DATA SHEET

TL431C, TL431AC, TL431I, TL431AI, LM431AC

Adjustable precision shunt regulators

Product data
Supersedes data of 1997 Feb 25

2002 Jan 22

Philips
Semiconductors

PHILIPS

Adjustable precision shunt regulators

TL431C, TL431AC, TL431I, TL431AI, LM431AC

DESCRIPTION

The TL431 and TL431A are 3-terminal adjustable shunt regulators with specified thermal stability over applicable automotive and commercial temperature ranges. The output voltage may be set to any value between V_{REF} (approximately 2.5 V) and 36 V with two external resistors (see Figure 4). These devices have a typical output impedance of 0.2 Ω. Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent replacements for zener diodes in many applications like on-board regulation, adjustable power supplies and switching power supplies.

The TL431C and TL431AC are characterized for operation from 0 °C to +70 °C; the TL431I and TL431AI are characterized for operation from –40 °C to +85 °C.

FEATURES

- Equivalent full-range temperature coefficient: 30 ppm/°C
- 0.2 Ω typical output impedance
- Sink current capability: 1 mA to 100 mA
- Low output noise
- Adjustable output voltage: V_{REF} to 36 V

PIN CONFIGURATIONS

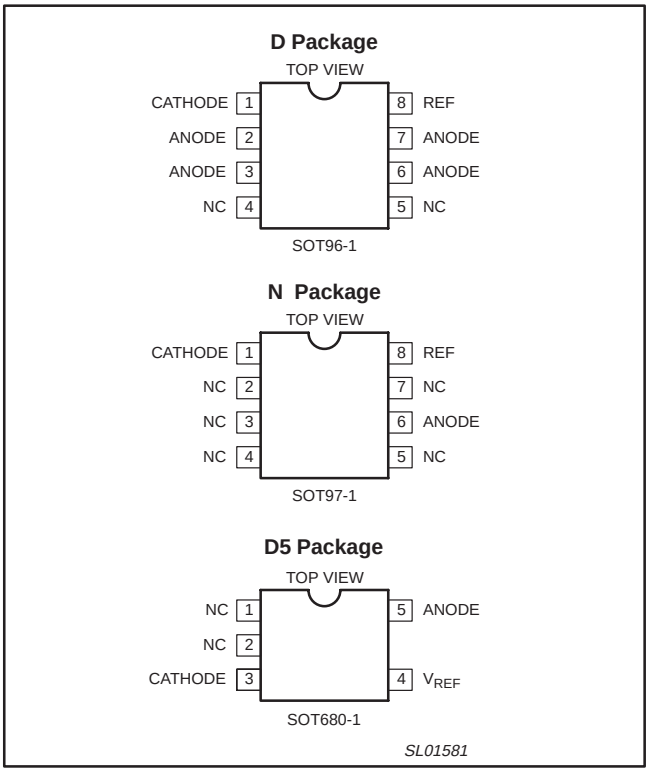


Figure 1. Pin configuration.

ORDERING INFORMATION

DESCRIPTION	TEMPERATURE RANGE	INDUSTRY STANDARD PART NUMBER	ORDER CODE	DWG #
8-Pin Plastic Small Outline (SO) package	0 °C to +70 °C	TL431CD	TL431CD	SOT96-1
8-Pin Plastic Small Outline (SO) package	–40 °C to +85 °C	TL431ID	TL431ID	SOT96-1
8-Pin Plastic Small Outline (SO) package	0 °C to +70 °C	TL431ACD	TL431ACD	SOT96-1
8-Pin Plastic Small Outline (SO) package	–40 °C to +85 °C	TL431AID	TL431AID	SOT96-1
8-Pin Plastic Small Outline (SO) package	0 °C to +70 °C	LM431ACM	LM431ACMD	SOT96-1
8-Pin Plastic Dual In-Line package (DIP)	0 °C to +70 °C	TL431CP	TL431CPN	SOT97-1
8-Pin Plastic Dual In-Line package (DIP)	–40 °C to +85 °C	TL431IP	TL431IPN	SOT97-1
8-Pin Plastic Dual In-Line package (DIP)	0 °C to +70 °C	TL431ACP	TL431ACPN	SOT97-1
8-Pin Plastic Dual In-Line package (DIP)	–40 °C to +85 °C	TL431AIP	TL431AIPN	SOT97-1
5-pin plastic small outline package (SO5)	0 °C to +70 °C		TL431ACD5	SOT680-1
5-pin plastic small outline package (SO5)	–40 °C to +85 °C		TL431AID5	SOT680-1
5-pin plastic small outline package (SO5)	0 °C to +70 °C		TL431CD5	SOT680-1
5-pin plastic small outline package (SO5)	–40 °C to +85 °C		TL431ID5	SOT680-1

NOTE:
1. SYMBOL INFORMATION: Parts will be marked with product name including temperature and electrical grade desginators, but not the package identifier.

ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	RATING	UNITS
V_{KA}	Cathode voltage (see Note 1)	37	V
	Continuous cathode current range	–100 to +150	mA
	Reference input current range	0.05 to 10	mA
T_{amb}	Operating free-air temperature range C suffix I suffix	 0 to +70 –40 to +85	 °C °C
T_{stg}	Temperature storage range	–65 to 150	°C
	Lead temperature 1.6 mm (1/16 in.) from case for 10 sec: D5, D or P pkgs	260	°C

NOTE:
1. Voltage values are with respect to the ANODE terminal unless otherwise noted.

RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	MIN	MAX	UNITS
V_{KA}	Cathode voltage	V_{REF}	36	V
I_K	Cathode current	1	100	mA

Table 1. Dissipation Rating Table – Free-Air Temperature

Package	Derating Factor Above T_{amb} = 25 °C	T_{amb} = 25 °C Power Rating	T_{amb} = 70 °C Power Rating	T_{amb} = 85 °C Power Rating
D5	5.1 mW/°C	637 mW	408 mW	332 mW
D	5.8 mW/°C	725 mW	464 mW	429 mW
P	8.0 mW/°C	1000 mW	640 mW	520 mW

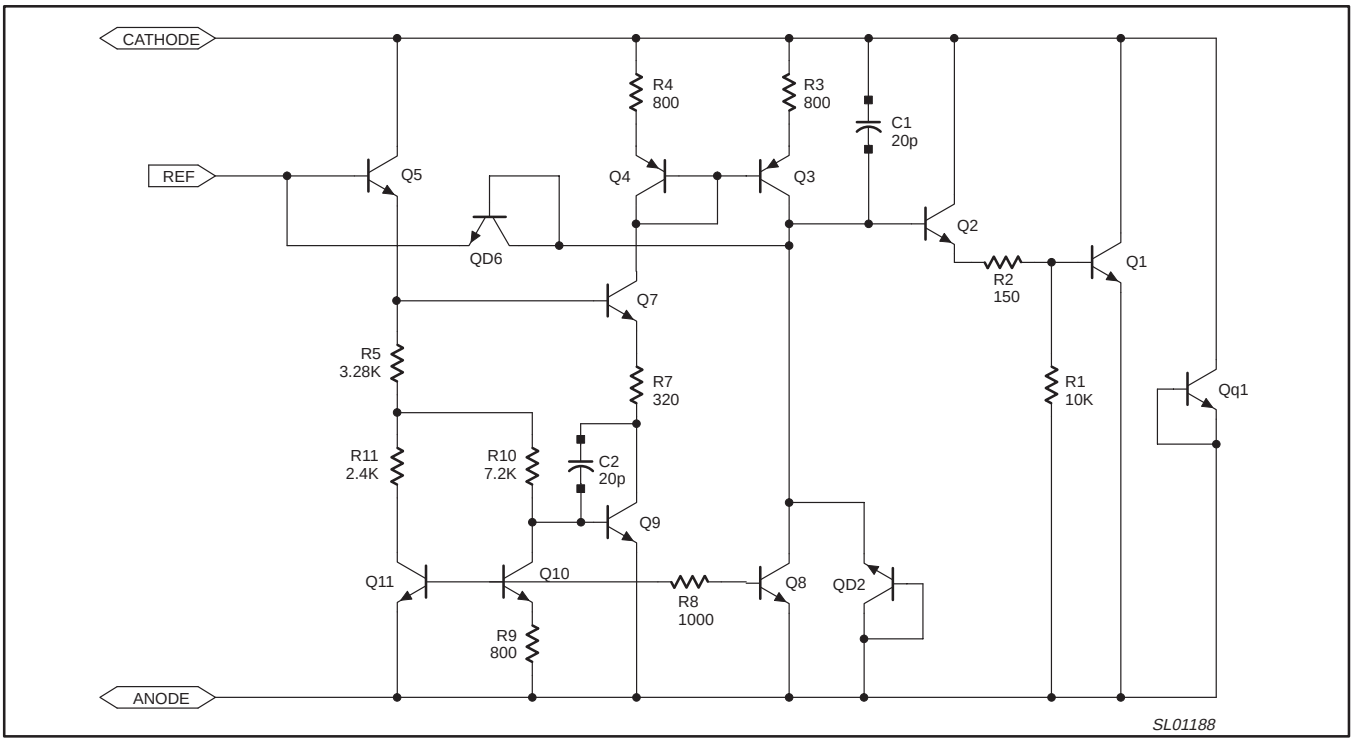


Figure 2. Equivalent schematic.

DC ELECTRICAL CHARACTERISTICS

25 °C free-air temperature, unless otherwise stated.

SYMBOL	PARAMETER	TEST CKT	TEST CONDITIONS	LIMITS						UNIT
				TL431AC			TL431C/LM431AC			
				MIN	TYP	MAX	MIN	TYP	MAX	
V_{REF}	Reference input voltage	Fig. 3	$V_{KA} = V_{REF}$, I_K = 10 mA	2470	2495	2520	2440	2495	2550	mV
$V_{REF(dev)}$	Deviation of reference input voltage over full temperature range[2]	Fig. 3	$V_{KA} = V_{REF}$, I_K = 10 mA; T_{amb} = full range[1]		4	15		4	17	mV
$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	Ratio of change in reference input voltage to the change in cathode voltage	Fig. 4	I_K = 10 mA; ΔV_{KA} = 10 V – V_{REF}		–1.4	–2.7		–1.4	–2.7	mV/V
			I_K = 10 mA; ΔV_{KA} = 36 V – 10 V		–1	–2		–1	–2	
I_{REF}	Reference input current	Fig. 4	I_K = 10 mA, R_1 = 10 kΩ, R_2 = ∞		2	4		2	4	µA
$I_{REF(dev)}$	Deviation of reference input current over full temperature range[2]	Fig. 4	I_K = 10 mA, R_1 = 10 kΩ, R_2 = ∞, T_{amb} = full range[1]		0.8	1.2		0.4	1.2	µA
I_{MIN}	Minimum cathode current for regulation	Fig. 3	$V_{KA} = V_{REF}$		0.4	0.6		0.4	1	mA
I_{OFF}	Off-state cathode current	Fig. 5	V_{KA} = 36 V, V_{REF} = 0		0.1	0.5		0.1	1	µA
$\lvert Z_{KA} \rvert$	Dynamic impedance[3]	Fig. 3	$V_{KA} = V_{REF}$, I_K = 1 mA to 100 mA; f ≤ 1 kHz		0.2	0.5		0.2	0.5	Ω

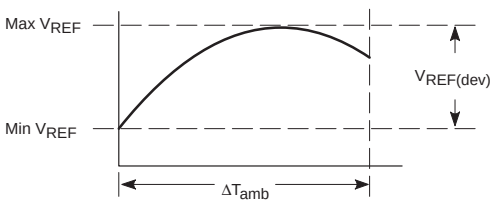
25 °C free-air temperature, unless otherwise stated.

