AUTOMOTIVE COMPLIANT ADJUSTABLE PRECISION SHUNT REGULATOR

Description

The ZTL431AQ, ZTL431BQ, ZTL432AQ, and ZTL432BQ are three terminal adjustable shunt regulators that offer excellent temperature stability and output current handling capability up to 100mA. The output voltage can be set to any chosen voltage between 2.5V and 20V by the 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).

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

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

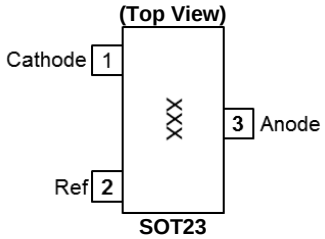
Features

- 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 and SOT25
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **The ZTL431AQ, ZTL431BQ, ZTL432AQ and ZTL432BQ are suitable for automotive applications requiring specific change control and are AEC-Q100 qualified, have a grade 1 temperature rating, are PPAP capable, and are manufactured in IATF16949:2016 certified facilities.**

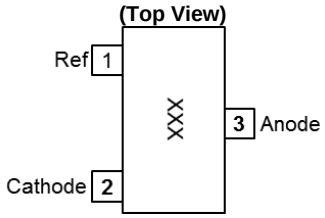
Applications

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

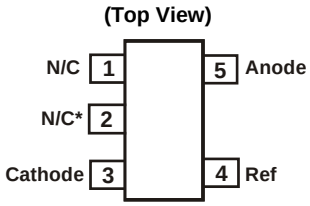
Pin Assignments



SOT23
(ZTL431AQ, ZTL431BQ)



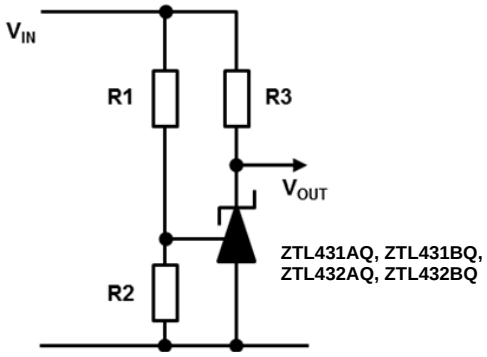
SOT23
(ZTL432AQ, ZTL432BQ)



*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) & 2015/863/EU (RoHS 3) compliant.
2. 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.
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.

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, can 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 can be affected by exposure to absolute maximum rating conditions for extended periods of time.

(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.)

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

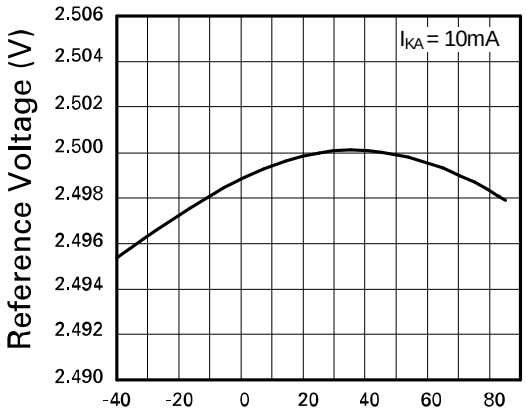
Recommended Operating Conditions (@T_A = +25°C, unless otherwise specified.)

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

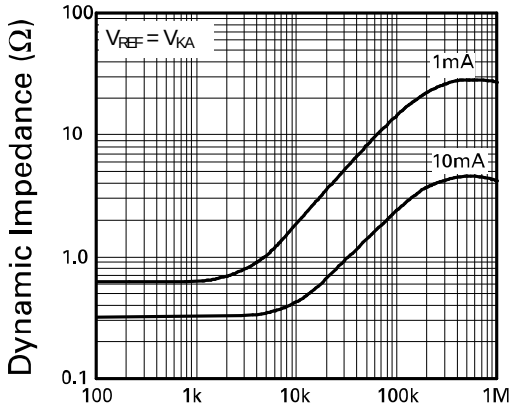
Electrical Characteristics (@T_A = +25°C, unless otherwise specified.)

