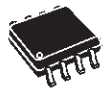
TL431

PROGRAMMABLE VOLTAGE REFERENCE

- ADJUSTABLE OUTPUT VOLTAGE : 2.5 to 36V
- SINK CURRENT CAPABILITY : 1 to 100mA
- TYPICAL OUTPUT IMPEDANCE : 0.22Ω
- 1% AND 2% VOLTAGE PRECISION

Z
TO92
(Plastic Package)



D
SO8
(Batwing Plastic Micropackage)

DESCRIPTION

The TL431 is a programmable shunt voltage reference with guaranteed temperature stability over the entire temperature range of operation.

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

The TL431 operates with a wide current range from 1 to 100mA with a typical dynamic impedance of 0.22Ω.

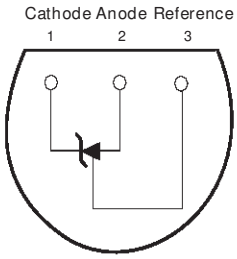
ORDER CODE

Part Number	Temperature Range	Package	
		Z	D
TL431C/AC	0°C, +70°C	•	•
TL431I/AI	-40°C, +105°C	•	•

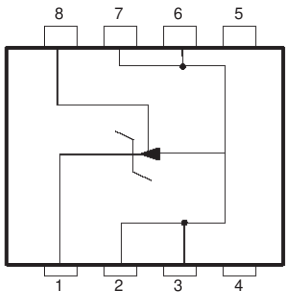
Z = TO92 Plastic package - also available in Bulk (Z), Tape & Reel (ZT) and Ammo Pack (AP)
D = Small Outline Package (SO) - also available in Tape & Reel (DT)

PIN CONNECTIONS (top view)

TO92
(Top view)



SO8
(Top view)



1- Cathode
2- Anode
3- Anode.
4- N.C.
5- N.C.
6- Anode
7- Anode.
8- Reference

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
p_d	Power Dissipation [1] TO92 SO8 batwing	625 960	mW
T_{stg}	Storage Temperature Range	-65 to +150	°C

1. Pd is calculated with T_{amb} = +25°C, T_j = +150°C and R_{thja} = 200°C/W for TO92 package
= 130°C/W for SO8 batwing package

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 TL431C/AC TL431I/AI	0 to +70 -40 to +105	°C

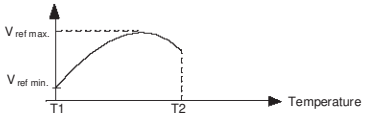
ELECTRICAL CHARACTERISTICS

T_{amb} = 25°C (unless otherwise specified)

Symbol	Parameter	TL431C			TL431AC			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
V_{ref}	Reference Input Voltage $V_{KA} = V_{ref}$, Ik = 10 mA T_{amb} = 25°C $T_{min} \le T_{amb} \le T_{max}$	2.44 2.423	2.495	2.55 2.567	2.47 2.453	2.495	2.52 2.537	V
ΔV_{ref}	Reference Input Voltage Deviation Over-Temperature Range - note 1 V_{KA} = Vref, Ik = 10 mA, $T_{min} \le T_{amb} \le T_{max}$		3	17		3	15	mV
$\frac{\Delta Vref}{\Delta Vka}$	Ratio of Change in Reference Input Voltage to Change in Cathode to Anode Voltage - (figure 2) Ik = 10mA ΔV_{KA} = 10V to Vref ΔV_{KA} = 36V to 10V		-1.4 -1	-2.7 -2		-1.4 -1	-2.7 -2	mV/V
I_{ref}	Reference Input Current Ik = 10mA, R1 = 10kΩ, R2 = ∞ T_{amb} = 25°C $T_{min} \le T_{amb} \le T_{max}$		1.8	4 5.2		1.8	4 5.2	µA
ΔI_{ref}	Reference Input Current Deviation Over Temperature Range Ik = 10mA, R1 = 10kΩ, R2 =∞ $T_{min} \le T_{amb} \le T_{max}$		0.4	1.2		0.4	1.2	µA
I_{min}	Minimum Cathode Current for Regulation $V_{KA} = V_{ref}$		0.5	1		0.5	0.6	mA
I_{off}	Off-State Cathode Current		2.6	1000		2.6	1000	nA
$\lvert ZKA \rvert$	Dynamic Impedance - note 2 $V_{KA} = V_{ref}$, Δ Ik = 1 to100mA, f ≤1kHZ		0.22	0.5		0.22	0.5	Ω

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

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



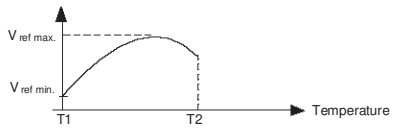
2) The dynamic Impedance is definied as $\lvert ZKA \rvert = \frac{\Delta VKA}{\Delta IK}$

