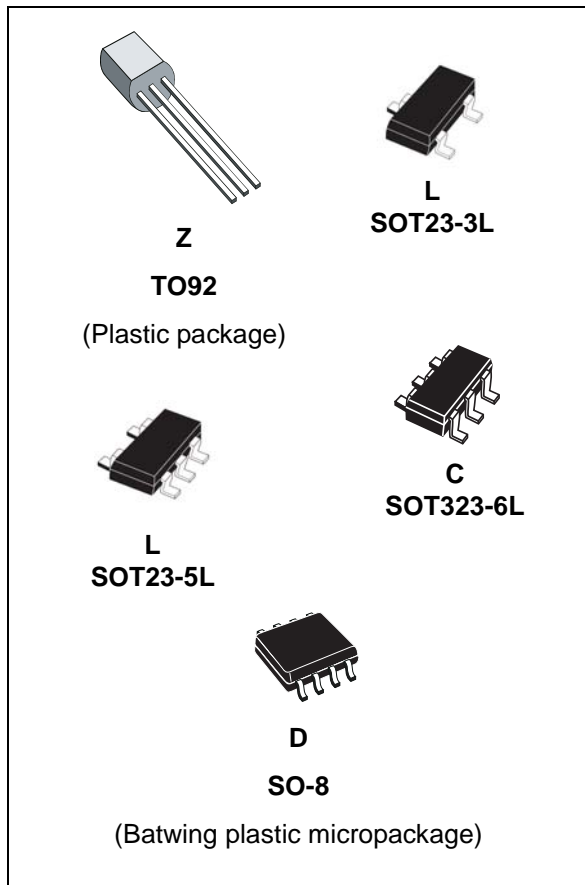


Programmable voltage reference

Datasheet - production data



Features

- Adjustable output voltage: V_{REF} to 36 V
- Sink current capability: 1 to 100 mA
- Typical output impedance: 0.22 Ω
- 0.4 % and 0.25 % voltage precision
- Automotive temp. range - 40 °C to +125 °C

Description

The TL1431 is a programmable shunt voltage reference with guaranteed temperature stability over the entire operating temperature range.

The output voltage may be set to any value between 2.5 V and 36 V with two external resistors.

The TL1431 operates with a wide current range from 1 to 100 mA with a typical dynamic impedance of 0.2 Ω .

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1 Schematic diagrams

Figure 1. TO92 pin connections (top view)

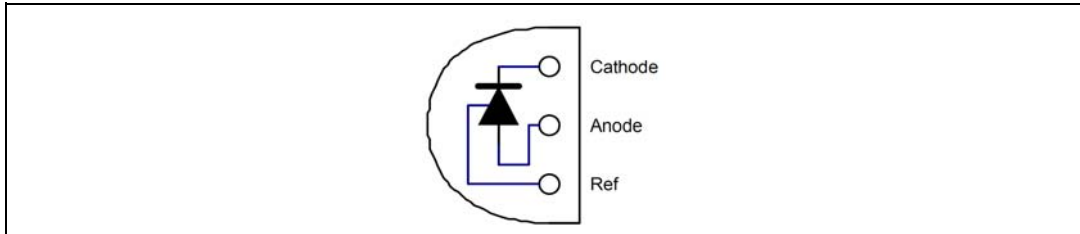


Figure 2. SO-8 batwing pin connections (top view)

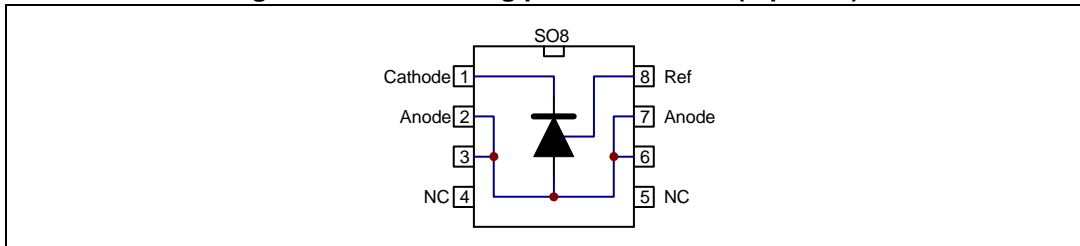


Figure 3. SOT23-5L and SOT23-3L pin connections (top view)

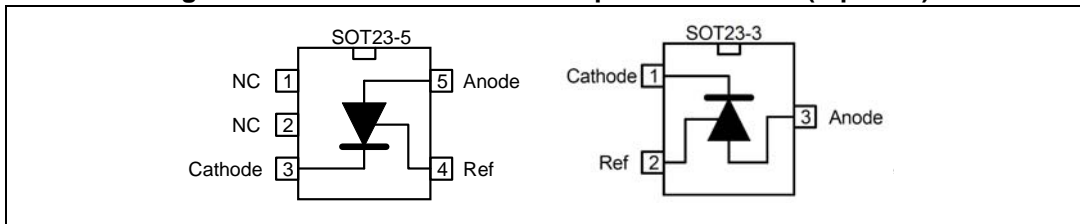


Figure 4. SOT323-6L pin connections (top view)

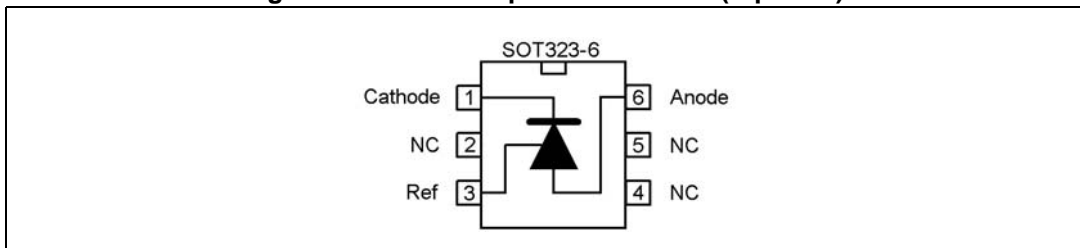
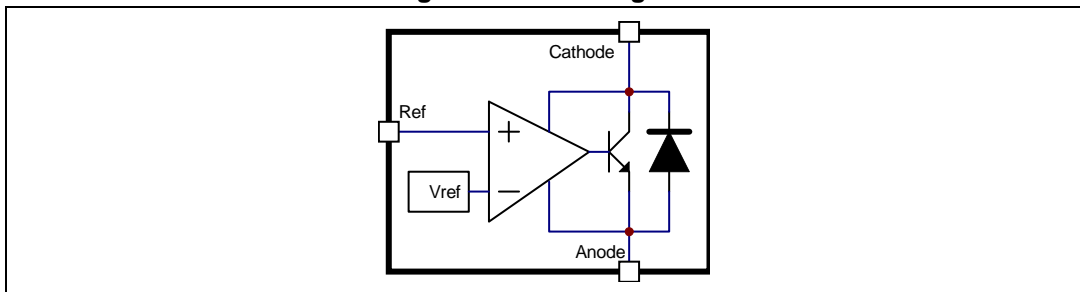


Figure 5. Block diagram



2 Absolute maximum ratings and operating conditions

Table 1. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{KA}	Cathode to anode voltage	37	V
I_k	Continuous cathode current range	-100 to +150	mA
I_{ref}	Reference input current range	-0.05 to +10	mA
T_j	Junction temperature	+150	°C
P_d	Power dissipation ⁽¹⁾		mW
	TO92	625	
	SO-8 batwing	960	
	SOT23-3L	500	
	SOT23-5L	790	
	SOT323-6L	565	
T_{stg}	Storage temperature range	-65 to +150	°C
ESD	HBM: human body model ⁽²⁾	2000	V
	MM: machine model ⁽³⁾	200	
	CDM: charged device model ⁽⁴⁾	1500	

1. Calculated with $T_j=+150$ °C and $T_{amb}=+25$ °C with relative R_{thja} depending on the package.
2. Human body model: A 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 kΩ resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
3. Machine model: A 200 pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω). This is done for all couples of connected pin combinations while the other pins are floating.
4. Charged device model: all pins and the package are charged together to the specified voltage and then discharged directly to the ground through only one pin. This is done for all pins.