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

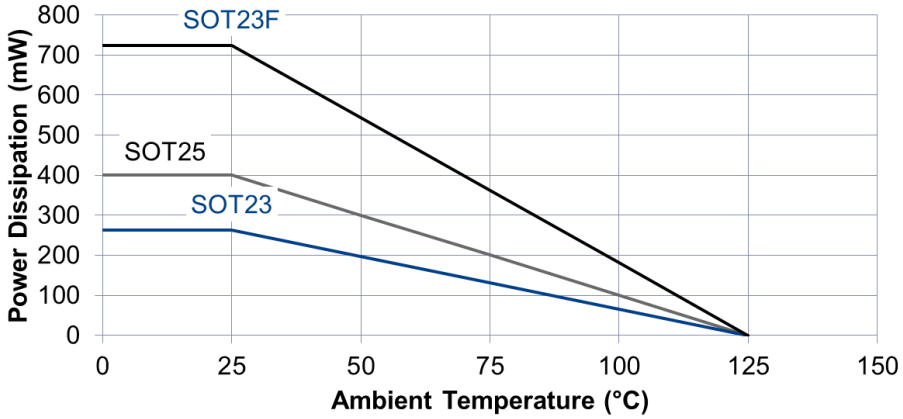
Typical Characteristics



Reference Voltage vs. Temperature

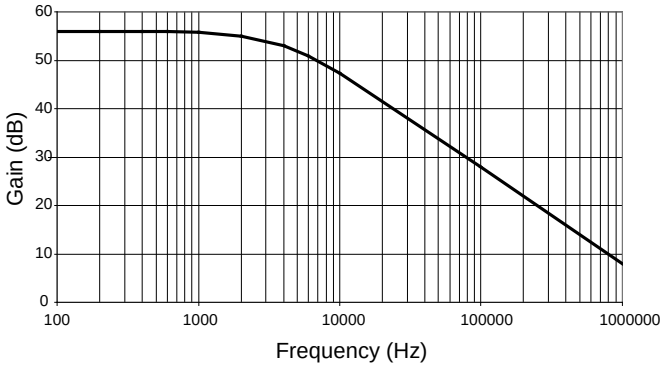


Dynamic Impedance vs. Frequency

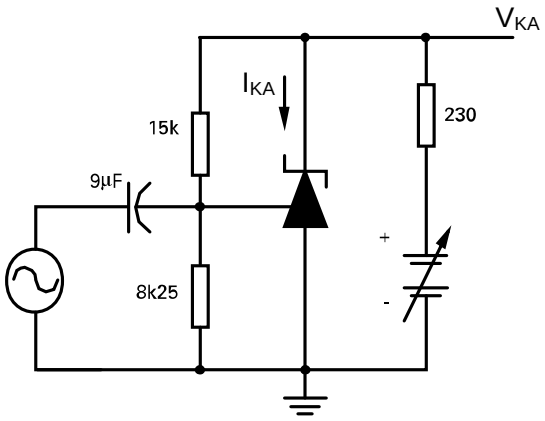


Power Dissipation Derating

Typical Characteristics (continued)