ELECTRICAL CHARACTERISTICS

T_{amb} = 25°C (unless otherwise specified)

Symbol	Parameter	TL431I			TL431AI			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
V_{ref}	Reference Input Voltage $V_{KA} = V_{ref}$, Ik = 10 mA T_{amb} = 25°C $T_{min} \le T_{amb} \le T_{max}$	2.44 2.41	2.495	2.55 2.58	2.47 2.44	2.495	2.52 2.55	V
ΔV_{ref}	Reference Input Voltage Deviation Over-Temperature Range - note 1 $V_{KA} = V_{ref}$, Ik =10 mA, $T_{min} \le T_{amb} \le T_{max}$		7	30		7	30	mV
$\frac{\Delta Vref}{\Delta Vka}$	Ratio of Change in Reference Input Voltage to Change in Cathode to Anode Voltage Ik = 10mA ΔV_{KA} = 10V to V_{ref} ΔV_{KA} = 36V to 10V		-1.4 -1	-2.7 -2		-1.4 -1	-2.7 -2	mV/V
Iref	Reference Input Current Ik = 10mA, R1 = 10kΩ, R2 = ∞ T_{amb} = 25°C $T_{min} \le T_{amb} \le T_{max}$		1.8	4 6.5		1.8	4 6.5	µA
ΔIref	Reference Input Current Deviation Over Temperature Range Ik = 10mA, R1 = 10kΩ, R2 =∞ $T_{min} \le T_{amb} \le T_{max}$		0.8	2.5		0.8	1.2	µA
Imin	Minimum Cathode Current for Regulation $V_{KA} = V_{ref}$		0.5	1		0.5	0.7	mA
Ioff	Off-State Cathode Current		2.6	1000		2.6	1000	nA
$\lvert Z_{KA} \rvert$	Dynamic Impedance note 2 $V_{KA} = V_{ref}$,Δ Ik = 1 to100mA, f ≤1kHZ		0.22	0.5		0.22	0.5	Ω

1) ΔV_{ref} is defined as the difference between the maximum and minimum values obtained over the full temperature range.
$\Delta V_{ref} = V_{ref\ max.} - V_{ref\ min.}$



2) The dynamic Impedance is definied as $\lvert Z_{KA} \rvert = \frac{\Delta V_{KA}}{\Delta I_K}$