Table 2. Operating conditions

Symbol	Parameter	Value	Unit
V_{KA}	Cathode to anode voltage	V_{ref} to 36	V
I_k	Cathode current	1 to 100	mA
T_{oper}	Operating free-air temperature range		°C
	TL1431C/AC	-20 to +70	
	TL1431I/AI	-40 to +105	
	TL1431IY/AIY	-40 to +125	

Table 2. Operating conditions

Symbol	Parameter	Value	Unit
R_{thja}	Thermal resistance junction to ambient		°C/W
	SO-8 batwing	130	
	TO92	200	
	SOT23-3L	248	
	SOT23-5L	157	
	SOT323-6L	221	
R_{thjc}	Thermal resistance junction to case ⁽¹⁾		°C/W
	SO-8 batwing	30	
	SOT23-3L	136	
	SOT23-5L	67	
	SOT323-6L	110	

1. Short-circuits can cause excessive heating. These values are typical.

3 Electrical characteristics

$T_{amb} = 25\text{ °C}$ (unless otherwise specified).

Table 3. Electrical characteristics for TL1431C, TL1431AC

Symbol	Parameter	TL1431C			TL1431AC			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
V_{ref}	Reference input voltage - see Figure 6 $V_{KA} = V_{ref}$, $I_k = 10\text{ mA}$	2.490	2.500	2.510	2.493	2.500	2.507	V
ΔV_{ref}	Reference input voltage deviation over temperature range ⁽¹⁾ - see Figure 6 $V_{KA} = V_{ref}$, $I_k = 10\text{ mA}$, $T_{min} \leq T_{amb} \leq T_{max}$		3	20		3	20	mV
$\frac{\Delta V_{ref}}{\Delta T}$	Temperature coefficient of reference input voltage ⁽²⁾ $V_{KA} = V_{ref}$, $I_k = 10\text{ mA}$, $T_{min} \leq T_{amb} \leq T_{max}$		± 13	± 90		± 13	± 90	ppm/°C
$\frac{\Delta V_{ref}}{\Delta V_{ka}}$	Ratio of change in reference input voltage to change in cathode to anode voltage - see Figure 7 $I_k = 10\text{ mA}$ - $\Delta V_{KA} = 36\text{ V}$ to 3 V	-2	-1.1		-2	-1.1		mV/V
I_{ref}	Reference input current $I_k = 10\text{ mA}$, $R1 = 10\text{ k}\Omega$, $R2 = \infty$ $T_{min} \leq T_{amb} \leq T_{max}$		1.5	2.5 3		1.5	2.5 3	μA
ΔI_{ref}	Reference input current deviation over temperature range $I_k = 10\text{ mA}$, $R1 = 10\text{ k}\Omega$, $R2 = \infty$, $T_{min} \leq T_{amb} \leq T_{max}$		0.2	1.2		0.2	1.2	μA
I_{min}	Minimum cathode current for regulation - Figure 6 $V_{KA} = V_{ref}$		0.5	1		0.5	0.6	mA
I_{off}	Off-state cathode current - see Figure 8		180	500		180	500	nA
$ Z_{KA} $	Dynamic impedance ⁽³⁾ $V_{KA} = V_{ref}$, $\Delta I_k = 1\text{ to }100\text{ mA}$, $f \leq 1\text{ kHz}$		0.2	0.5		0.2	0.5	Ω

1. See [Reference input voltage deviation over temperature range](#) in [Section 4: Parameter definitions on page 12](#).

2. See [Temperature coefficient of reference input voltage](#) in [Section 4: Parameter definitions on page 12](#).

3. See [Dynamic impedance](#) in [Section 4: Parameter definitions on page 12](#).

$T_{amb} = 25\text{ °C}$ (unless otherwise specified).

Table 4. Electrical characteristics for TL1431I, TL1431AI

Symbol	Parameter	TL1431I			TL1431AI			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
V_{ref}	Reference input voltage - see Figure 6 $V_{KA} = V_{ref}$, $I_k = 10\text{ mA}$	2.490	2.500	2.510	2.493	2.500	2.507	V
ΔV_{ref}	Reference input voltage deviation over temperature range ⁽¹⁾ - see Figure 6 $V_{KA} = V_{ref}$, $I_k = 10\text{ mA}$, $T_{min} \leq T_{amb} \leq T_{max}$		7	30		7	30	mV
$\frac{\Delta V_{ref}}{\Delta T}$	Temperature coefficient of reference input voltage ⁽²⁾ $V_{KA} = V_{ref}$, $I_k = 10\text{ mA}$, $T_{min} \leq T_{amb} \leq T_{max}$		± 22	± 100		± 22	± 100	ppm/°C
$\frac{\Delta V_{ref}}{\Delta V_{ka}}$	Ratio of change in reference input voltage to change in cathode to anode voltage - see Figure 7 $I_k = 10\text{ mA}$ - $\Delta V_{KA} = 36\text{ V}$ to 3 V	-2	-1.1		-2	-1.1		mV/V
I_{ref}	Reference input current $I_k = 10\text{ mA}$, $R1 = 10\text{ k}\Omega$, $R2 = \infty$ $T_{min} \leq T_{amb} \leq T_{max}$		1.5	2.5 3		1.5	2.5 3	μA
ΔI_{ref}	Reference input current deviation over temperature range $I_k = 10\text{ mA}$, $R1 = 10\text{ k}\Omega$, $R2 = \infty$, $T_{min} \leq T_{amb} \leq T_{max}$		0.5	1		0.8	1.2	μA
I_{min}	Minimum cathode current for regulation - see Figure 6 $V_{KA} = V_{ref}$		0.5	1		0.5	0.7	mA
I_{off}	Off-state cathode current - see Figure 8		180	500		180	500	nA
$ Z_{KA} $	Dynamic impedance ⁽³⁾ $V_{KA} = V_{ref}$, $\Delta I_k = 1\text{ to }100\text{ mA}$, $f \leq 1\text{ kHz}$		0.2	0.5		0.2	0.5	Ω

