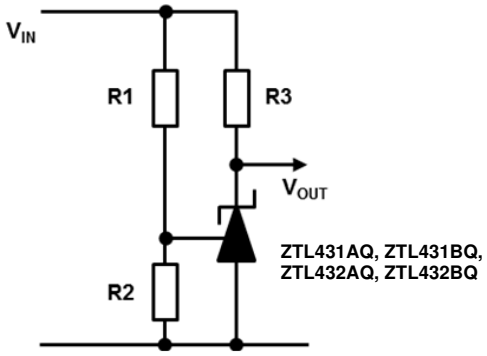
SOT23, SOT23F
(ZTL432AQ, ZTL432BQ)



*must be left floating or connected to pin 5

SOT25
(ZTL431AQ, ZTL431BQ)

Typical Application



Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
2. See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.
4. Automotive Compliant products are AEC-Q100 qualified and are PPAP capable. Refer to http://www.diodes.com/product_compliance_definitions.html.

Absolute Maximum Ratings (Voltages specified are relative to the Anode pin unless otherwise stated.)

Parameter		Rating	Unit
Cathode Voltage (V_{KA})		20	V
Continuous Cathode Current (I_{KA})		150	mA
Reference Input Current Range (I_{REF})		-50µA to +10mA	—
Operating Junction Temperature		-40 to +150	°C
Storage Temperature		-55 to +150	°C
ESD Susceptibility			
HBM	Human Body Model	2	kV
MM	Machine Model	200	V
CDM	Charged Device Model	1	kV

Caution: Stresses greater than the 'Absolute Maximum Ratings' specified above, may cause permanent damage to the device. These are stress ratings only; functional operation of the device at conditions between maximum recommended operating conditions and absolute maximum ratings is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time.

(Semiconductor devices are ESD sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices.)

Package Thermal Data

Package	θ_{JA}	P_{DIS} T_A = +25°C, T_J = +125°C
SOT23	380°C/W	260mW
SOT23F	138°C/W	720mW
SOT25	250°C/W	400mW

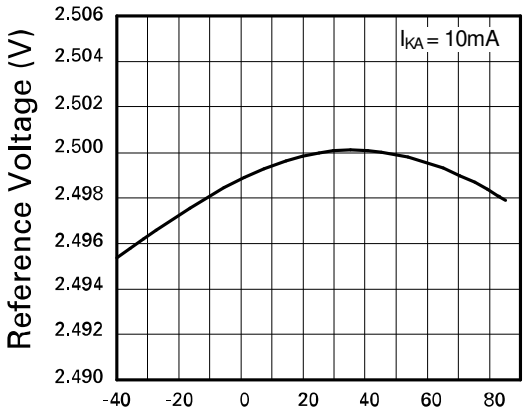
Recommended Operating Conditions (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Unit
V_{KA}	Cathode Voltage	V_{REF}	20	V
I_{KA}	Cathode Current	1	100	mA
T_A	Operating Ambient Temperature Range	-40	+125	°C

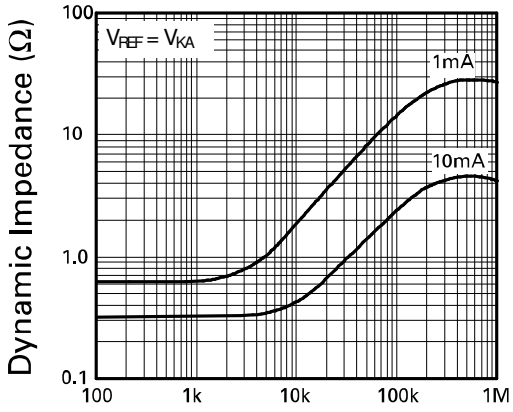
Electrical Characteristics (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
V_{REF}	Reference Voltage	V_{KA} = V_{REF} I_{KA} = 10mA	A - grade	2.475	2.5	2.525	V
			B - grade	2.487	2.5	2.513	
V_{DEV}	Deviation of Reference Voltage Over Full Temperature Range	V_{KA} = V_{REF} I_{KA} = 10mA	T_A = 0 to +70°C	—	6	16	mV
			T_A = -40 to +85°C	—	14	34	
			T_A = -40 to +125°C	—	14	34	
$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	Ratio of Change In Reference Voltage To the Change In Cathode Voltage	I_{KA} = 10mA	V_{KA} = V_{REF} to 10V	—	-1.4	-2.7	mV/V
			V_{KA} = 10V to 20V	—	-1.0	-2.0	
I_{REF}	Reference Input Current	I_{KA} = 10mA, R1 = 10kΩ, R_2 = open		—	2	4	µA
ΔI_{REF}	I_{REF} Deviation Over Full Temperature Range	I_{KA} = 10mA R_1 = 10kΩ R_2 = open	T_A = 0 to +70°C	—	0.8	1.2	µA
			T_A = -40 to +85°C	—	0.8	2.5	
			T_A = -40 to +125°C	—	0.8	2.5	
$I_{KA(MIN)}$	Minimum Cathode Current for Regulation	V_{KA} = V_{REF}	—	—	0.4	0.6	mA
$I_{KA(OFF)}$	Off State Current	V_{KA} = 20V, V_{REF} = 0V	—	—	0.1	0.5	µA
R_Z	Dynamic Output Impedance	V_{KA} = V_{REF}, f = 0Hz	—	—	0.2	0.5	Ω