Figure 1 : Test Circuit for $V_{KA} = V_{REF}$

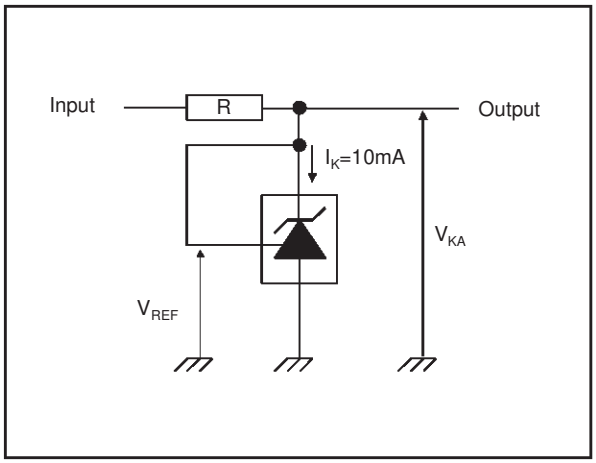


Figure 2 : Test Circuit for $V_{KA} > V_{REF}$

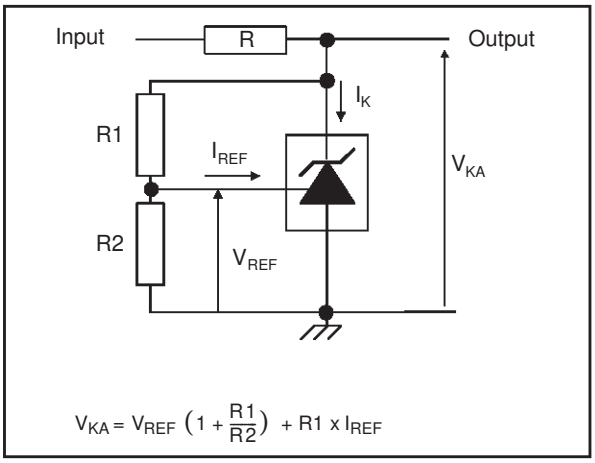


Figure 3 : Test Circuit for I_{OFF}

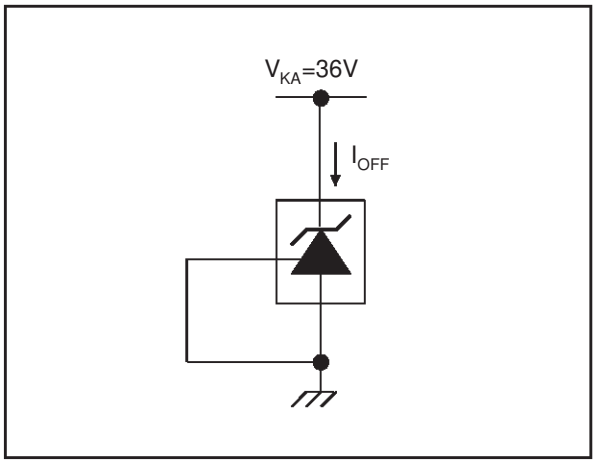


Figure 4 : Test Circuit for Phase Margin and Voltage Gain

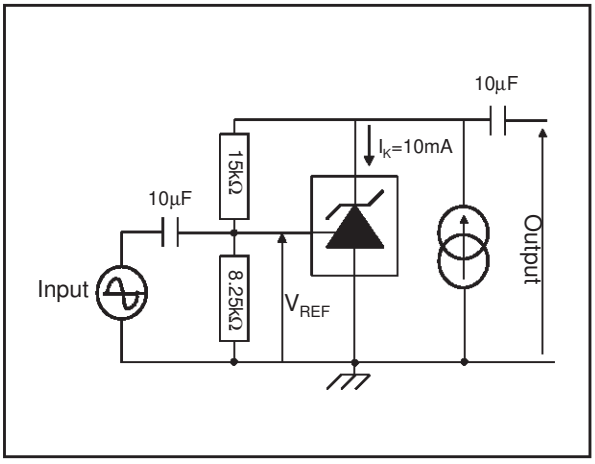


Figure 5 : Block diagram of TL1431

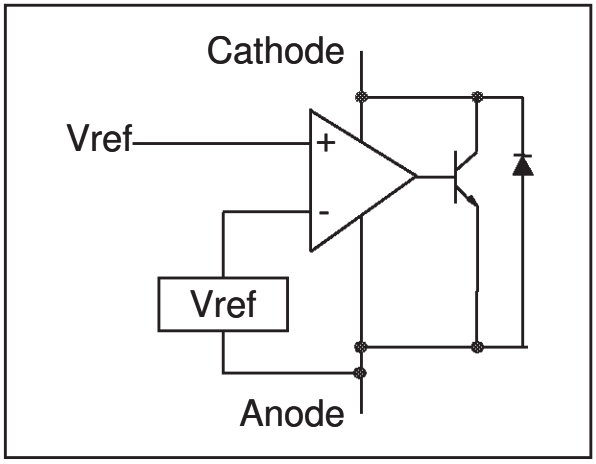
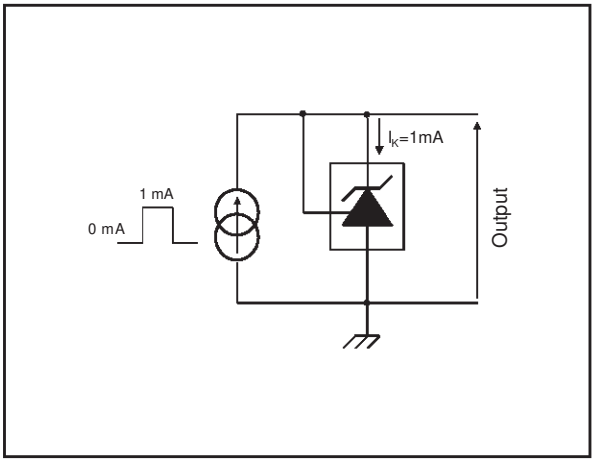
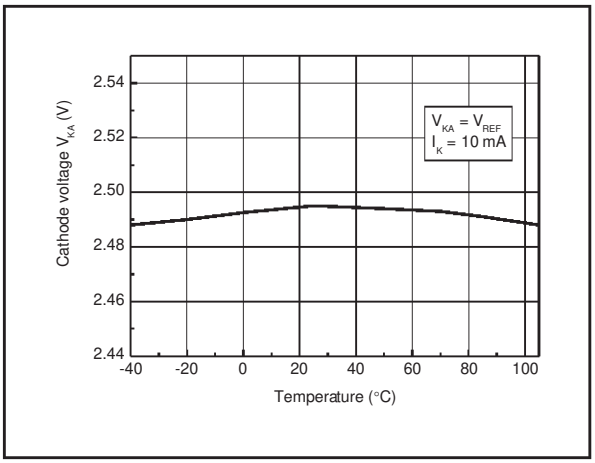