SYMBOL	PARAMETER	TEST CKT	TEST CONDITIONS	LIMITS						UNIT
				TL431AI			TL431I			
				MIN	TYP	MAX	MIN	TYP	MAX	
V_{REF}	Reference input voltage	Fig. 3	$V_{KA} = V_{REF}$, I_K = 10 mA	2470	2495	2520	2440	2495	2550	mV
$V_{REF(dev)}$	Deviation of reference input voltage over full temperature range[2]	Fig. 3	$V_{KA} = V_{REF}$, I_K = 10 mA, T_{amb} = full range[1]		5	25		5	30	mV
$\frac{\Delta V_{REF}}{\Delta V_{KA}}$	Ratio of change in reference input voltage to the change in cathode voltage	Fig. 4	I_K = 10 mA; ΔV_{KA} = 10 V – V_{REF}		–1.4	–2.7		–1.4	–2.7	mV/V
			I_K = 10 mA; ΔV_{KA} = 36 V – 10 V		–1	–2		–1	–2	
I_{REF}	Reference input current	Fig. 4	I_K = 10 mA, R_1 = 10 kΩ, R_2 = ∞		2	4		2	4	µA
$I_{REF(dev)}$	Deviation of reference input current over full temperature range[2]	Fig. 4	I_K = 10 mA, R_1 = 10 kΩ, R_2 = ∞, T_{amb} = full range[1]		0.8	2.5		0.8	2.5	µA
I_{MIN}	Minimum cathode current for regulation	Fig. 3	$V_{KA} = V_{REF}$		0.4	0.7		0.4	1	µA
I_{OFF}	Off-state cathode current	Fig. 5	V_{KA} = 36 V, V_{REF} = 0		0.1	0.5		0.1	1	µA
$\lvert Z_{KA} \rvert$	Dynamic impedance[3]	Fig. 3	$V_{KA} = V_{REF}$, I_K = 1 mA to 100 mA, f ≤ 1 kHz		0.2	0.5		0.2	0.5	Ω

NOTES:

1. Full temperature range is –40 °C to +85 °C for the TL431I and TL431AI, and 0 °C to +70 °C for the TL431C and TL431AC.
2. The deviation parameters $V_{REF(dev)}$ and $I_{REF(dev)}$ are defined as the differences between the maximum and minimum values obtained over the rated termperature range. The average full-range temperature coefficient of the reference input voltage, αV_{REF}, is defined as:

$$\lvert \alpha V_{REF} \rvert \left(\frac{ppm}{deg\,C}\right) = \frac{\left(\frac{V_{REF(dev)}}{V_{REF\ at\ 25^oC}}\right) \cdot 10^6}{\Delta T_{amb}}$$



where ΔT_{amb} is the rated operating free-air temperature range of the device.

αV_{REF} can be positive or negative depending on whether minimum V_{REF} of maximum V_{REF}, respectively, occurs at the lower temperature. Example: Max V_{REF} = 2496 mV at 30 °C, Min V_{REF} = 2492 mV at 0 °C, V_{REF} = 2495 mV at 25 °C, DTA = 70 °C for TL431C.

$$| \alpha V_{REF} | = \frac{\left(\frac{4mV}{2495mV}\right) \cdot 10^6}{70^oC} = 23ppm/^oC$$

Because minimum V_{REF} occurs at the lower temperature, the coefficient is positive.

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

When the device is operating with two external resistors, (see Figure 4), the total dynamic impedance of the circuit is given by:

$$| Z' | = \frac{\Delta V}{\Delta I} \approx | Z_{KA} | \left(1 + \frac{R1}{R2}\right)$$