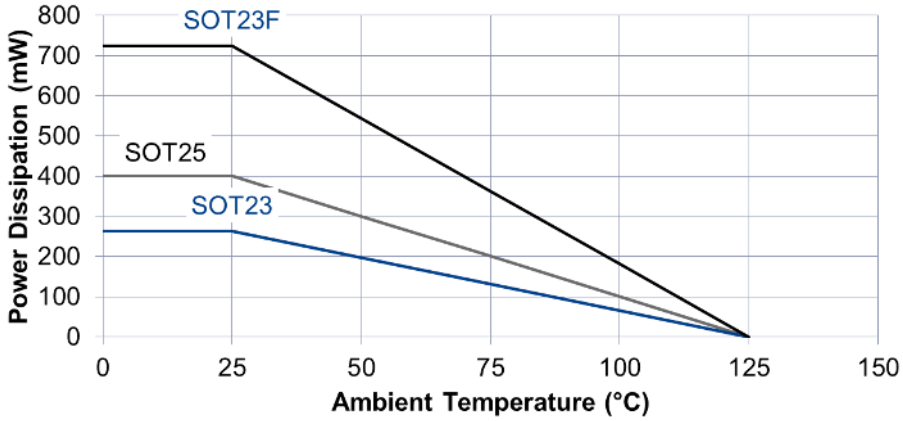
Typical Characteristics



Reference Voltage vs. Temperature

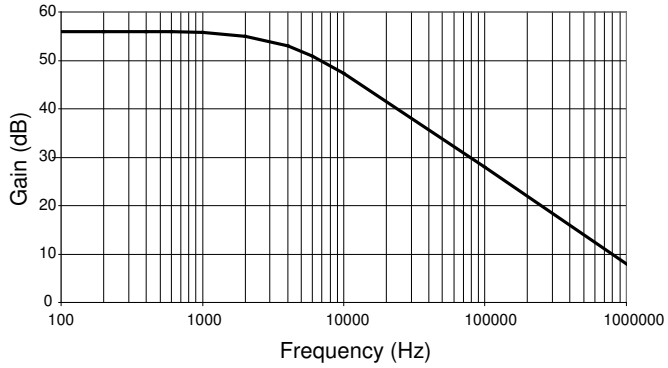


Dynamic Impedance vs. Frequency

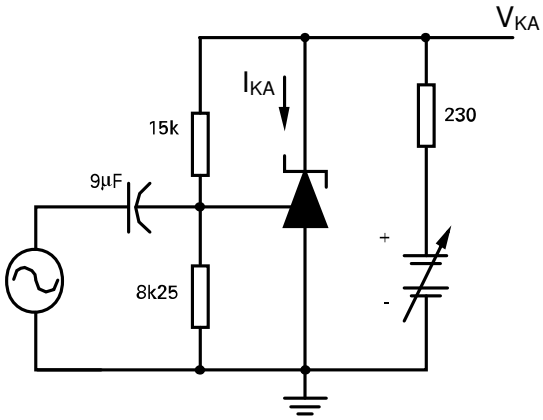


Power Dissipation Derating

Typical Characteristics (Cont.)