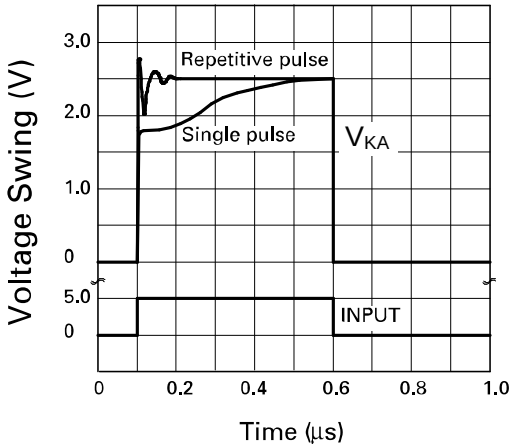


Gain vs. Frequency

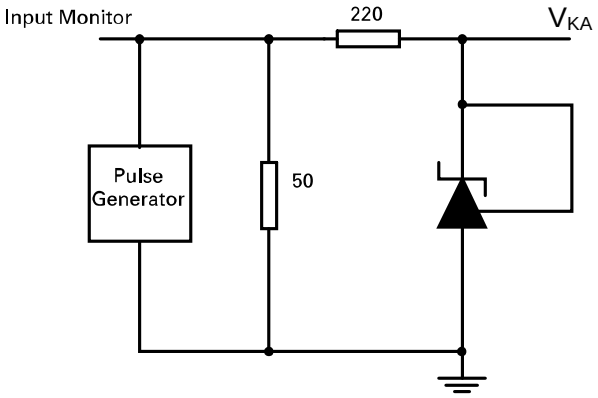


I_{KA} = 10mA, T_A = 25°C

Test Circuit for Open Loop Voltage Gain

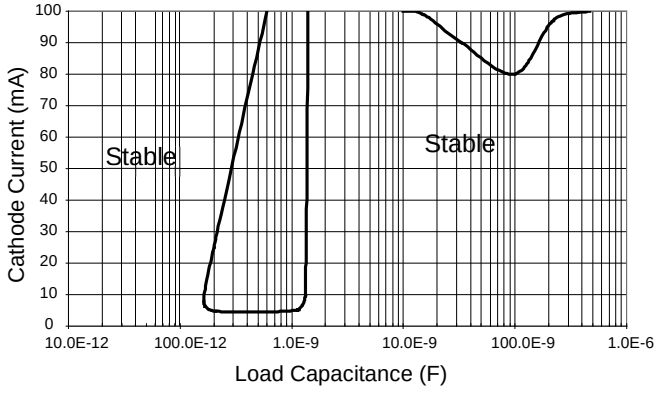


Pulse Response

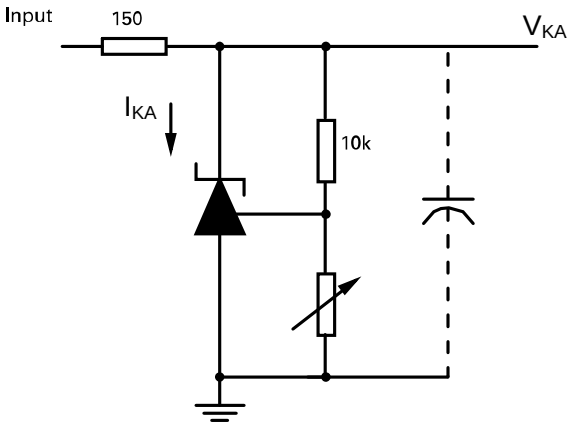


T_A = 25°C

Test Circuit for Pulse Response



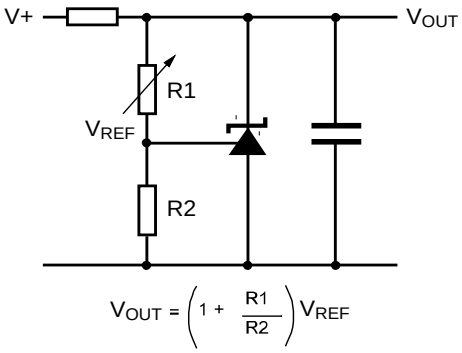
Stability Boundary Condition



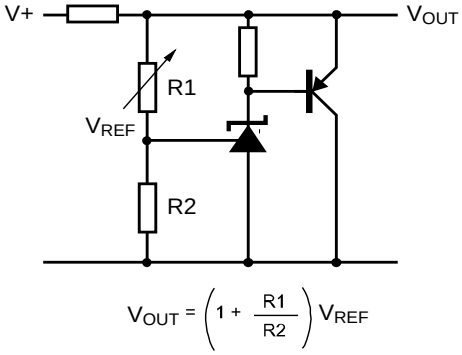
V_{REF} < V_{KA} < 20V, I_{KA} = 10mA, T_A = +25°C