PARAMETER MEASUREMENT INFORMATION

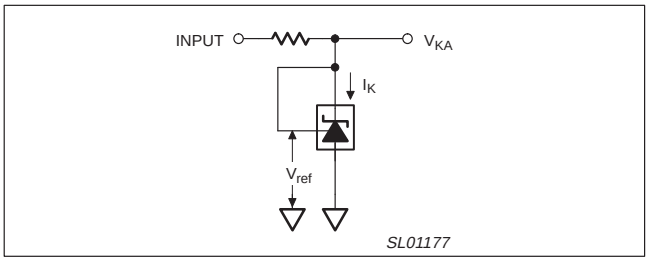


Figure 3. Test Circuit for $V_{KA} = V_{ref}$

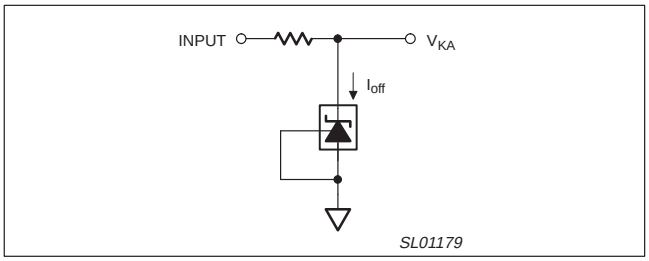


Figure 5. Test Circuit for I_{OFF}

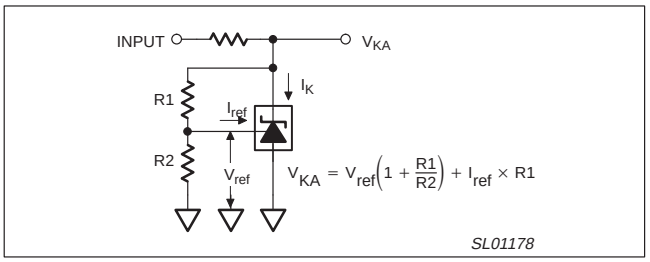


Figure 4. Test Circuit for $V_{KA} > V_{ref}$

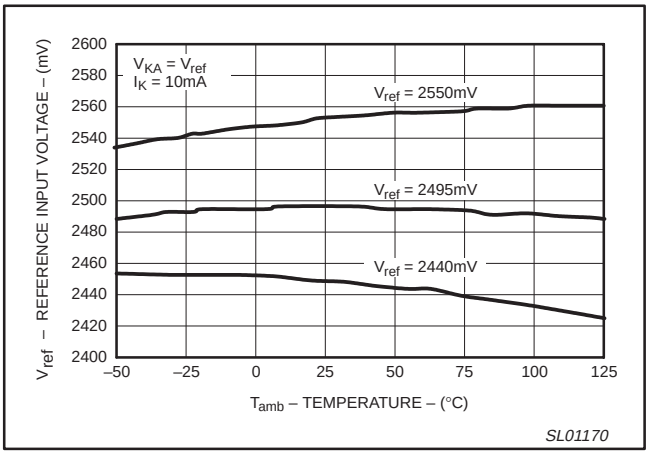


Figure 6. Reference Input Voltage vs. Temperature

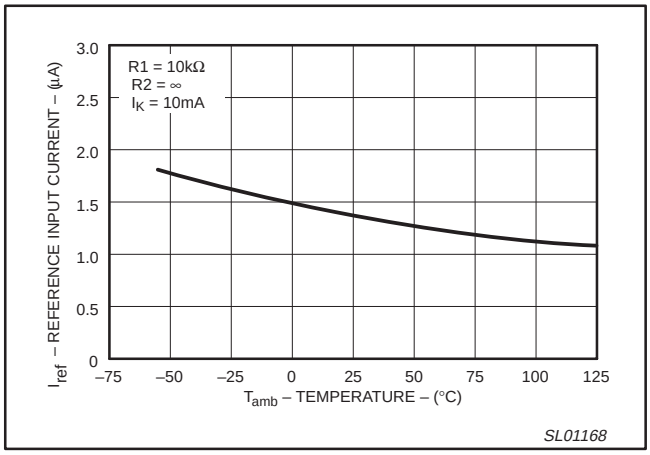


Figure 9. Reference Input Current vs. Temperature

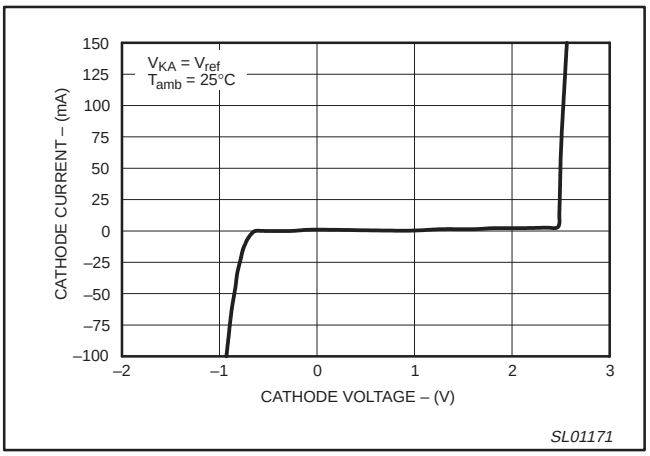


Figure 7. Cathode Current vs. Cathode Voltage