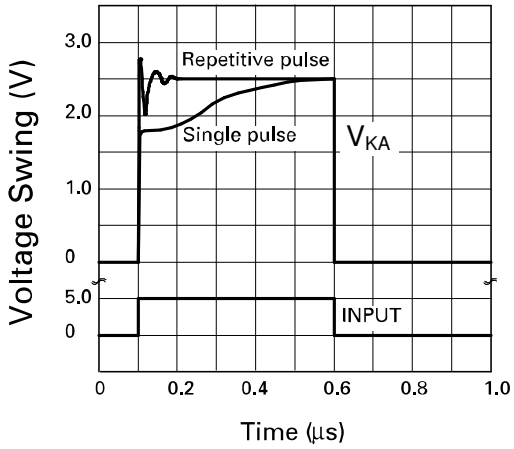


Gain vs. Frequency

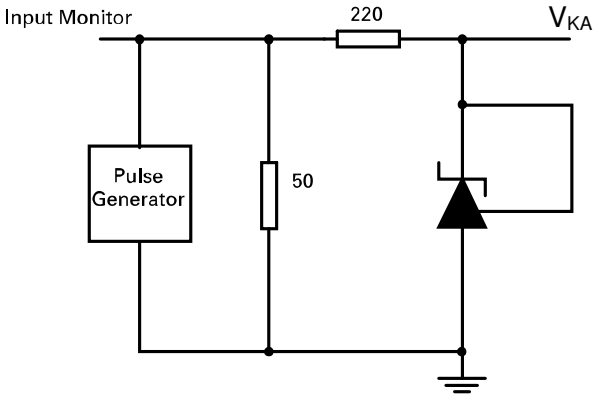


I_{KA} = 10mA, T_A = 25°C

Test Circuit for Open Loop Voltage Gain

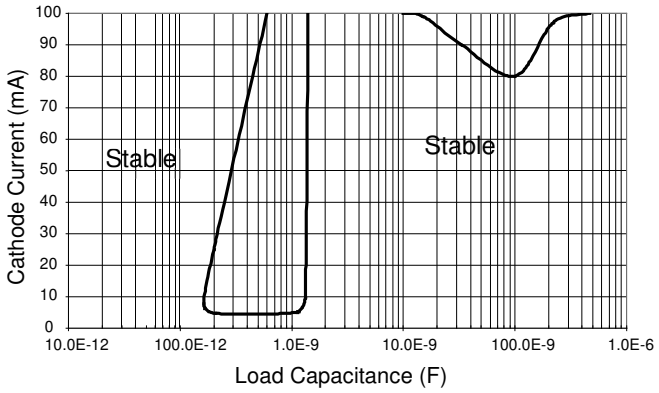


Pulse Response

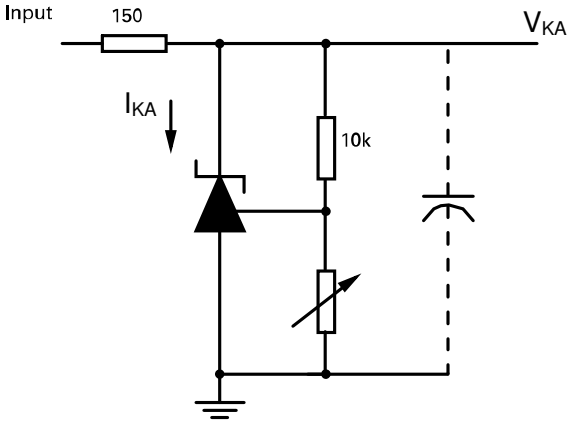


T_A = 25°C

Test Circuit for Pulse Response



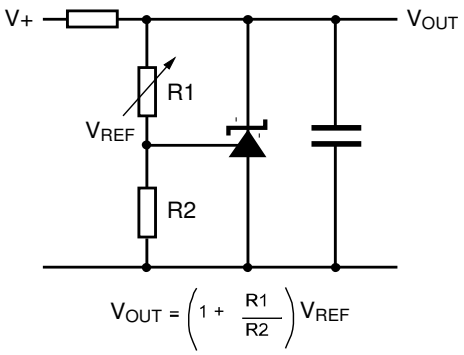
Stability Boundary Condition



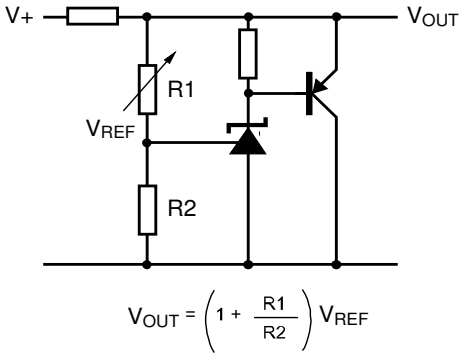
V_{REF} < V_{KA} < 20V, I_{KA} = 10mA, T_A = +25°C