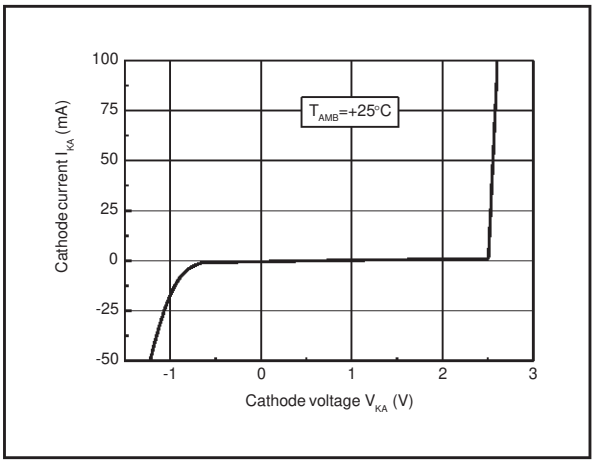
Figure 6 : Test Circuit for Response time



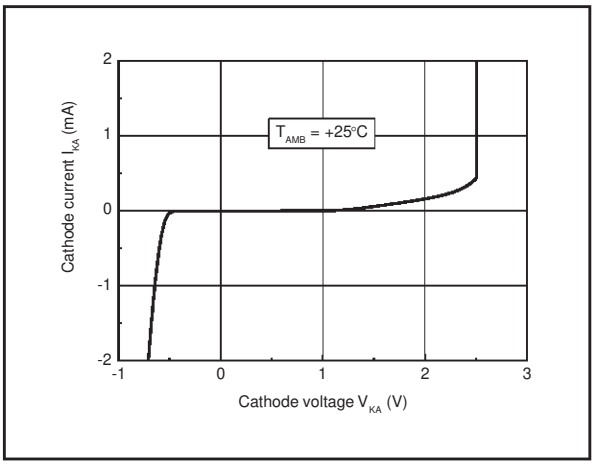
Reference voltage vs Temperature



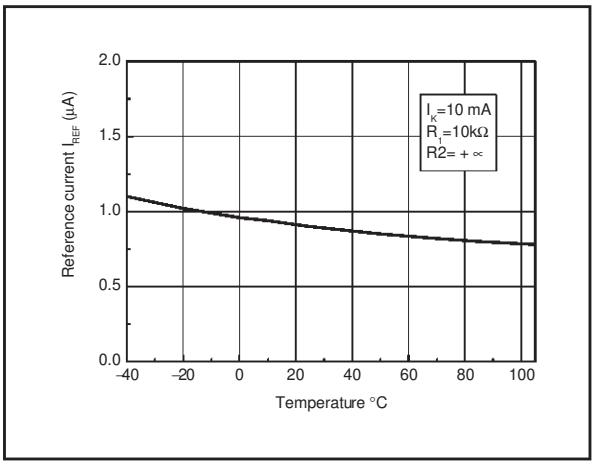
Reference voltage vs cathode current



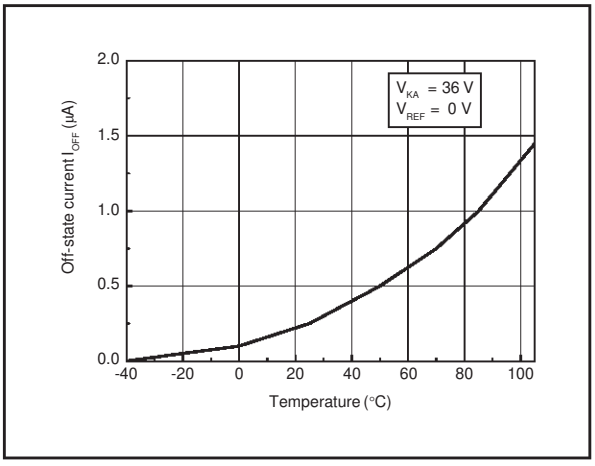
Reference voltage vs cathode current



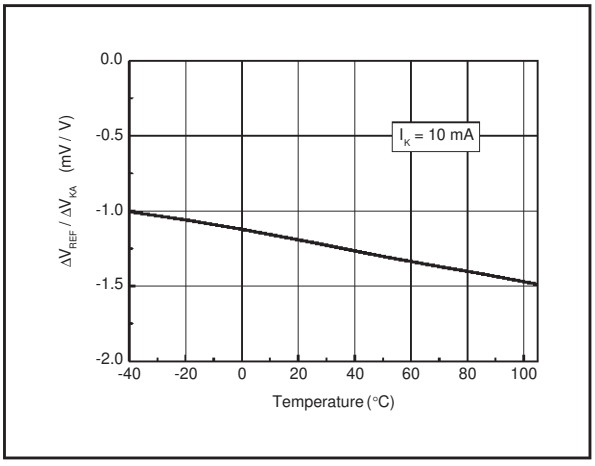
Reference current vs temperature



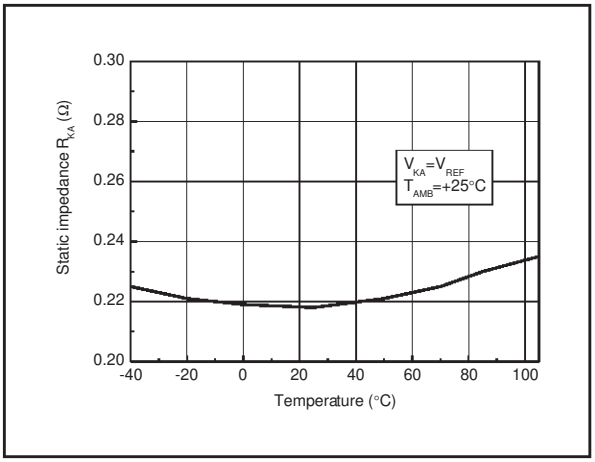
Off-state cathode current vs temperature



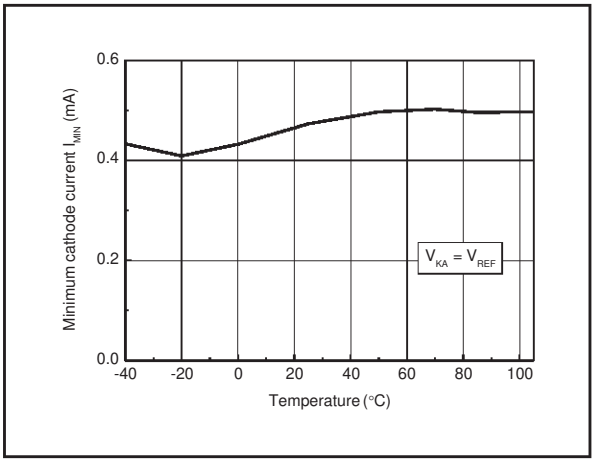
Ratio of change in V_{REF} to change in V_{KA} vs Temperature



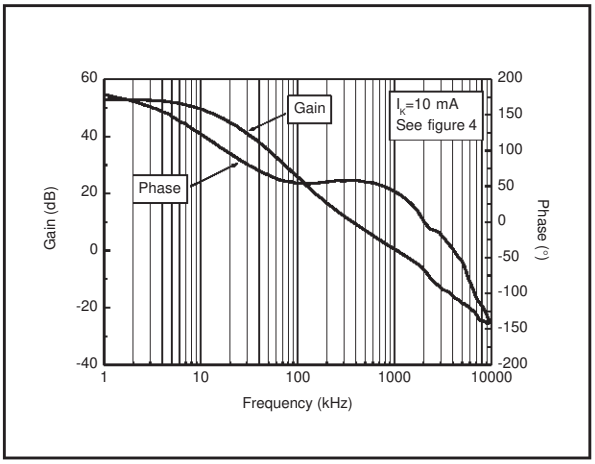
Static impedance R_{KA} vs Temperature



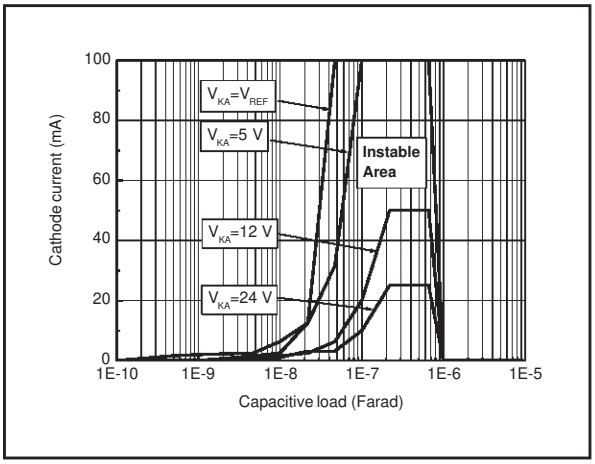
Minimum operating current vs temperature