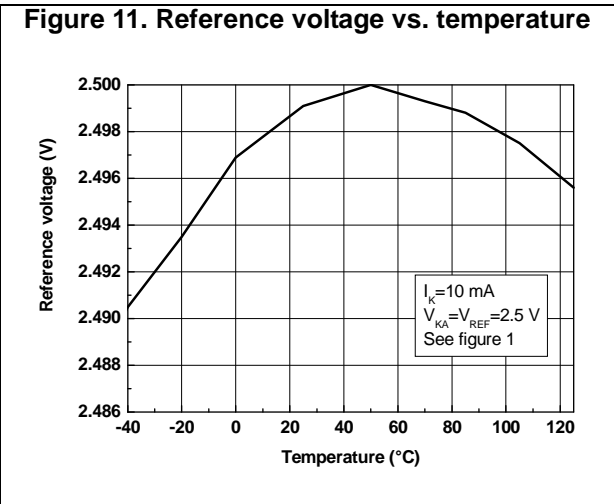
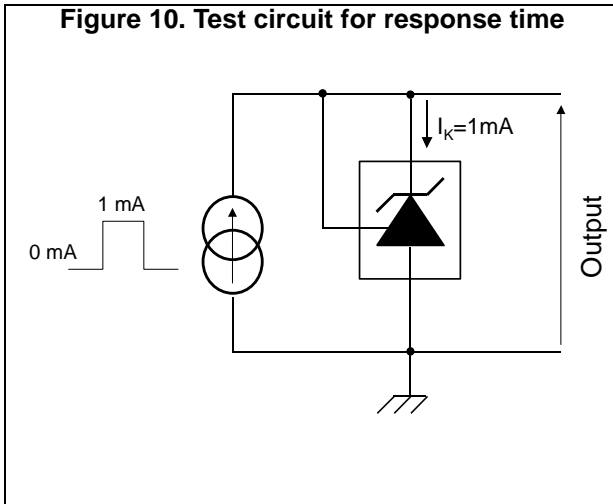
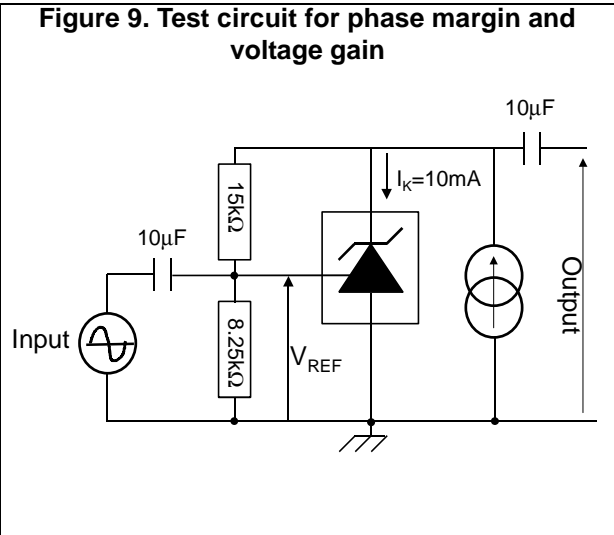
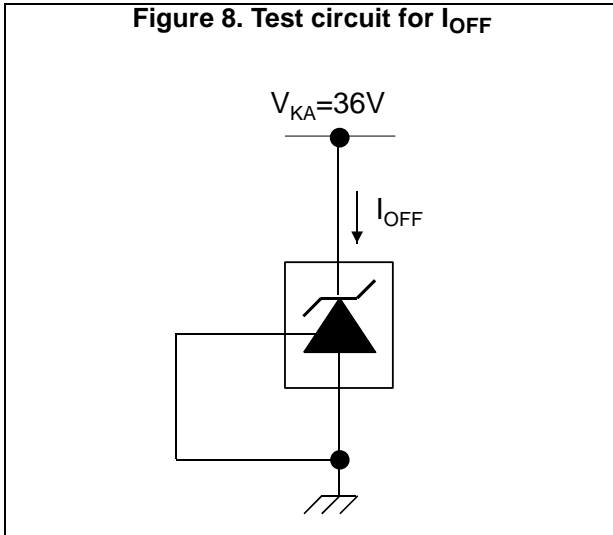
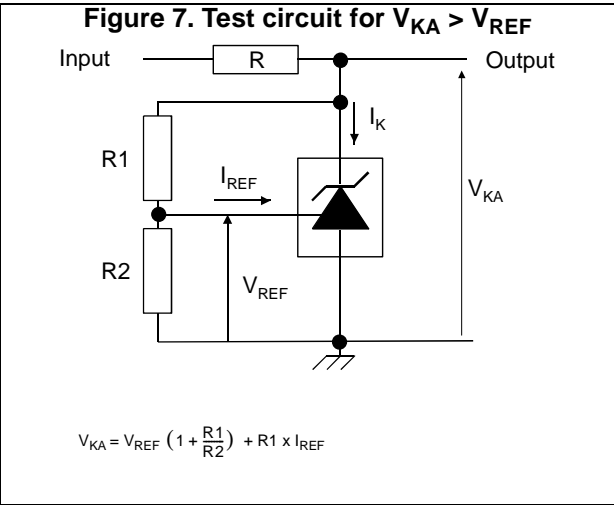
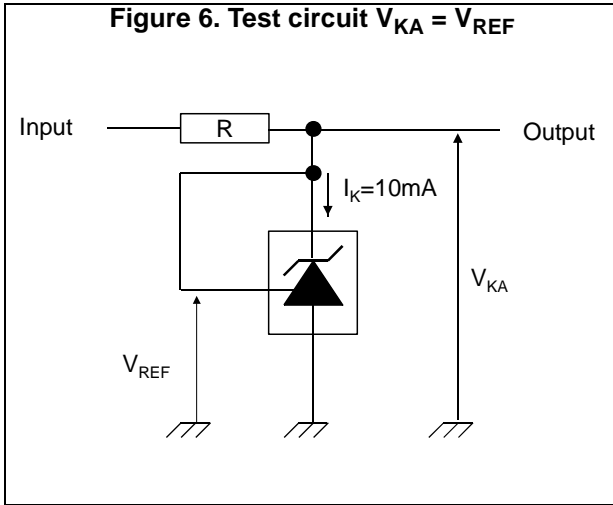
1. See [Reference input voltage deviation over temperature range](#) in [Section 4: Parameter definitions on page 12](#).
2. See [Temperature coefficient of reference input voltage](#) in [Section 4: Parameter definitions on page 12](#).
3. See [Dynamic impedance](#) in [Section 4: Parameter definitions on page 12](#).

$T_{amb} = 25\text{ °C}$ (unless otherwise specified).

Table 5. Electrical characteristics for TL1431IY, TL1431AIY

Symbol	Parameter	TL1431IY			TL1431AIY			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
V_{ref}	Reference input voltage - see Figure 6 $V_{KA} = V_{ref}, I_k = 10\text{ mA}$	2.490	2.500	2.510	2.493	2.500	2.507	V
ΔV_{ref}	Reference input voltage deviation over temperature range ⁽¹⁾ - see Figure 6 $V_{KA} = V_{ref}, I_k = 10\text{ mA}, T_{min} \leq T_{amb} \leq T_{max}$		7	30		7	30	mV
$\frac{\Delta V_{ref}}{\Delta T}$	Temperature coefficient of reference input voltage ⁽²⁾ $V_{KA} = V_{ref}, I_k = 10\text{ mA}, T_{min} \leq T_{amb} \leq T_{max}$		± 22	± 100		± 22	± 100	ppm/°C
$\frac{\Delta V_{ref}}{\Delta V_{ka}}$	Ratio of change in reference input voltage to change in cathode to anode voltage - see Figure 7 $I_k = 10\text{ mA} - \Delta V_{KA} = 36\text{ V to } 3\text{ V}$	-2	-1.1		-2	-1.1		mV/V
I_{ref}	Reference input current $I_k = 10\text{ mA}, R1 = 10\text{ k}\Omega, R2 = \infty$ $T_{min} \leq T_{amb} \leq T_{max}$		1.5	2.5 3		1.5	2.5 3	μA
ΔI_{ref}	Reference input current deviation over temperature range $I_k = 10\text{ mA}, R1 = 10\text{ k}\Omega, R2 = \infty, T_{min} \leq T_{amb} \leq T_{max}$		0.5	1		0.8	1.2	μA
I_{min}	Minimum cathode current for regulation - see Figure 6 $V_{KA} = V_{ref}$		0.5	1		0.5	0.7	mA
I_{off}	Off-state cathode current - see Figure 8		180	500		180	500	nA
$ Z_{KA} $	Dynamic impedance ⁽³⁾ $V_{KA} = V_{ref}, \Delta I_k = 1\text{ to }100\text{ mA}, f \leq 1\text{ kHz}$		0.2	0.5		0.2	0.5	Ω

1. See [Reference input voltage deviation over temperature range](#) in [Section 4: Parameter definitions on page 12](#).
2. See [Temperature coefficient of reference input voltage](#) in [Section 4: Parameter definitions on page 12](#).
3. See [Dynamic impedance](#) in [Section 4: Parameter definitions on page 12](#).