Test Circuit for Stability Boundary Conditions

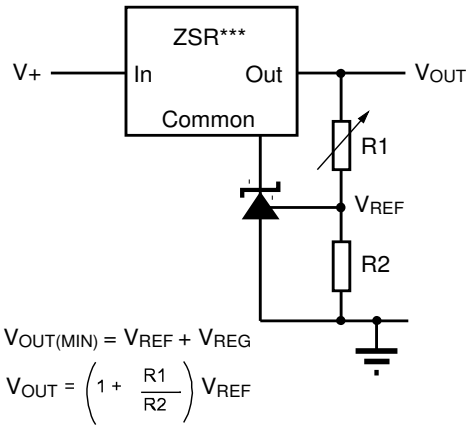
Application Circuits



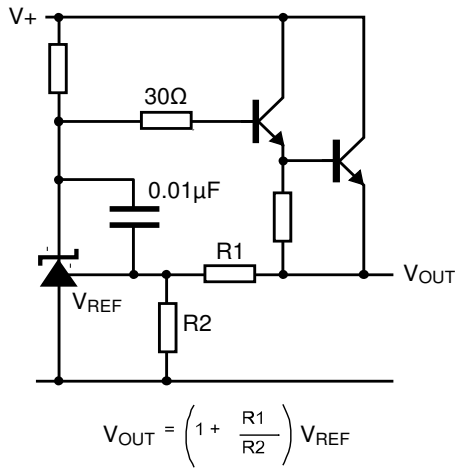
Shunt regulator



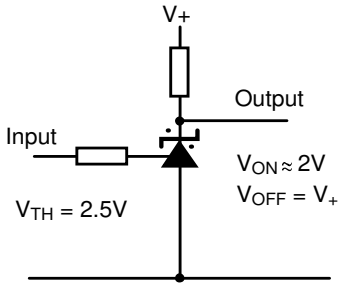
Higher current shunt regulator



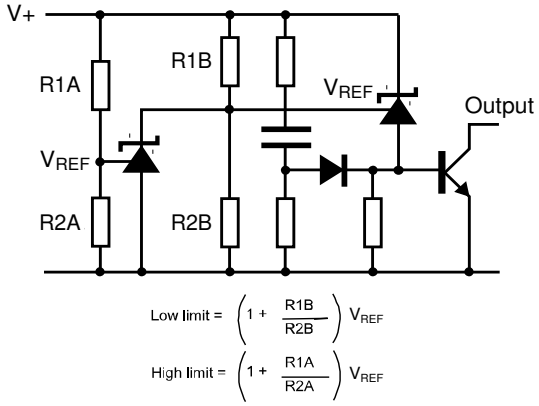
Output control of a three terminal fixed regulator



Series regulator



Single supply comparator with temperature compensated threshold



Over voltage / under voltage protection circuit

DC Test Circuits

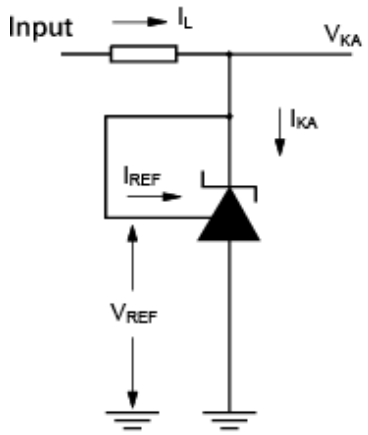


Figure 1. Test circuit for $V_{KA} = V_{REF}$

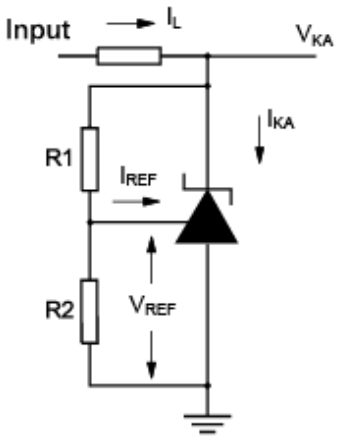


Figure 2. Test circuit for $V_{KA} > V_{REF}$

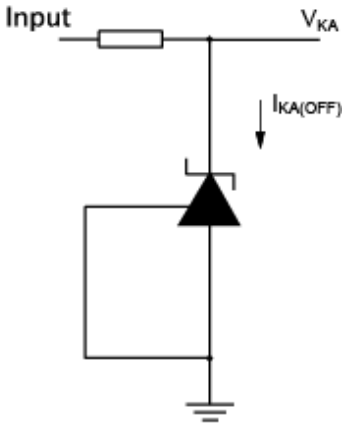


Figure 3. Test circuit for off state current

Notes

Deviation of reference input voltage, V_{DEV}, is defined as the maximum variation of the reference input voltage over the full temperature range.