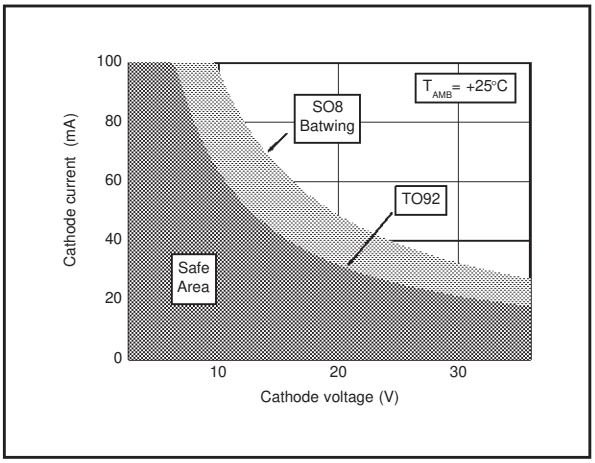
Gain & Phase vs Frequency



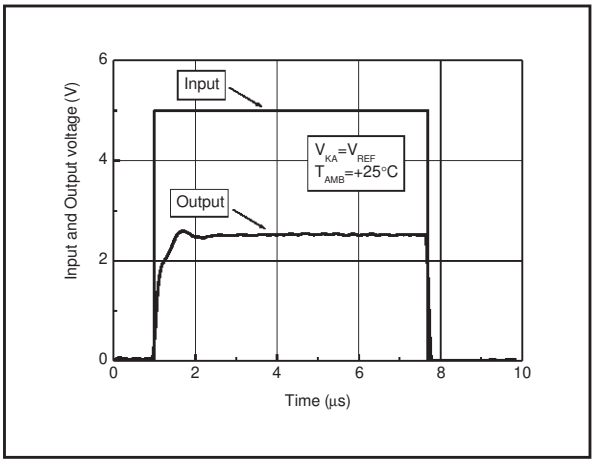
Stability behaviour with capacitive loads