Test Circuit for Stability Boundary Conditions

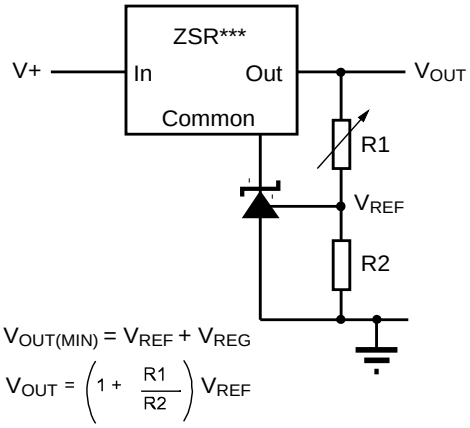
Application Circuits



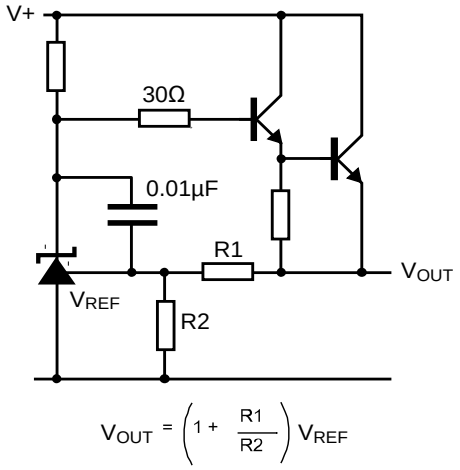
Shunt regulator



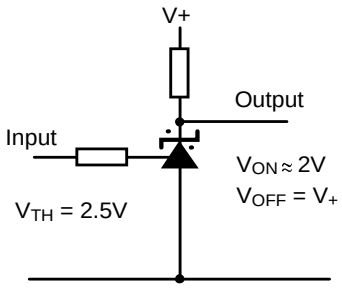
Higher current shunt regulator



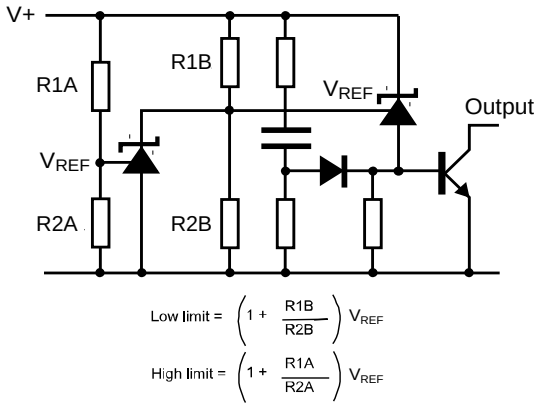
Output control of a three terminal fixed regulator



Series regulator



Single supply comparator with temperature compensated threshold



Over voltage / under voltage protection circuit

DC Test Circuits

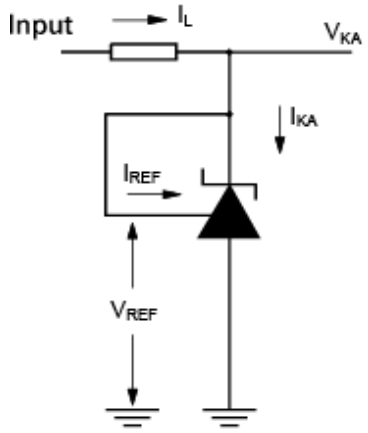


Figure 1. Test circuit for $V_{KA} = V_{REF}$

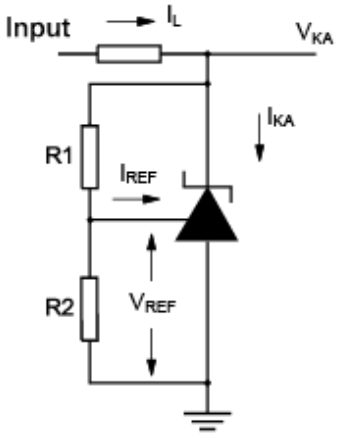


Figure 2. Test circuit for $V_{KA} > V_{REF}$

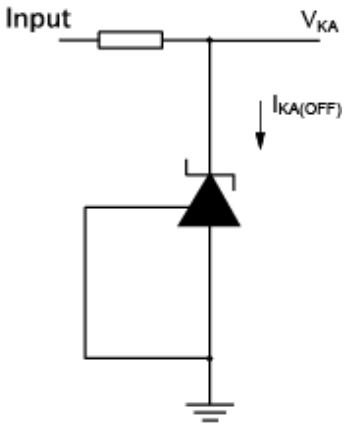


Figure 3. Test circuit for off state current

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:

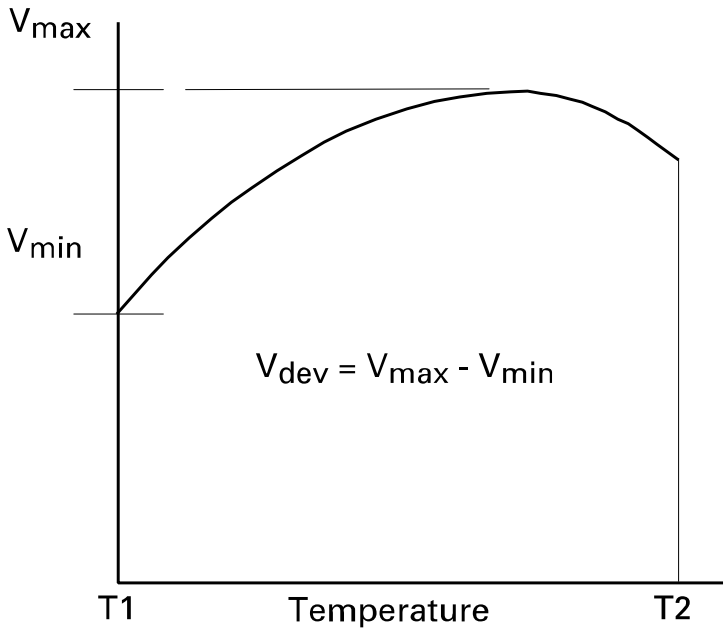
$$V_{REF}(ppm/°C) = \frac{V_{DEV} \times 1{,}000{,}000}{V_{REF}(T1-T2)}$$