The average temperature coefficient of the reference input voltage, V_{REF} is defined as:

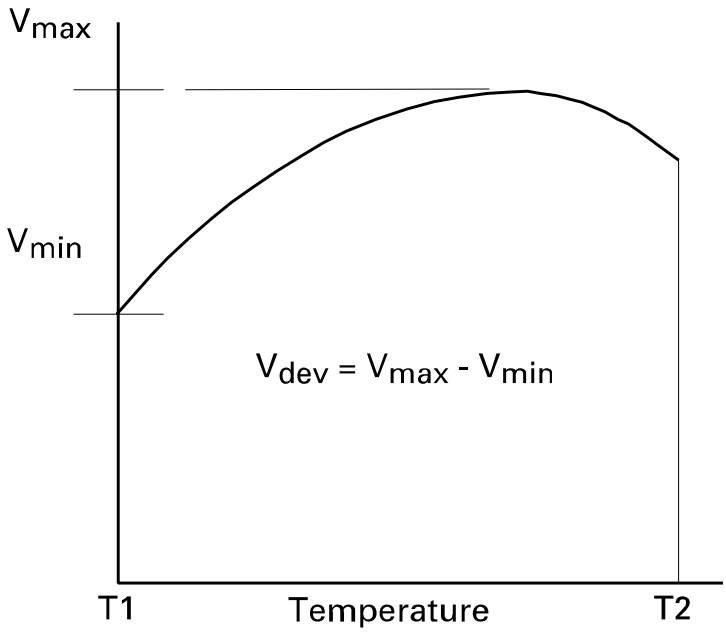
$$V_{REF}(ppm/°C) = \frac{V_{DEV} \times 1{,}000{,}000}{V_{REF}(T1-T2)}$$

The dynamic output impedance, R_Z, is defined as:

$$R_Z = \frac{\Delta V_Z}{\Delta I_Z}$$

When the device is programmed with two external resistors, R1 and R2, (Figure 2), the dynamic output impedance of the overall circuit, R'_Z, is defined as:

$$R'_Z = R_Z \left(1 + \frac{R1}{R2}\right)$$



Stability Boundary

The ZTL431AQ, ZTL431BQ, ZTL432AQ and ZTL432BQ are stable with a range of capacitive loads. A zone of instability exists as demonstrated in the typical characteristic graph on page 4. The graph shows typical conditions. To ensure reliable stability, a capacitor of 4.7nF or greater is recommended between anode and cathode.

Ordering Information

ZTL43 X X Q XX TA

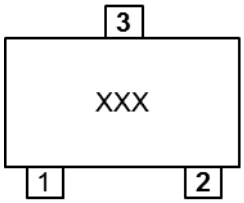
Pinout variation	Tolerance	Compliance	Package	Packing
1 : Standard pin out 2 : Reversed pin out in SOT23, SOT23F	A : ±1.0% B : ±0.5%	Q : Automotive Compliant	E5 : SOT25 F : SOT23 FF : SOT23F	TA : 7" Tape & Reel

Tol.	Ordering Code	Package Code	Packaging (Note 5)	Part Mark	Reel Size	Tape Width (mm)	Quantity per Reel	Qualification (Note 6)
1%	ZTL431AQE5TA	E5	SOT25	31A	7", 180mm	8	3,000	Automotive Compliant
	ZTL431AQFFTA	FF	SOT23F	1V1	7", 180mm	8	3,000	Automotive Compliant
	ZTL431AQFTA	F	SOT23	31A	7", 180mm	8	3,000	Automotive Compliant
	ZTL432AQFFTA	FF	SOT23F	1V2	7", 180mm	8	3,000	Automotive Compliant
	ZTL432AQFTA	F	SOT23	32A	7", 180mm	8	3,000	Automotive Compliant
0.5%	ZTL431BQE5TA	E5	SOT25	31B	7", 180mm	8	3,000	Automotive Compliant
	ZTL431BQFFTA	FF	SOT23F	1V3	7", 180mm	8	3,000	Automotive Compliant
	ZTL431BQFTA	F	SOT23	31B	7", 180mm	8	3,000	Automotive Compliant
	ZTL432BQFFTA	FF	SOT23F	1V4	7", 180mm	8	3,000	Automotive Compliant
	ZTL432BQFTA	F	SOT23	32B	7", 180mm	8	3,000	Automotive Compliant