Maximum Power dissipation

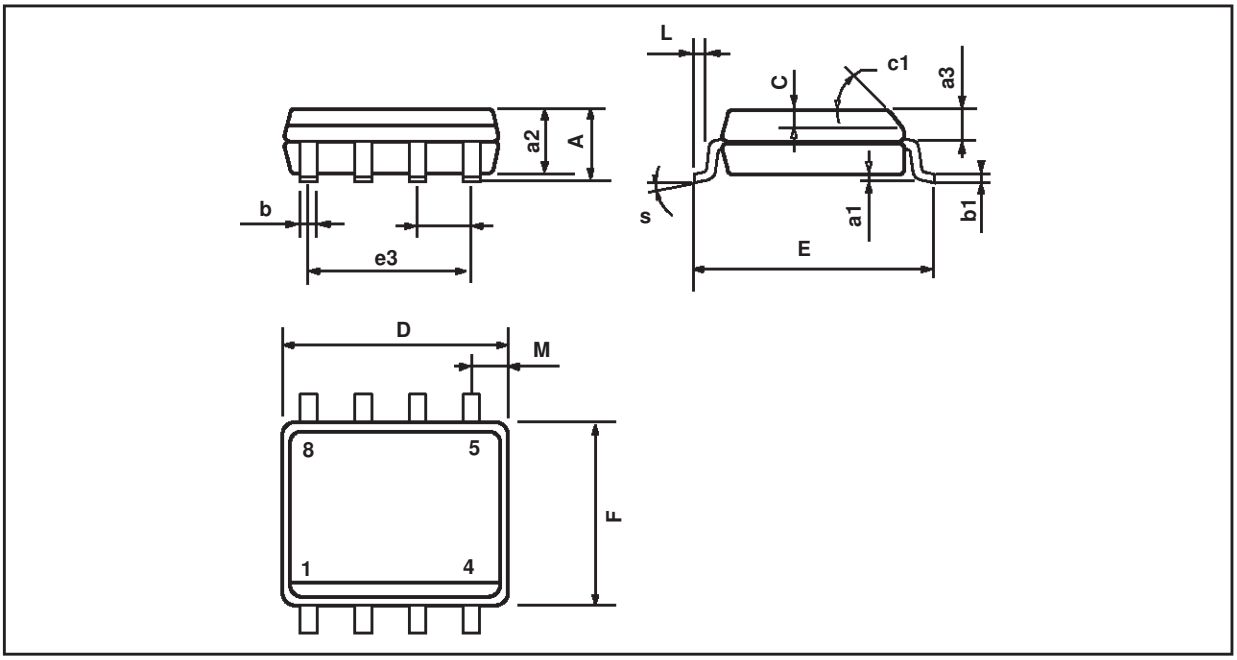


Pulse response for I_K=1mA



PACKAGE MECHANICAL DATA

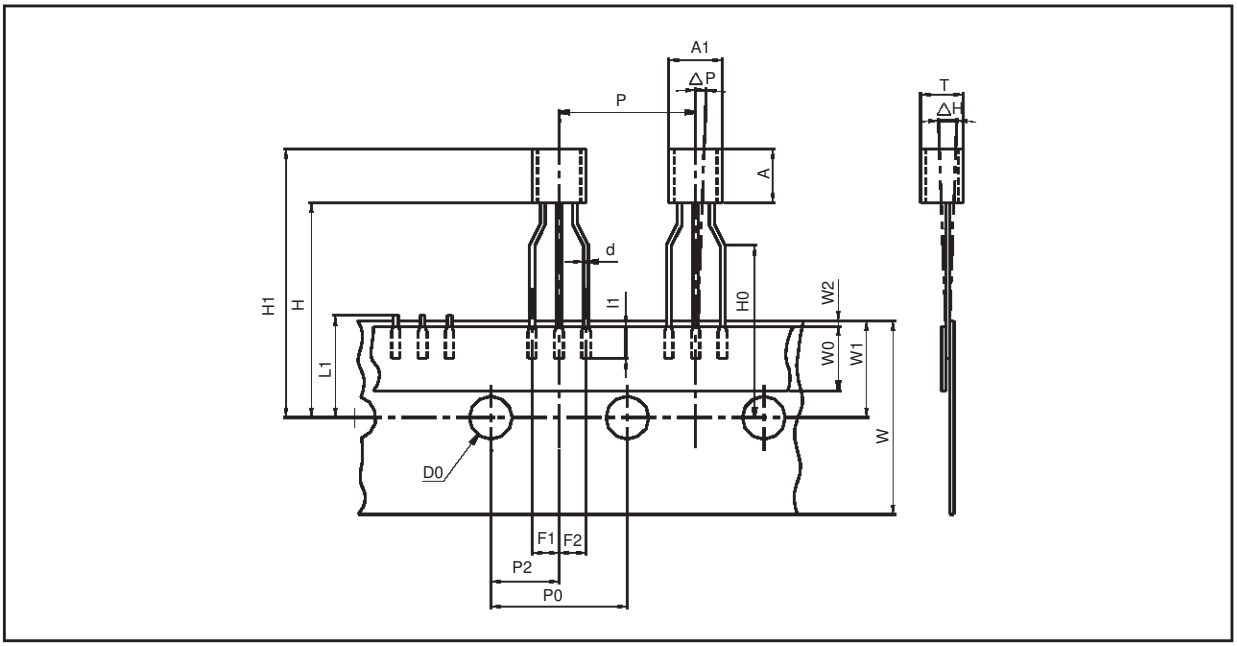
8 PINS - BATWING PLASTIC MICROPACKAGE (SO)



Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.25	0.004		0.010
a2			1.65			0.065
a3	0.65		0.85	0.026		0.033
b	0.35		0.48	0.014		0.019