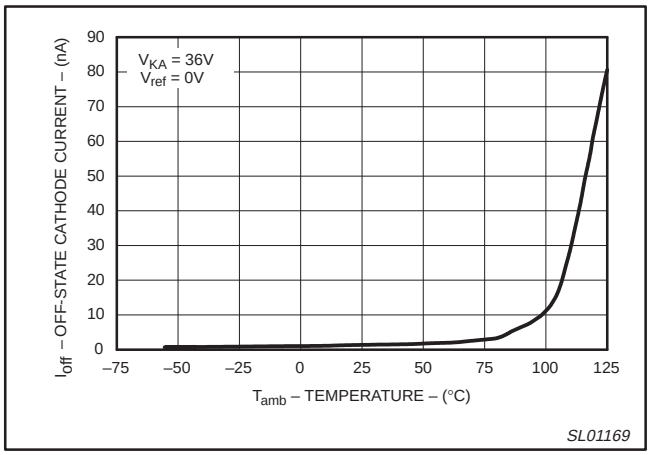


Figure 10. Off-State Cathode Current vs. Temperature

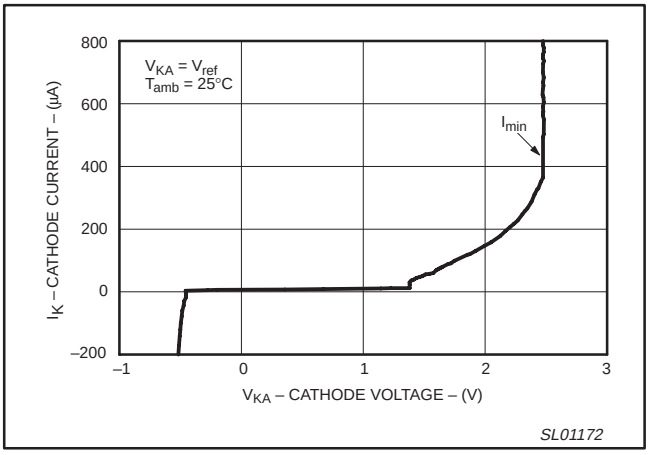


Figure 8. Cathode Current vs. Cathode Voltage

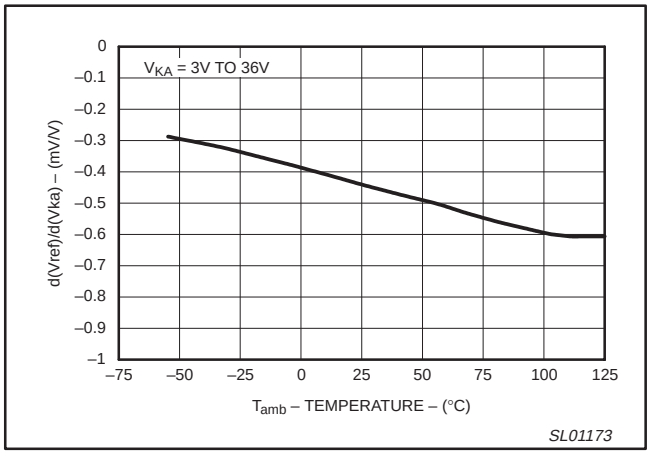
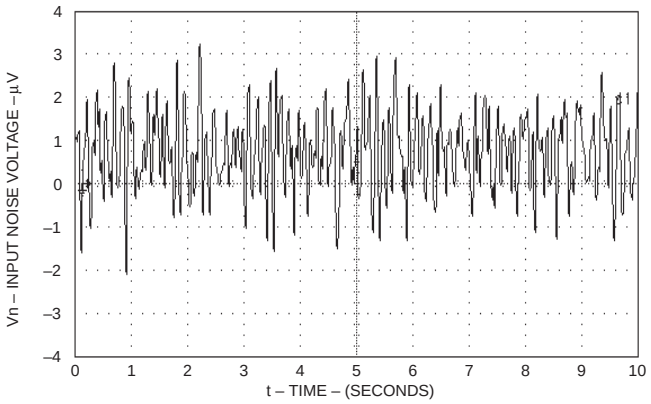
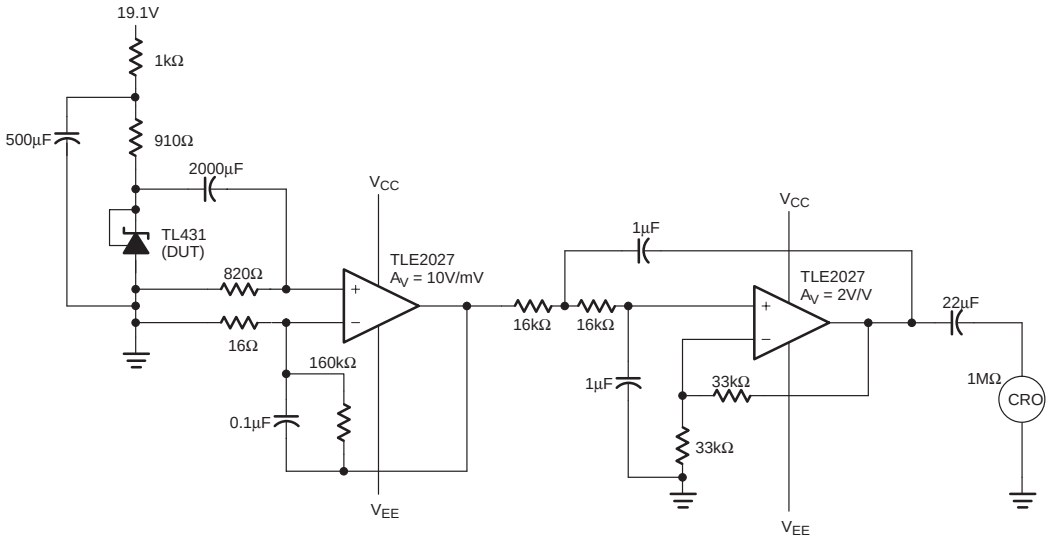


Figure 11. Ratio of Delta Reference Voltage to Delta Cathode Voltage over Temperature



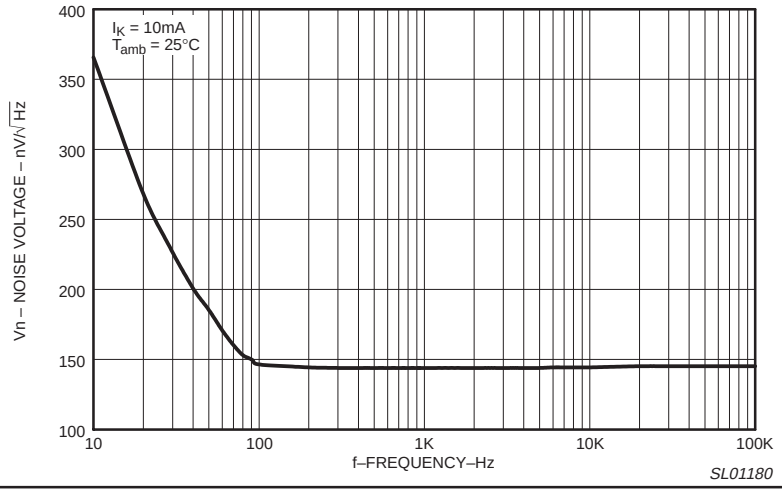
Equivalent Input Noise Voltage Over a 10-Second Period



Test Circuit

SL01174

Figure 12.