Notes: 5. Pad layout shown at http://www.diodes.com/package-outlines.html.
6. ZTL431AQ, ZTL431BQ, ZTL432AQ and ZTL432BQ are qualified to AEC-Q100 grade 1 and are classified as "Automotive Compliant" supporting PPAP documentation. Automotive, AEC-Q100 and standard products are electrically and thermally the same, except where specified.
For more information, please refer to http://www.diodes.com/product_compliance_definitions.html.
See ZTL431/ZTL432 datasheet for commercial qualified versions.

Package Marking Dimensions

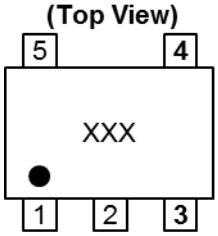
(1) SOT23 and SOT23F



XXX : Identification code

Orderable	Identification Code
ZTL431AQFFTA	1V1
ZTL431AQFTA	31A
ZTL432AQFFTA	1V2
ZTL432AQFTA	32A
ZTL431BQFFTA	1V3
ZTL431BQFTA	31B
ZTL432BQFFTA	1V4
ZTL432BQFTA	32B

(2) SOT25



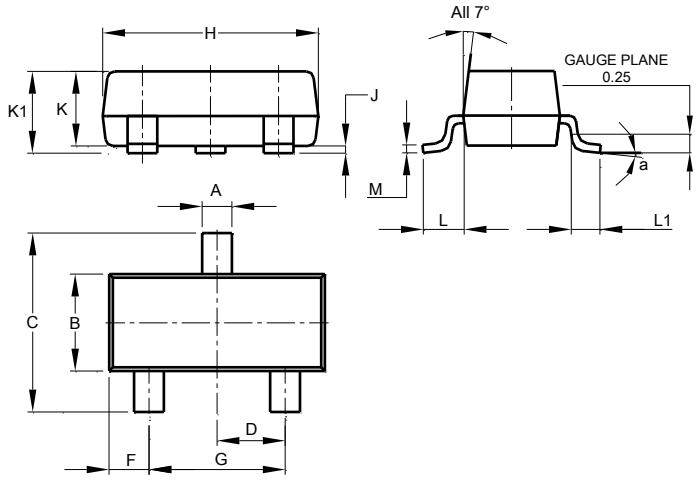
XXX : Identification code

Orderable	Identification Code
ZTL431AQE5TA	31A
ZTL431BQE5TA	31B

Package Outline Dimensions

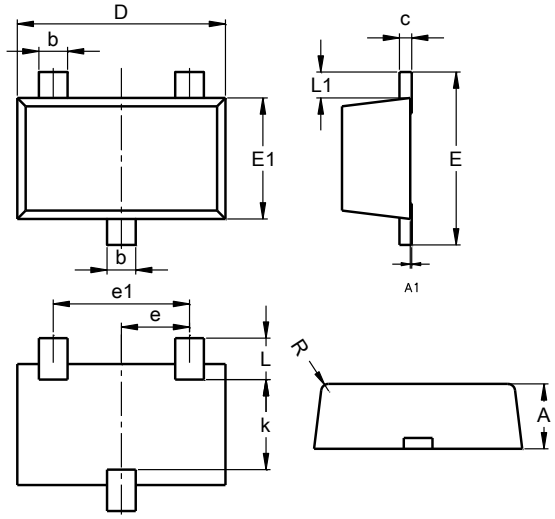
Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) Package Type: SOT23