b1	0.19		0.25	0.007		0.010
C	0.25		0.5	0.010		0.020
c1	45° (typ.)					
D	4.8		5.0	0.189		0.197
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		3.81			0.150	
F	3.8		4.0	0.150		0.157
L	0.4		1.27	0.016		0.050
M			0.6			0.024
S	8° (max.)					

PACKAGE MECHANICAL DATA

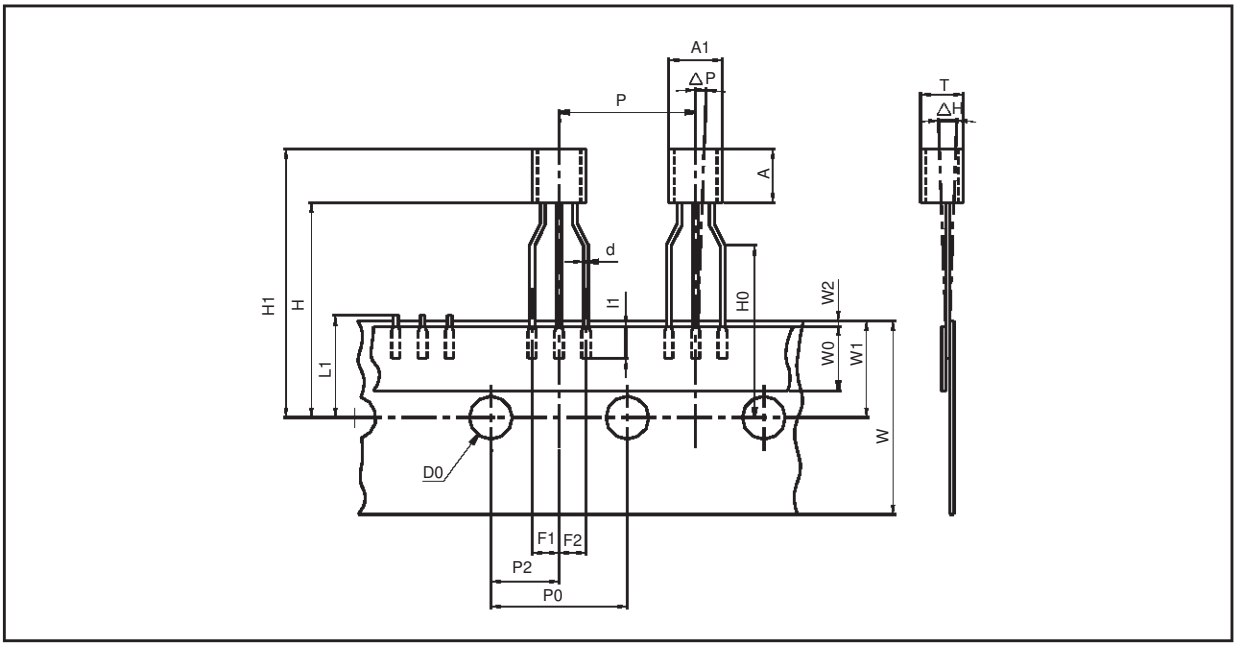
3 PINS - PLASTIC PACKAGE TO92 (TAPE & REEL)