SL01180

Figure 13. Equivalent Input Noise Voltage vs. Frequency

TYPICAL CHARACTERISTICS

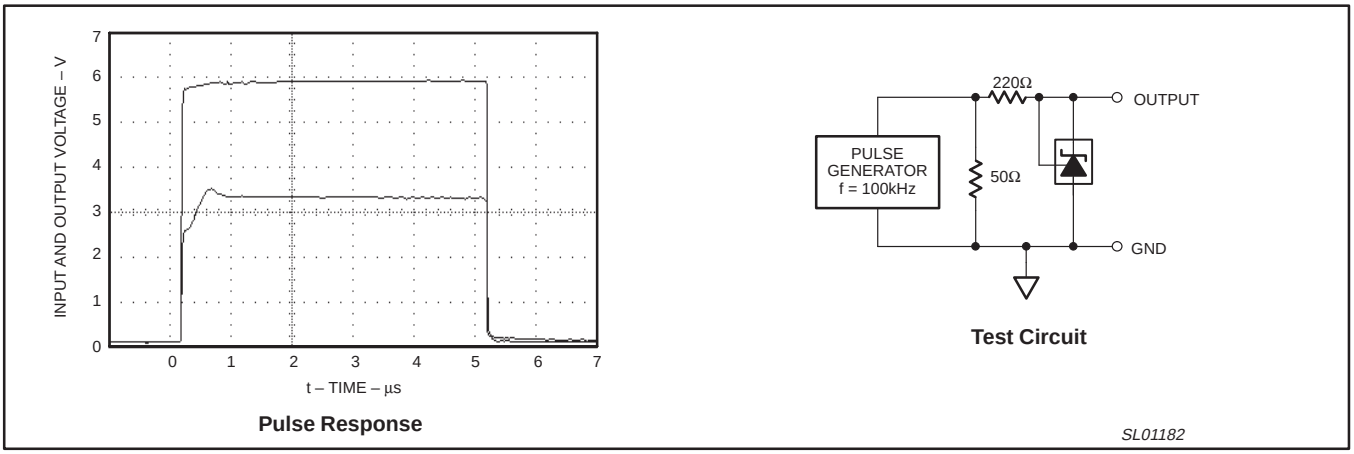