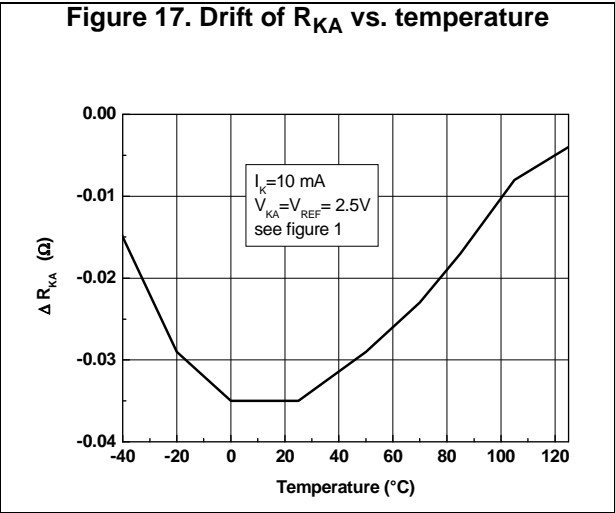
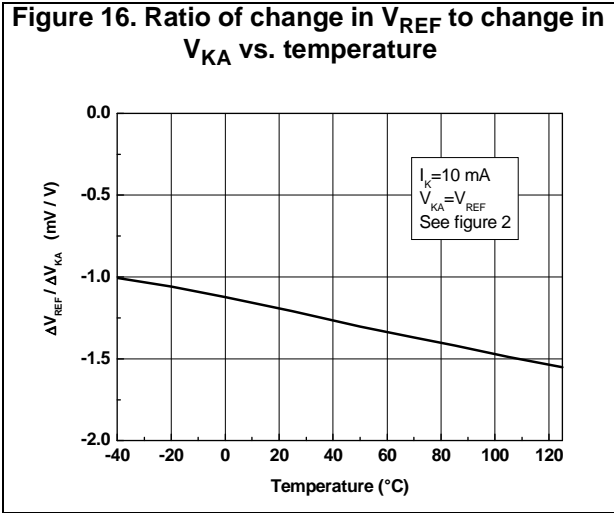
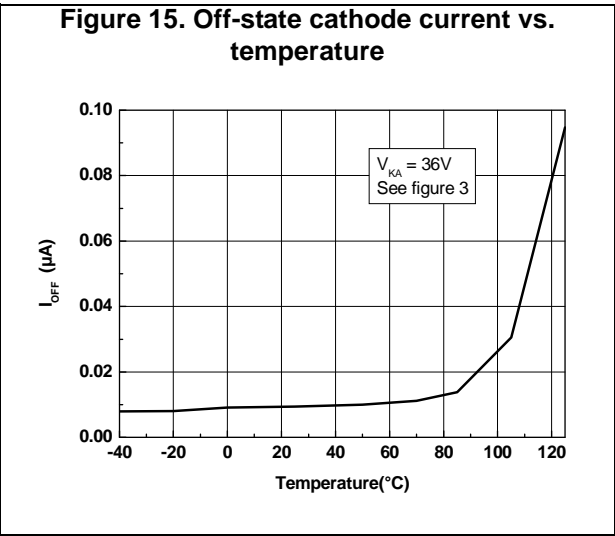
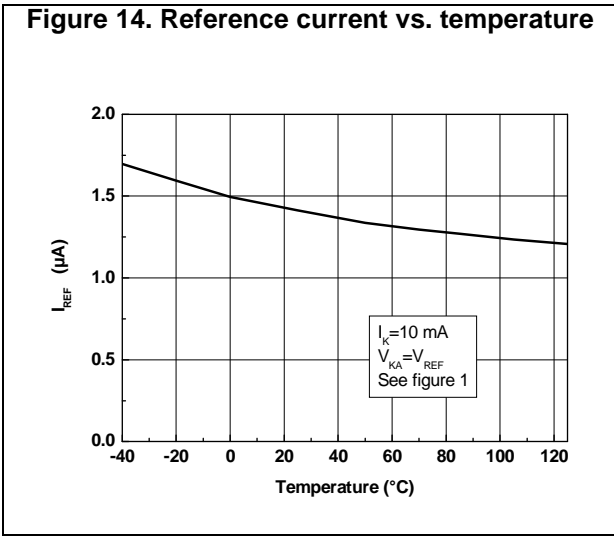
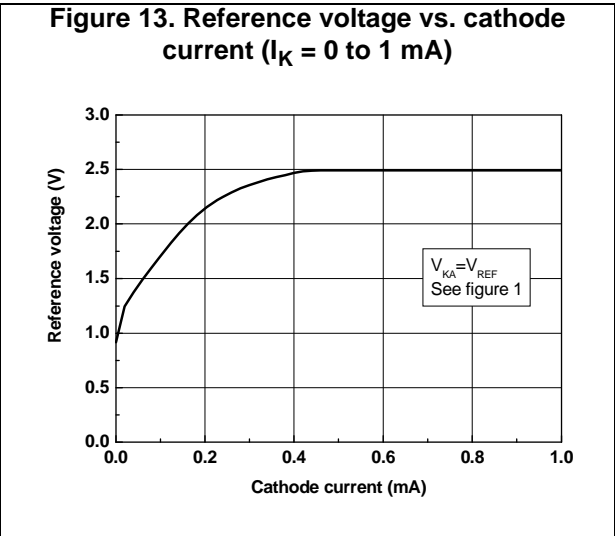
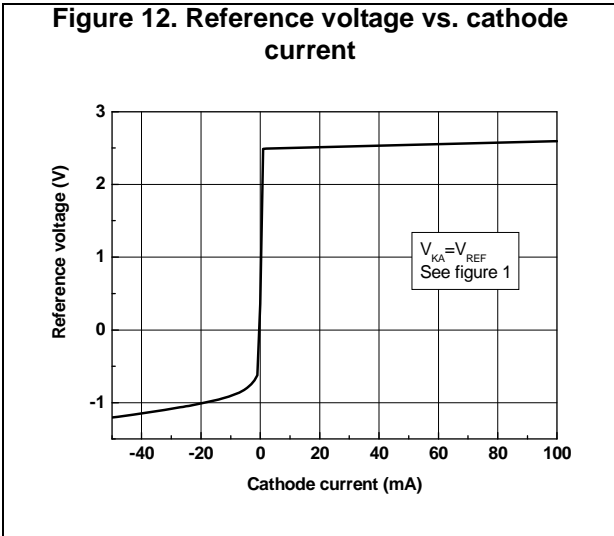


Figure 18. Maximum operating current vs. temperature

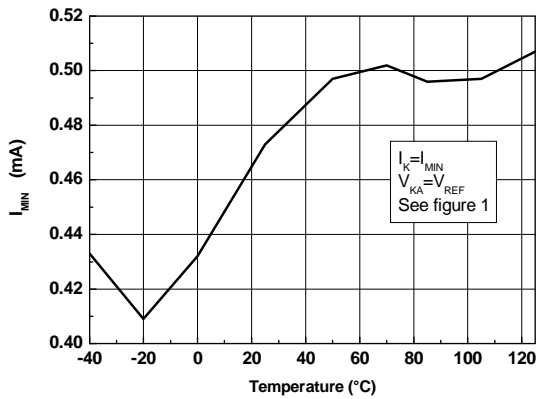


Figure 19. Gain and phase vs. frequency

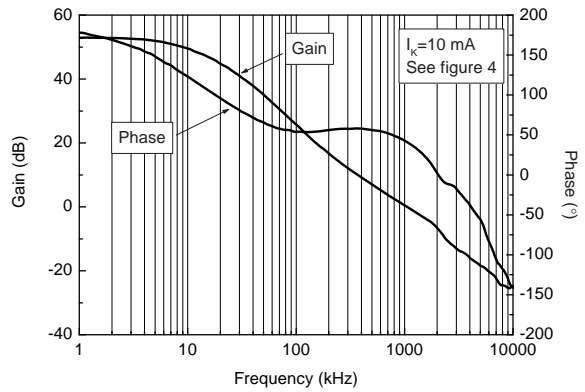


Figure 20. Stability behavior with capacitive loads

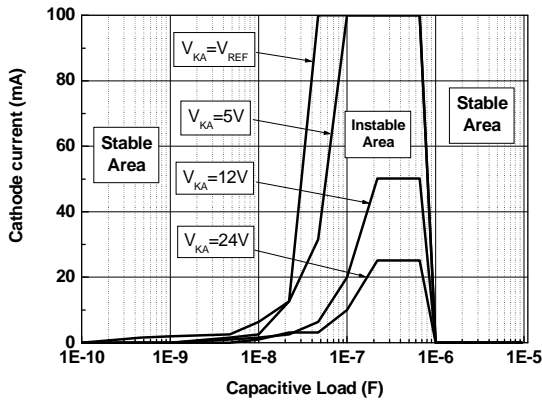


Figure 21. Maximum power dissipation

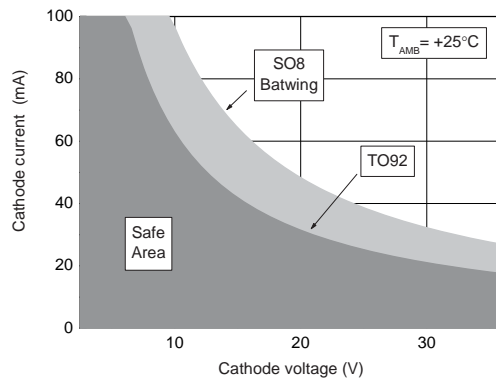
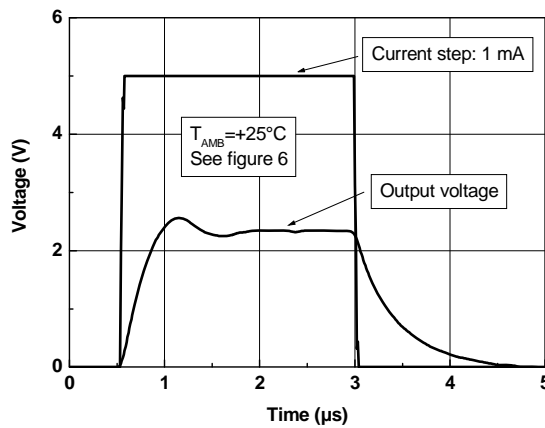


Figure 22. Pulse response for $I_K = 1$ mA



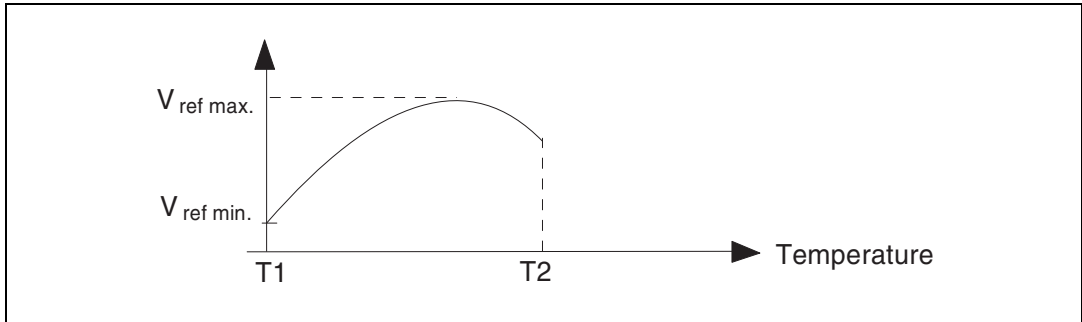
4 Parameter definitions

4.1 Reference input voltage deviation over temperature range

ΔV_{ref} is defined as the difference between the maximum and minimum values obtained over the full temperature range.