Dim.	Millimeters			Inches		
	Min	Typ.	Max.	Min.	Typ.	Max.
AL			5.0			0.197
A			5.0			0.197
T			4.0			0.157
d		0.45			0.018	
I1	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

PACKAGE MECHANICAL DATA

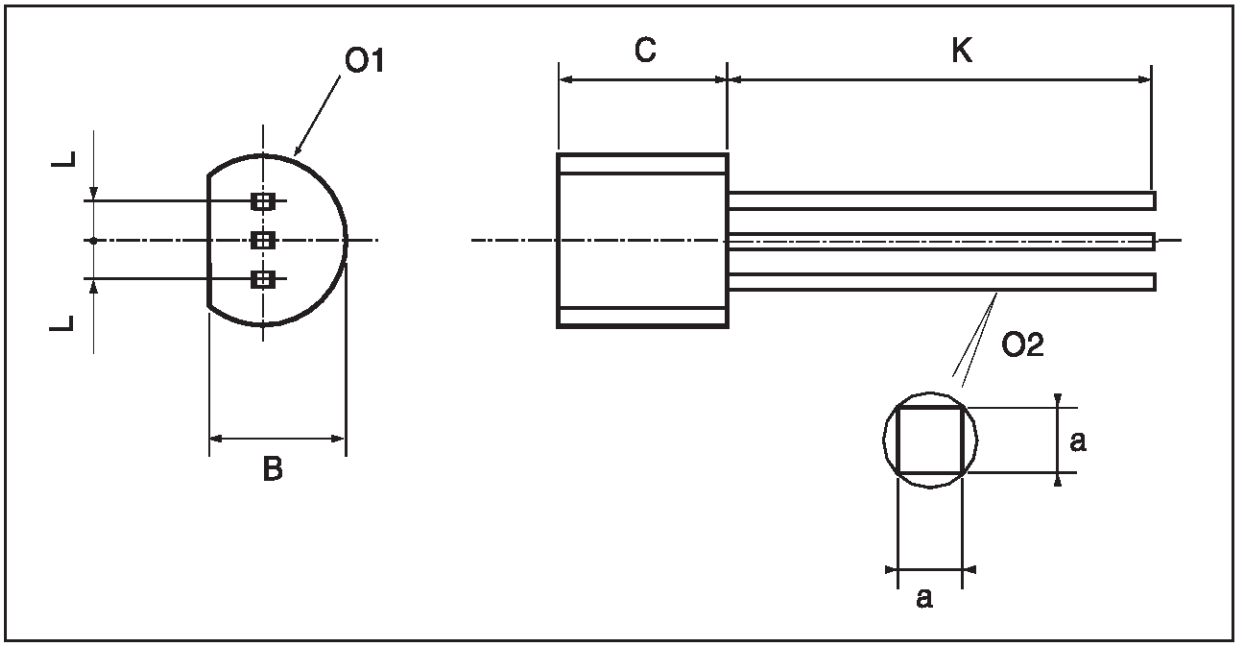
3 PINS - PLASTIC PACKAGE TO92 (TAPE AMMO PACK)



Dim.	Millimeters			Inches		
	Min	Typ.	Max.	Min.	Typ.	Max.
AL			5.0			0.197
A			5.0			0.197
T			4.0			0.157
d		0.45			0.018	
I1	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

PACKAGE MECHANICAL DATA

3 PINS - PLASTIC PACKAGE TO92 (BULK)



Dim.	Millimeters			Inches		
	Min	Typ.	Max.	Min.	Typ.	Max.
L		1.27			0.05	
B	3.2	3.7	4.2	0.126	0.1457	0.1654
O1	4.45	5.00	5.2	0.1752	0.1969	0.2047
C	4.58	5.03	5.33	0.1803	0.198	0.2098
K	12.7			0.5		
O2	0.407	0.5	0.508	0.016	0.0197	0.02
a	0.35			0.0138		

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