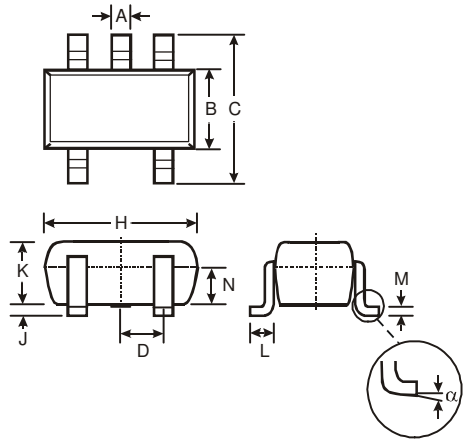
SOT23			
Dim	Min	Max	Typ
A	0.37	0.51	0.40
B	1.20	1.40	1.30
C	2.30	2.50	2.40
D	0.89	1.03	0.915
F	0.45	0.60	0.535
G	1.78	2.05	1.83
H	2.80	3.00	2.90
J	0.013	0.10	0.05
K	0.890	1.00	0.975
K1	0.903	1.10	1.025
L	0.45	0.61	0.55
L1	0.25	0.55	0.40
M	0.085	0.150	0.110
a	0°	8°	--
All Dimensions in mm			

(2) Package Type: SOT23F



SOT23F			
Dim	Min	Max	Typ
A	0.80	1.00	0.90
A1	0.00	0.10	0.01
b	0.35	0.50	0.44
c	0.10	0.20	0.16
D	2.80	3.00	2.90
e	0.95 REF		
e1	0.190 REF		
E	2.30	2.50	2.40
E1	1.50	1.70	1.65
k	1.20	-	-
L	0.30	0.65	0.50
L1	0.30	0.50	0.40
R	0.05	0.15	-
All Dimensions in mm			

(3) Package Type: SOT25

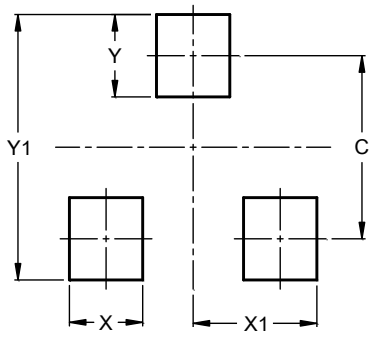


SOT25			
Dim	Min	Max	Typ
A	0.35	0.50	0.38
B	1.50	1.70	1.60
C	2.70	3.00	2.80
D	-	-	0.95
H	2.90	3.10	3.00
J	0.013	0.10	0.05
K	1.00	1.30	1.10
L	0.35	0.55	0.40
M	0.10	0.20	0.15
N	0.70	0.80	0.75
α	0°	8°	-
All Dimensions in mm			

Suggested Pad Layout

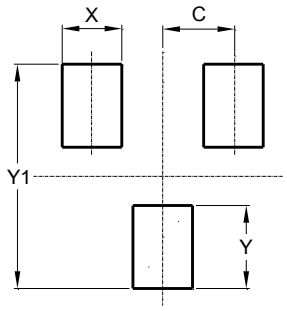
Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) Package Type: SOT23



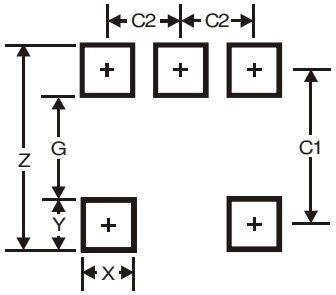
Dimensions	Value (in mm)
C	2.0
X	0.8
X1	1.35
Y	0.9
Y1	2.9

(2) Package Type: SOT23F



Dimensions	Value (in mm)
C	0.95
X	0.80
Y	1.110
Y1	3.000

(3) Package Type: SOT25



Dimensions	Value (in mm)
Z	3.20
G	1.60
X	0.55
Y	0.80
C1	2.40
C2	0.95

Revision History

<table>
<tr><th>Date</th><th>Revision</th><th>Changes</th></tr>
<tr><td>August 2014</td><td>1-2</td><td>Initial release</td></tr>
<tr><td>July 2016</td><td>2-2</td><td>
Added further clarification of Automotive Grade and reference to Diodes' definition (Pages 1 and 7)

Amended generic part numbers from ZTL431Q/ZTL432Q to ZTL431xQ/ZTL432xQ (All pages Header)

Addition of SOT23F variants:
Pinout (page 1)
Thermal impedance (Pages 2 and 3)
Ordering information (page 7)
<table>
<tr><th>Tol.</th><th>Ordering Code</th></tr>
<tr><td rowspan="2">1%</td><td>ZTL431AQFFTA</td></tr>
<tr><td>ZTL432AQFFTA</td></tr>
<tr><td rowspan="2">0.5%</td><td>ZTL431BQFFTA</td></tr>
<tr><td>ZTL432BQFFTA</td></tr>
</table>
Package dimensions (page 8) and landing pad info (page 9)

Correction of ESD ratings (Note 7) (Page 2):
<table>
<tr><td colspan="2">ESD Rating</td><td>Incorrect revision 1-2 specification</td><td>Corrected revision 2-2 specification</td><td>Unit</td></tr>
<tr><td>HBM</td><td>Human Body Model</td><td>4000</td><td>2000</td><td>V</td></tr>
<tr><td>MM</td><td>Machine Model</td><td>400</td><td>200</td><td>V</td></tr>
<tr><td>CDM</td><td>Charged Device Model</td><td>1000</td><td>1000</td><td>V</td></tr>
</table>
Note 7 The actual physical ESD withstand capability is unaltered.