$$\Delta V_{ref} = V_{ref\ max.} - V_{ref\ min.}$$

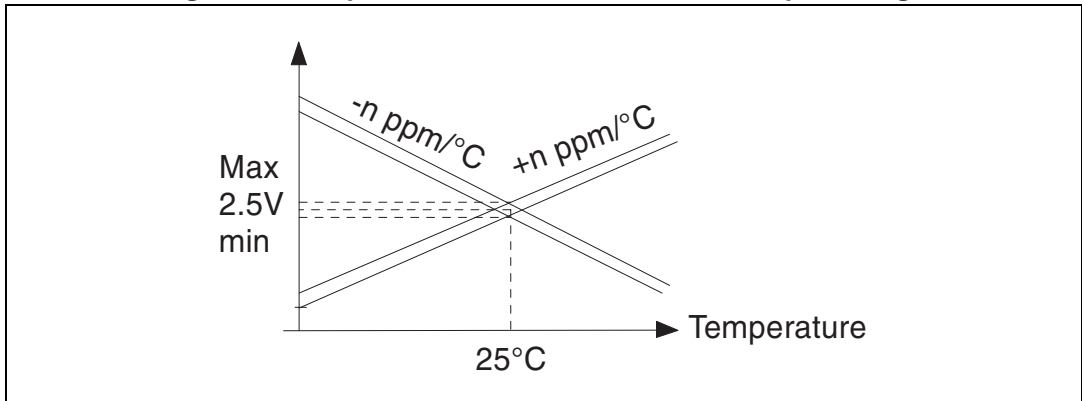
Figure 23. Reference input voltage deviation over temperature range



4.2 Temperature coefficient of reference input voltage

The temperature coefficient is defined as the slopes (positive and negative) of the voltage versus temperature limits within which the reference is guaranteed.

Figure 24. Temperature coefficient of reference input voltage



4.3 Dynamic impedance

The dynamic impedance is defined as $|Z_{KA}| = \frac{\Delta V_{KA}}{\Delta I_K}$

5 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK[®] packages, depending on their level of environmental compliance. ECOPACK[®] specifications, grade definitions and product status are available at: www.st.com. ECOPACK[®] is an ST trademark.

5.1 SO-8 package information

Figure 25. SO-8 package outline

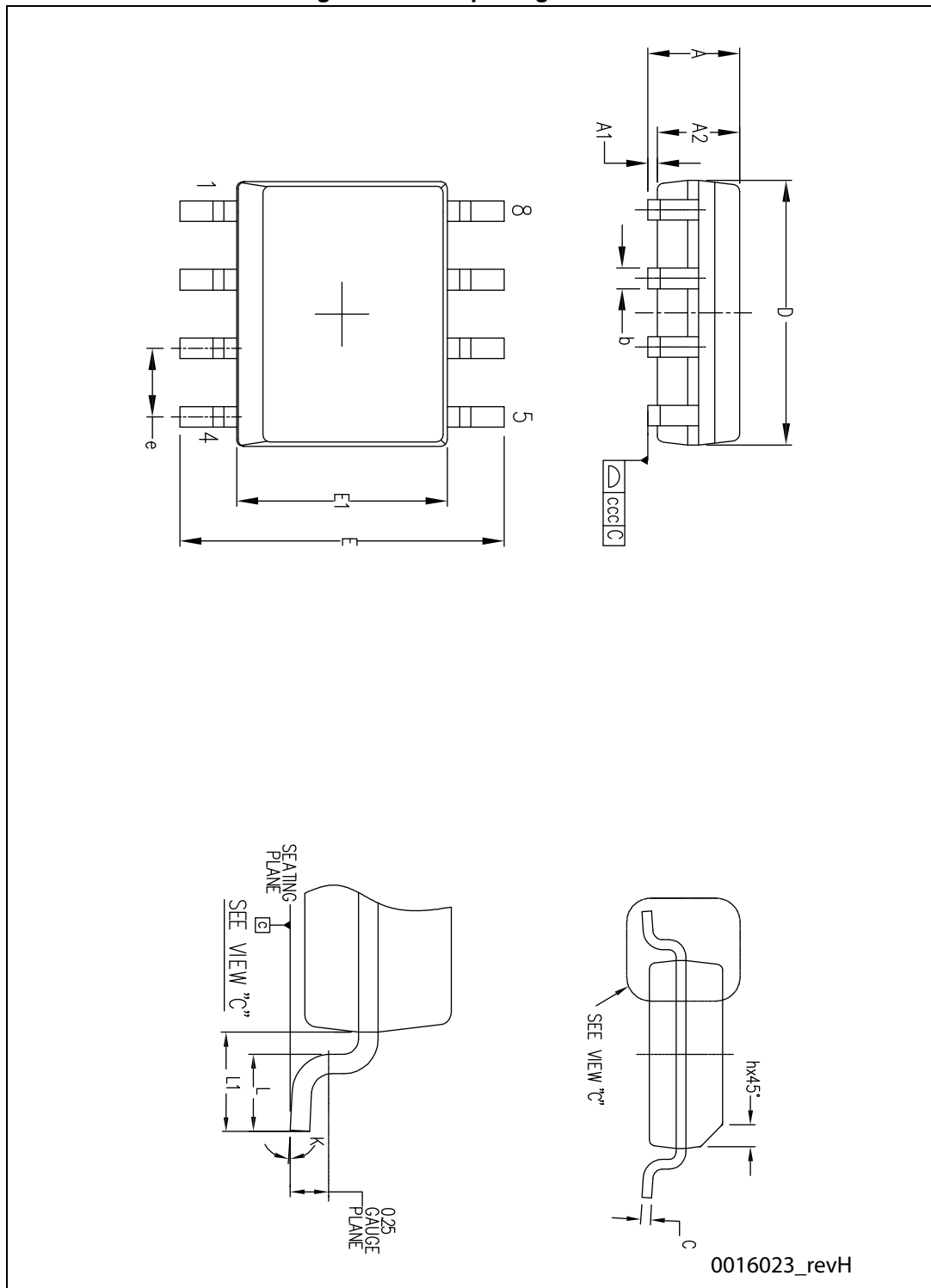


Table 6. SO-8 mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A			1.75
A1	0.10		0.25
A2	1.25		
b	0.28		0.48
c	0.17		0.23
D	4.80	4.90	5.00
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e		1.27	
h	0.25		0.50
L	0.40		1.27
L1		1.04	
k	0		8
ccc			0.10