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:

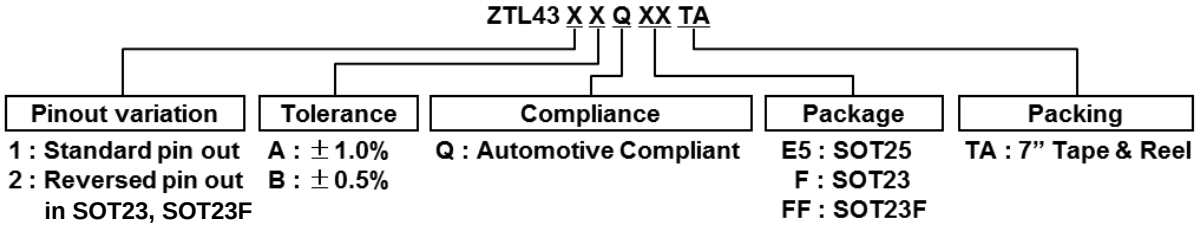
$$R'_Z = R_Z \left(1 + \frac{R1}{R2}\right)$$



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 (Note 5)

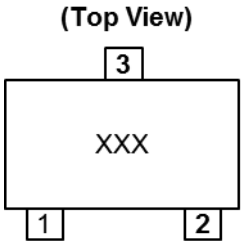


Tol.	Ordering Code	Package Code	Packaging (Note 4)	Part Mark	Reel Size	Tape Width (mm)	Quantity per Reel	Qualification	Status
1%	ZTL431AQE5TA	E5	SOT25	31A	7", 180mm	8	3,000	Automotive Compliant	Active
	ZTL431AQFFTA	FF	SOT23F	1V1	7", 180mm	8	3,000	Automotive Compliant	EOL (Note 6)
	ZTL431AQFTA	F	SOT23	31A	7", 180mm	8	3,000	Automotive Compliant	Active
	ZTL432AQFFTA	FF	SOT23F	1V2	7", 180mm	8	3,000	Automotive Compliant	EOL (Note 6)
	ZTL432AQFTA	F	SOT23	32A	7", 180mm	8	3,000	Automotive Compliant	Active
0.5%	ZTL431BQE5TA	E5	SOT25	31B	7", 180mm	8	3,000	Automotive Compliant	Active
	ZTL431BQFFTA	FF	SOT23F	1V3	7", 180mm	8	3,000	Automotive Compliant	EOL (Note 6)
	ZTL431BQFTA	F	SOT23	31B	7", 180mm	8	3,000	Automotive Compliant	Active
	ZTL432BQFFTA	FF	SOT23F	1V4	7", 180mm	8	3,000	Automotive Compliant	EOL (Note 6)
	ZTL432BQFTA	F	SOT23	32B	7", 180mm	8	3,000	Automotive Compliant	Active

Notes: 4. Pad layout as shown in Diodes Incorporated's package outline PDFs, which can be found on our website at http://www.diodes.com/package-outlines.html.
5. See ZTL431/ZTL432 datasheet for commercial qualified versions.
6. ZTL431AQFFTA, ZTL431BQFFTA, ZTL432AQFFTA and ZTL432BQFFTA were made End-of-Life (EOL) PCN-2365 (https://www.diodes.com/assets/PCN-Files/Diodes-PCN-2365-Rev1-EOL-Automotive.pdf) with effect date 4 April, 2019.