Amendment of Recommended Maximum Power Dissipation based on revised maximum junction temperature of 125°C (Pages 2 and 3):
<table>
<tr><th rowspan="2">Package</th><th>Unchanged</th><th>Rev 1-2 specification</th><th>Rev 2-2 specification</th></tr>
<tr><th>θ_{JA}</th><th>P_{DIS}
T_A = +25°C, T_J = +150°C</th><th>P_{DIS}
T_A = +25°C, T_J = +125°C</th></tr>
<tr><td>SOT23</td><td>380°C/W</td><td>330mW</td><td>260mW</td></tr>
<tr><td>SOT23F</td><td>138°C/W</td><td></td><td>720mW</td></tr>
<tr><td>SOT25</td><td>250°C/W</td><td>500mW</td><td>400mW</td></tr>
</table>
</td></tr>
<tr><td>December 2016</td><td>3-2</td><td>
Now referring to Automotive Compliant instead of Automotive Grade throughout datasheet.

Correction of SOT23F variants part marks (page 7)
<table>
<tr><th rowspan="2">SOT23F Orderable</th><th>Rev 2-2 specification</th><th>Rev 3-2 specification</th></tr>
<tr><th colspan="2">Part Mark</th></tr>
<tr><td>ZTL431AQFFTA</td><td>31A</td><td>1V1</td></tr>
<tr><td>ZTL432AQFFTA</td><td>32A</td><td>1V2</td></tr>
<tr><td>ZTL431BQFFTA</td><td>31B</td><td>1V3</td></tr>
<tr><td>ZTL432BQFFTA</td><td>32B</td><td>1V4</td></tr>
</table>
Amendment of pin number within datasheet (pages 1 and 7).
</td></tr>
</table>

IMPORTANT NOTICE

DIODES INCORPORATED MAKES NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, WITH REGARDS TO THIS DOCUMENT, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION).

Diodes Incorporated and its subsidiaries reserve the right to make modifications, enhancements, improvements, corrections or other changes without further notice to this document and any product described herein. Diodes Incorporated does not assume any liability arising out of the application or use of this document or any product described herein; neither does Diodes Incorporated convey any license under its patent or trademark rights, nor the rights of others. Any Customer or user of this document or products described herein in such applications shall assume all risks of such use and will agree to hold Diodes Incorporated and all the companies whose products are represented on Diodes Incorporated website, harmless against all damages.

Diodes Incorporated does not warrant or accept any liability whatsoever in respect of any products purchased through unauthorized sales channel. Should Customers purchase or use Diodes Incorporated products for any unintended or unauthorized application, Customers shall indemnify and hold Diodes Incorporated and its representatives harmless against all claims, damages, expenses, and attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized application.

Products described herein may be covered by one or more United States, international or foreign patents pending. Product names and markings noted herein may also be covered by one or more United States, international or foreign trademarks.

This document is written in English but may be translated into multiple languages for reference. Only the English version of this document is the final and determinative format released by Diodes Incorporated.

LIFE SUPPORT

Diodes Incorporated products are specifically not authorized for use as critical components in life support devices or systems without the express written approval of the Chief Executive Officer of Diodes Incorporated. As used herein:

A. Life support devices or systems are devices or systems which:

1. are intended to implant into the body, or
2. support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in significant injury to the user.

B. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or to affect its safety or effectiveness.

Customers represent that they have all necessary expertise in the safety and regulatory ramifications of their life support devices or systems, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of Diodes Incorporated products in such safety-critical, life support devices or systems, notwithstanding any devices- or systems-related information or support that may be provided by Diodes Incorporated. Further, Customers must fully indemnify Diodes Incorporated and its representatives against any damages arising out of the use of Diodes Incorporated products in such safety-critical, life support devices or systems.

www.diodes.com