5.2 SO-8 packing information

Figure 26. SO-8 tape and reel outline

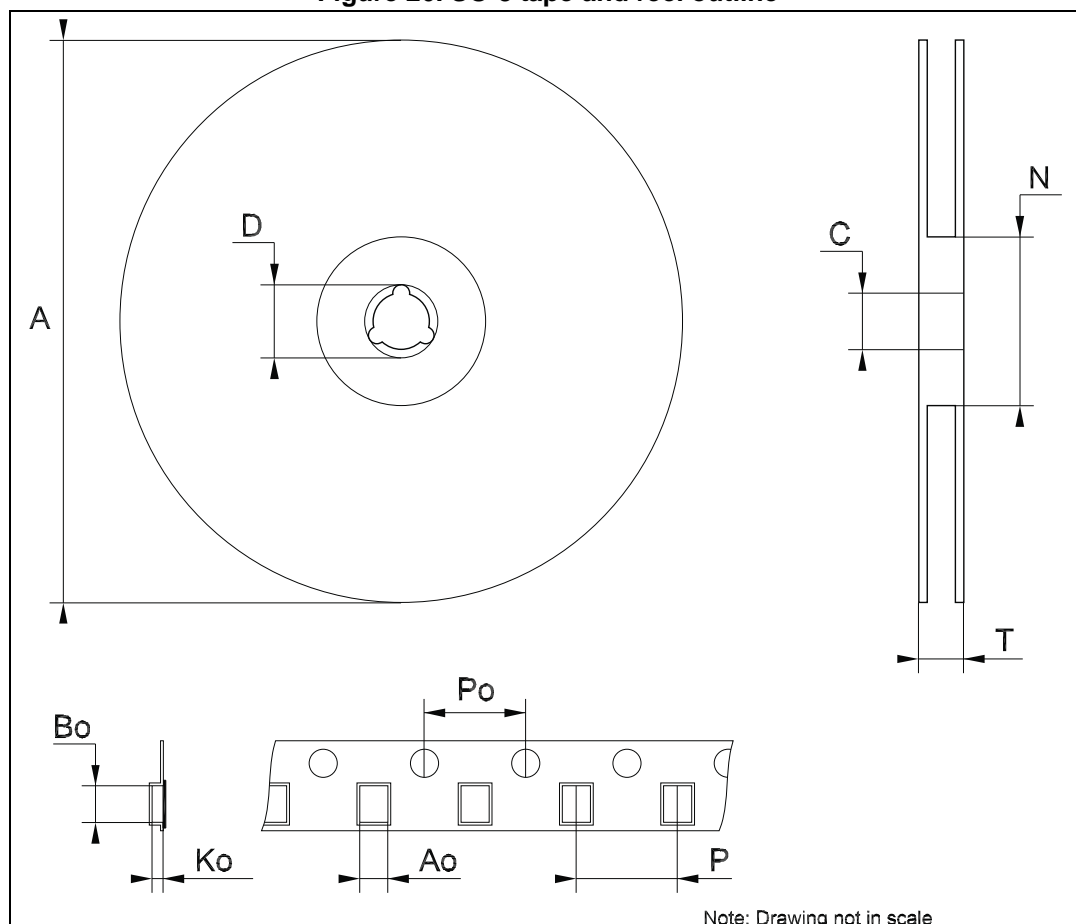


Table 7. SO-8 tape and reel mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A		-	330
C	12.8	-	13.2
D	20.2	-	
N	60	-	
T		-	22.4
Ao	8.1	-	8.5
Bo	5.5	-	5.9
Ko	2.1	-	2.3
Po	3.9	-	4.1
P	7.9	-	8.1

5.3 TO92 Ammopack package information

Figure 27. TO92 Ammopack package outline

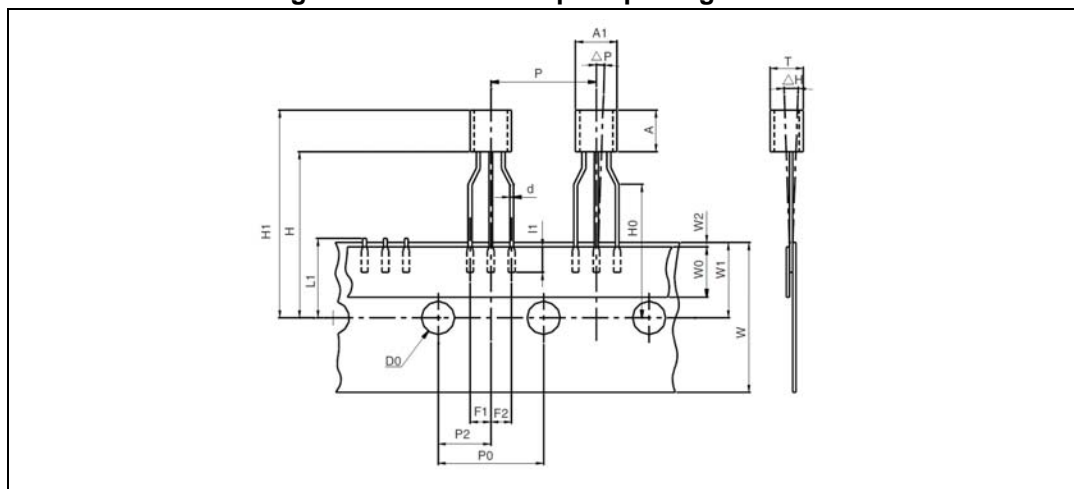


Table 8. TO92 Ammopack package mechanical data

Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A1			5.0			0.197
A			5.0			0.197
T			4.0			0.157
d		0.45			0.018	
l1	2.5			0.098		
P	11.7	12.7	13.7	0.461	0.500	0.539
PO	12.4	12.7	13	0.488	0.500	0.512
P2	5.95	6.35	6.75	0.234	0.250	0.266
F1/F2	2.4	2.5	2.8	0.094	0.098	0.110
Δh	-1	0	1	-0.039	0	0.039
ΔP	-1	0	1	-0.039	0	0.039
W	17.5	18.0	19.0	0.689	0.709	0.748
W0	5.7	6	6.3	0.224	0.236	0.248
W1	8.5	9	9.75	0.335	0.354	0.384
W2			0.5			0.020
H			20			0.787
H0	15.5	16	16.5	0.610	0.630	0.650
H1			25			0.984
DO	3.8	4.0	4.2	0.150	0.157	0.165
L1			11			0.433

5.4 TO92 (bulk) package information

Figure 28. TO92 bulk package outline

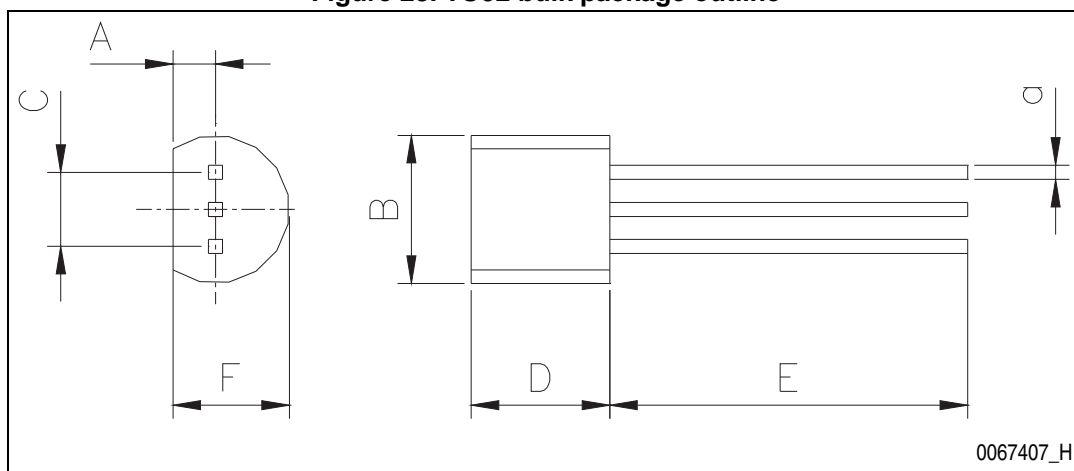


Table 9. TO92 bulk package mechanical data

Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A		1.35			0.053	
B			4.70			0.185
C		2.54			0.100	
D	4.40			0.173		
E	12.70			0.500		
F			3.70			0.146
a			0.5			0.019