Figure 14. Pulse Response

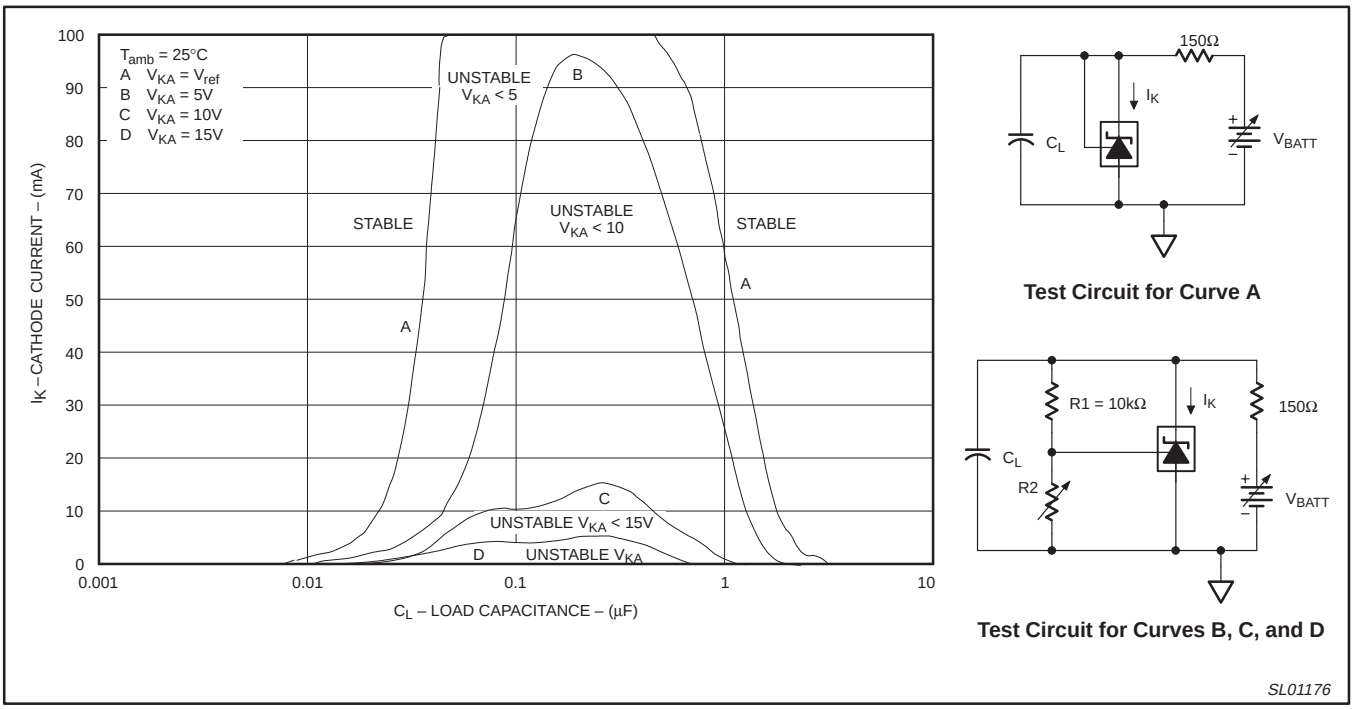
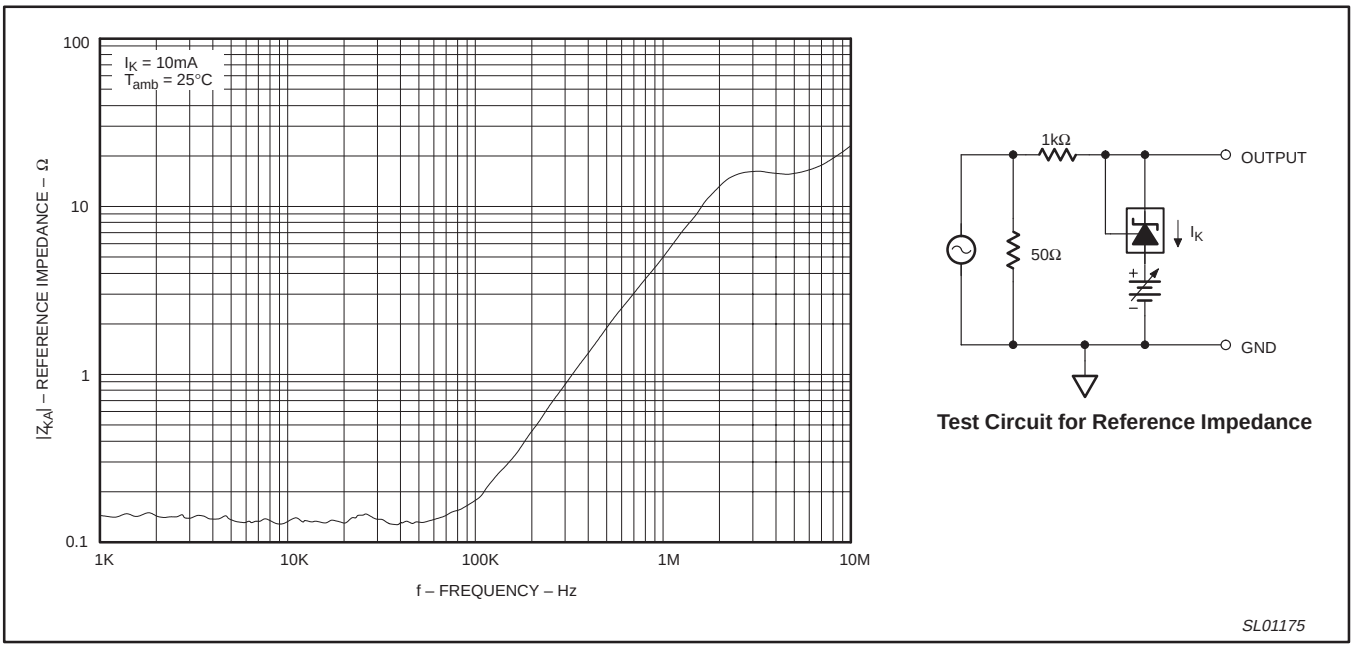
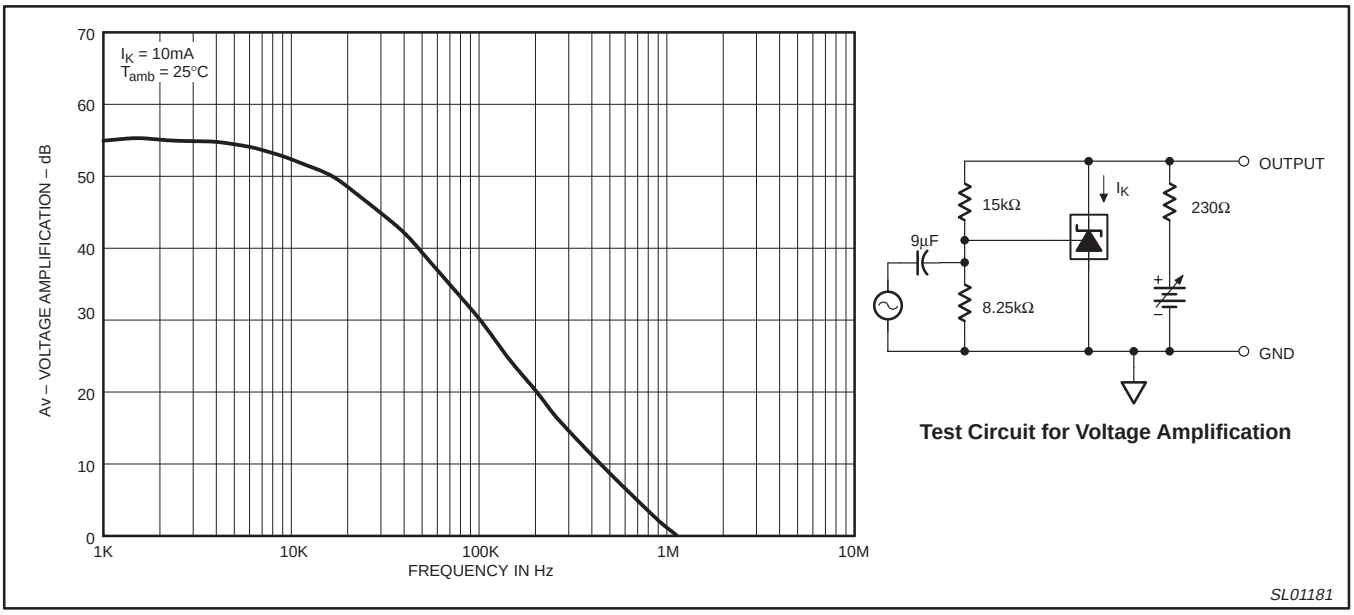