Marking Information

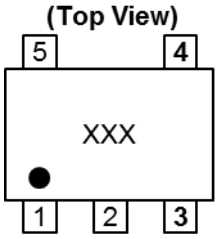
(1) SOT23 and SOT23F (EOL – See Note 6)



XXX : Identification code

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

(2) SOT25



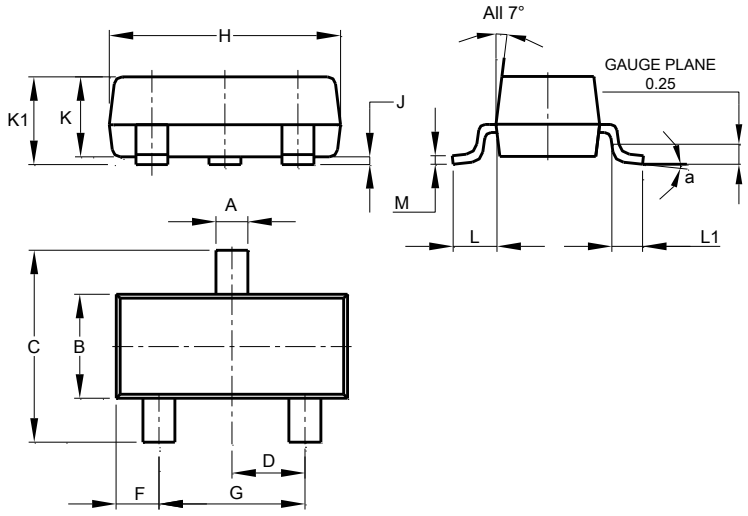
XXX : Identification code

Orderable	Identification Code
ZTL431AQE5TA	31A
ZTL431BQE5TA	31B

Package Outline Dimensions

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

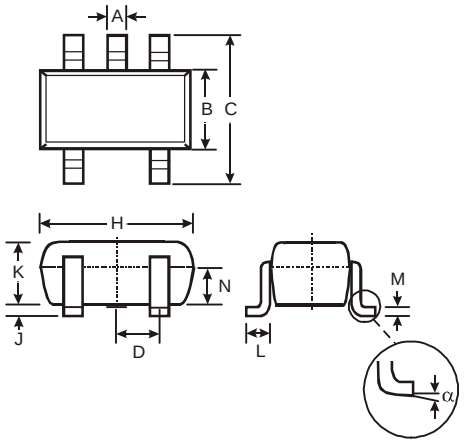
(1) Package Type: SOT23



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 (EOL – See Note 6)

(3) Package Type: SOT25

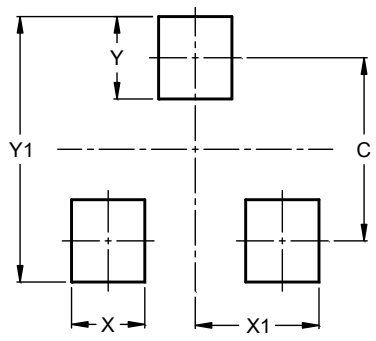


SOT25			
Dim	**Min**	**Max**	**Typ**
A	0.35	0.50	0.38
B	1.50	1.70	1.60
C	2.70	3.00	2.80
D	-	-	0.95
H	2.90	3.10	3.00
J	0.013	0.10	0.05
K	1.00	1.30	1.10
L	0.35	0.55	0.40
M	0.10	0.20	0.15
N	0.70	0.80	0.75
α	0°	8°	-
All Dimensions in mm			

Suggested Pad Layout

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

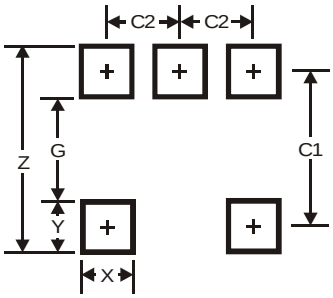
(1) Package Type: SOT23



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

(2) Package Type: SOT23F (EOL – See Note 6)

(3) Package Type: SOT25



Dimensions	Value
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 Incorporated's 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>
<tr><td>November 2018</td><td>4-2</td><td>
Announcement of the End of Life (EOL) (PCN-2365) of the following devices:

ZTL431AQFFTA
ZTL432AQFFTA
ZTL431BQFFTA
ZTL432BQFFTA
</td></tr>
<tr><td>July 2019</td><td>5-2</td><td>
Completion of the End of Life (EOL) (PCN-2365) of the following devices:

ZTL431AQFFTA
ZTL432AQFFTA
ZTL431BQFFTA
ZTL432BQFFTA

</td></tr>
</table>