5.5 SOT23-3L package information

Figure 29. SOT23-3L package outline

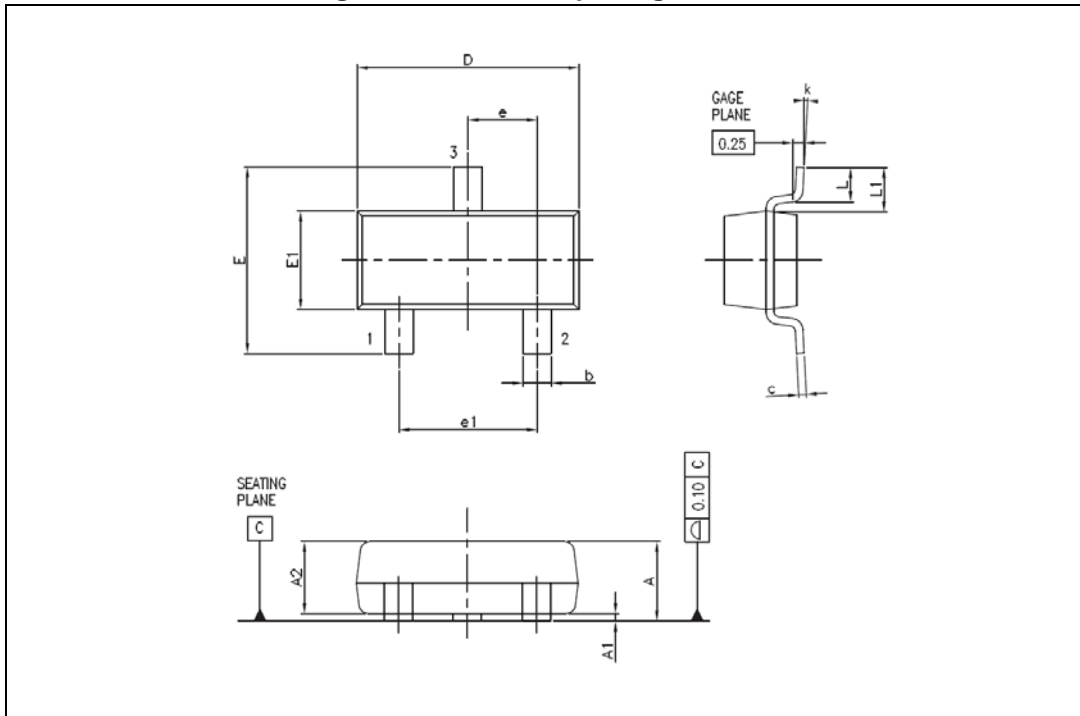
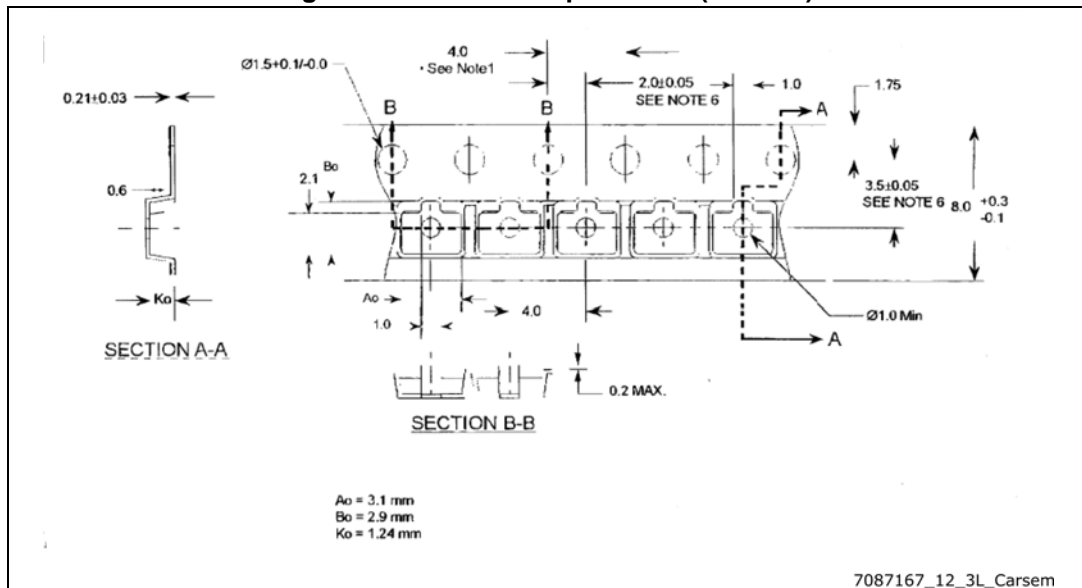


Table 10. SOT23-3L package mechanical data

Dimensions						
Ref.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.89		1.12	0.035		0.044
A1	0.01		0.10	0.0004		0.004
A2	0.88	0.95	1.02	0.035	0.037	0.040
b	0.30		0.50	0.012		0.020
c	0.08		0.20	0.003		0.008
D	2.80	2.90	3.04	0.110	0.114	0.120
E	2.10		2.64	0.083		0.104
E1	1.20	1.30	1.40	0.047	0.051	0.055
e		0.95			0.037	
e1		1.90			0.075	
L	0.40	0.50	0.60	0.016	0.020	0.024
L1		0.54			0.021	
k	0d		8d			

5.6 SOT23-3L packing information

Figure 30. SOT23-3L tape outline (Carsem)



5.7 SOT23-5L package information

Figure 31. SOT23-5L package outline

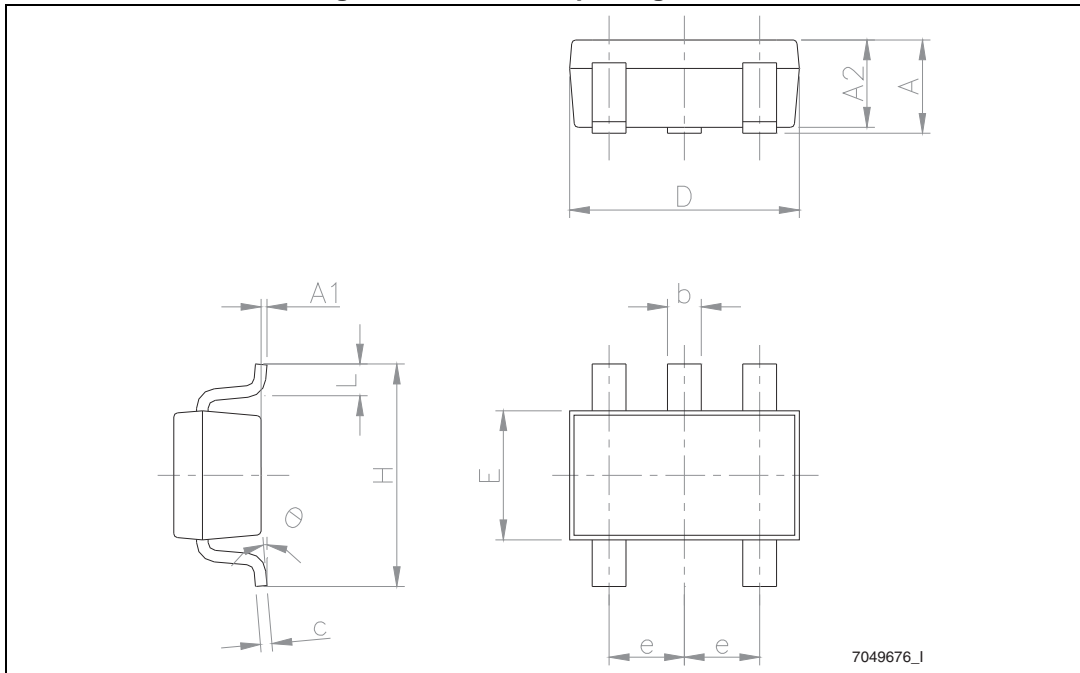
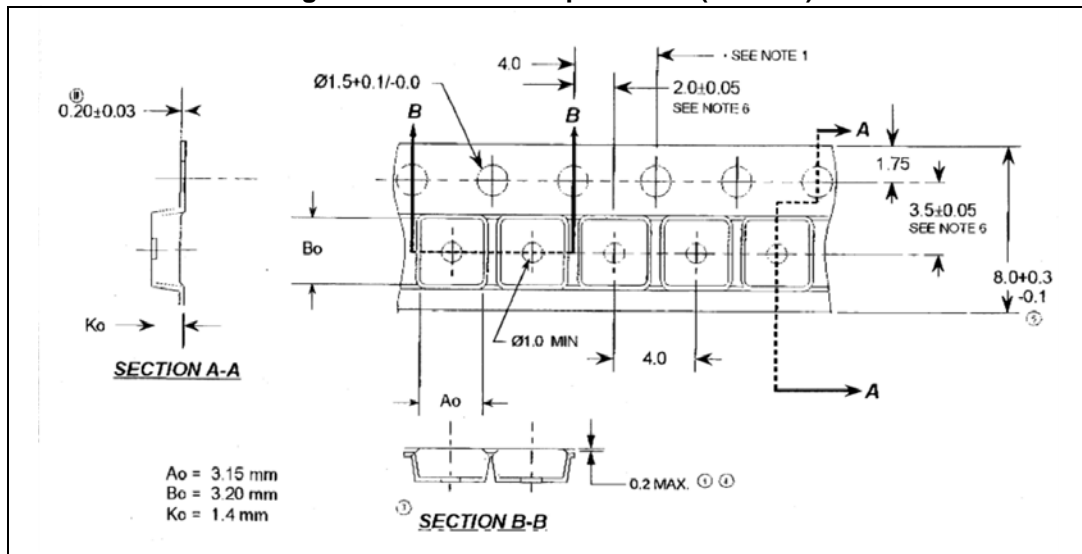


Table 11. SOT23-5L package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.90		1.45	0.035		0.057
A1			0.15			0.006
A2	0.90		1.30	0.035		0.051
b	0.35		0.50	0.014		0.020
c	0.09		0.20	0.004		0.008
D	2.80		3.05	0.110		0.120
E	1.50		1.75	0.059		0.069
e		0.95			0.037	
H	2.60		3.00	0.102		0.118
L	0.10		0.60	0.004		0.024
θ	0 degrees		10 degrees			

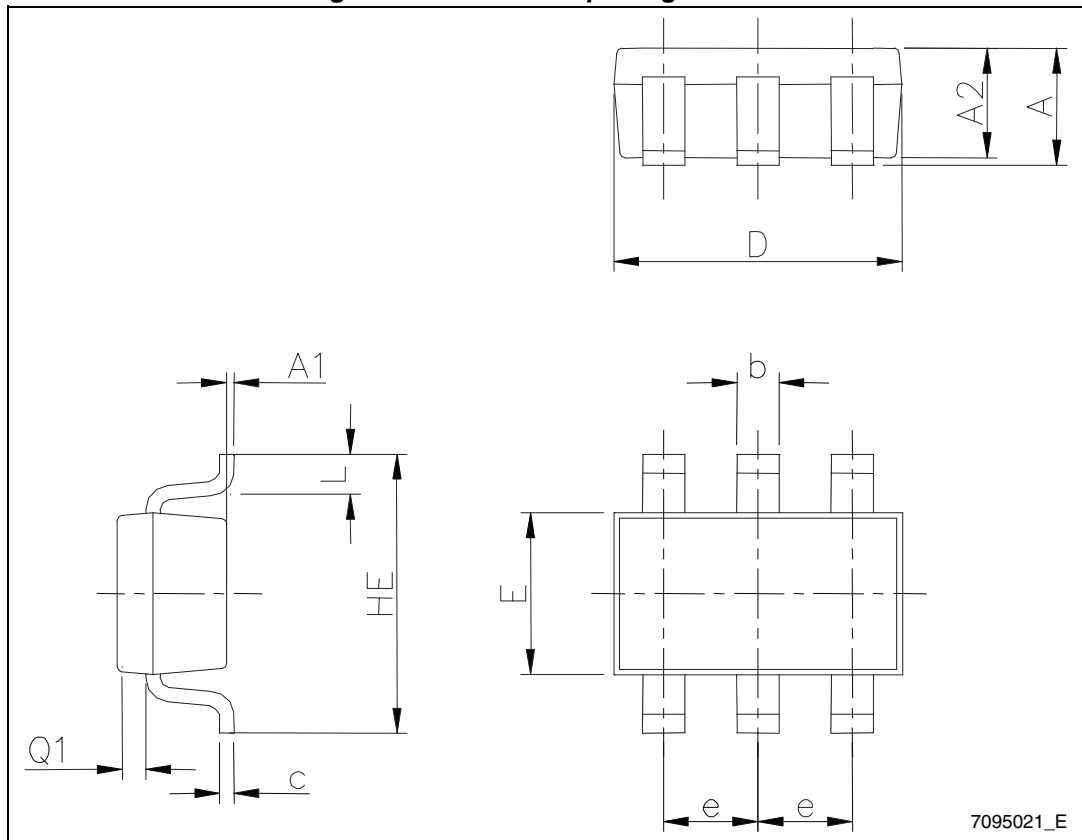
5.8 SOT23-5L packing information

Figure 32. SOT23-5L tape outline (Carsem)



5.9 SOT323-6L package information

Figure 33. SOT323-6L package outline



7095021_E

Table 12. SOT323-6L package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.80		1.10	0.031		0.043
A1	0		0.10			0.004
A2	0.80		1.00	0.031		0.039
b	0.15		0.30	0.006		0.012
c	0.10		0.18	0.004		0.007
D	1.80		2.20	0.071		0.087
E	1.15		1.35	0.045		0.053
e		0.65			0.026	
HE	1.80		2.40	0.071		0.094
L	0.10		0.40	0.004		0.016
Q1	0.10		0.40	0.004		0.016

5.10 SOT323-6L packing information

Figure 34. SOT323-6L tape outline

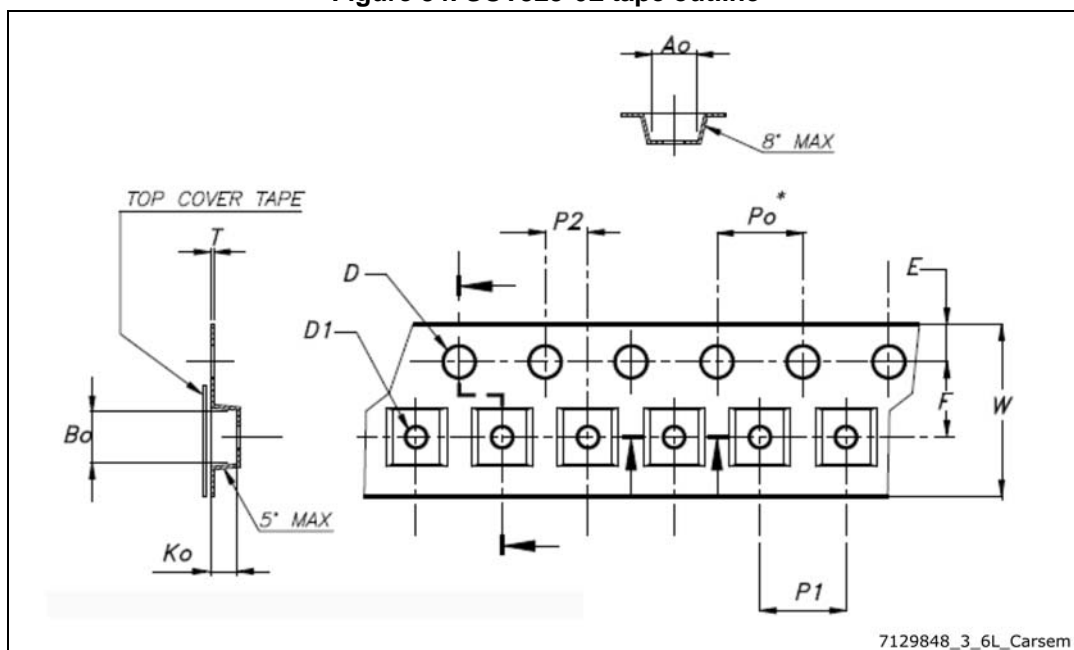


Table 13. SOT323-6L tape mechanical data

Dim.	Value
A_0	2.25 ± 0.1
B_0	2.4 ± 0.1
K_0	1.22 ± 0.1
F	3.5 ± 0.05
E	1.75 ± 0.1
W	$8 + 0.3 / - 0.1$
P_2	2 ± 0.05
P_0	4 ± 0.1
P_1	4 ± 0.1
T	0.30 ± 0.05
D	$\phi 1.5 + 0.1 / 0$
D_1	$\phi 1 + 0.25 / 0$

6 Ordering information

Table 14. Order code

Order code	Accuracy (%)	Temperature range	Package	Packing	Marking	
TL1431CD TL1431CDT	0.4	- 20°C, +70°C	SO-8	Tube or tape and reel	1431C	
TL1431ACD TL1431ACDT	0.25				1431AC	
TL1431CZ TL1431CZT TL1431CZ-AP	0.4		TO92	Bulk or Tape or ammopack	TL1431C	
TL1431ACZ TL1431ACZT TL1431ACZ-AP	0.25				TL1431AC	
TL1431CL3T	0.4		SOT23-3L	Tape and reel	1C	
TL1431ACL3T	0.25				1AC	
TL1431CL5T	0.4				SOT23-5L	1C
TL1431ACL5T	0.25					1AC
TL1431CCT	0.4				SOT323-6L	14C
TL1431ACCT	0.25					
TL1431ID TL1431IDT	0.4	-40°C, + 105°C	SO-8	Tube or tape and reel	1431I	
TL1431AID TL1431AIDT	0.25				1431AI	
TL1431IZ TL1431IZT TL1431IZ-AP	0.4		TO92	Bulk or tape or ammopack	TL1431I	
TL1431AIZ TL1431AIZT TL1431AIZ-AP	0.25				TL1431AI	
TL1431IYDT ⁽¹⁾	0.4				SO-8 (Automotive grade)	Tape and reel
TL1431AIYDT ⁽¹⁾	0.25		1431AIY			

1. Qualification and characterization according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 and Q 002 or equivalent.

7 Revision history

Table 15. Document revision history

Date	Revision	Changes
01-Mar-2002	1	Initial release.
01-Nov-2005	2	PPAP references inserted in the datasheet see Table 13: Order code on page 25.
25-Apr-2007	3	Minimum value for temperature range updated in Table 2: Operating conditions. Minimum values added and maximum values deleted for $\frac{\Delta V_{ref}}{\Delta V_{ka}}$ parameter in Table 4 in Section 3: Electrical characteristics. Package information for TO92 tape and reel updated, see Section 5: Package information. Format update.
11-Mar-2008	4	Corrected SO-8 package mechanical data. Corrected footnote for automotive grade order codes in order code table. Corrected packing information for TO92 devices in order code table.
11-Sep-2012	5	Added: feature Automotive temp. range - 40 °C to +125 °C on page 1. Updated: Table 14 on page 25.
01-Oct-2014	6	Updated Section 5: Package information. Minor text changes.
20-Nov-2015	7	Added SOT23-3L, SOT23-5L and SOT323-6L packages. Updated Section 1: Schematic diagrams , Section 2: Absolute maximum ratings and operating conditions , Section 5: Package information and Section 6: Ordering information . Minor text changes.

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