Figure 15. Stability Boundary Conditions



Test Circuit for Reference Impedance

Figure 16. Reference Impedance vs. Frequency



Test Circuit for Voltage Amplification

Figure 17. Small-Signal Voltage Amplification vs. Frequency

TYPICAL APPLICATIONS

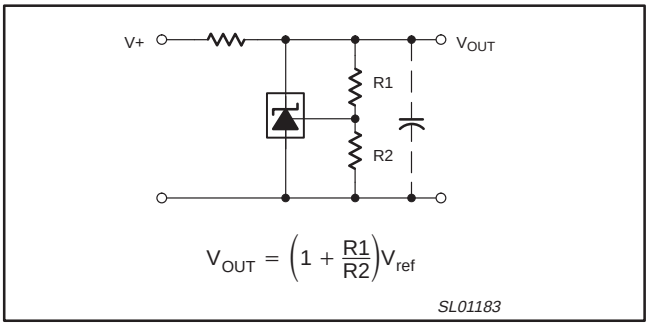


Figure 18. Shunt Regulator

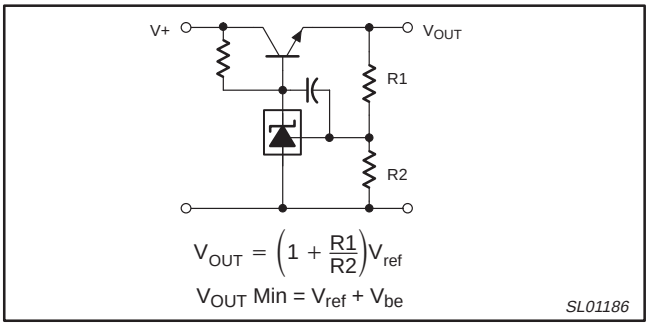
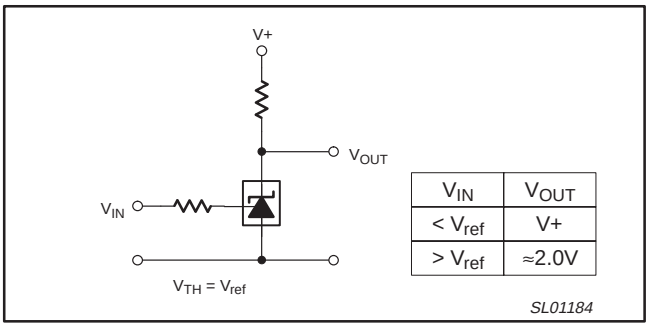


Figure 21. Series Pass Regulator



V_{IN}	V_{OUT}
< V_{ref}	V+
> V_{ref}	≈2.0V

Figure 19. Single-Supply Comparator with Temperature-Compensated Threshold

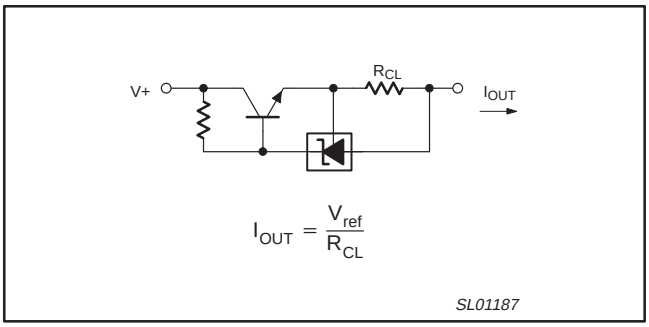


Figure 22. Constant Current Source

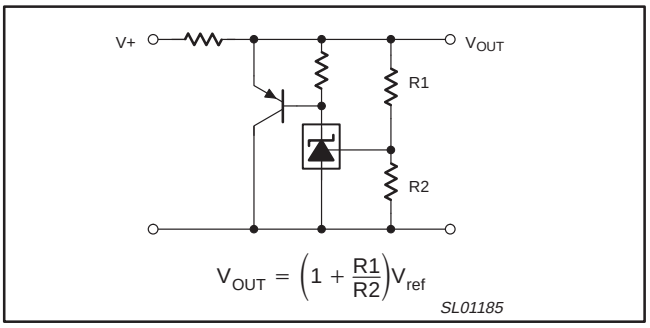


Figure 20. High Current Shunt Regulator

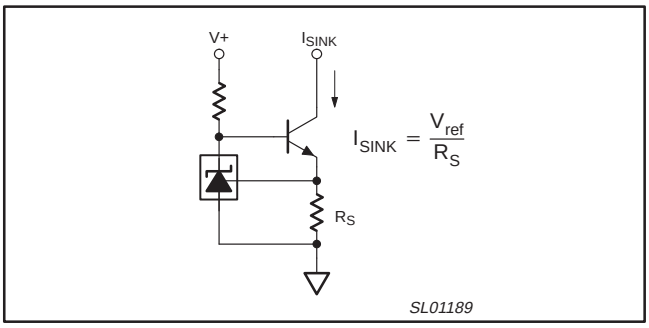
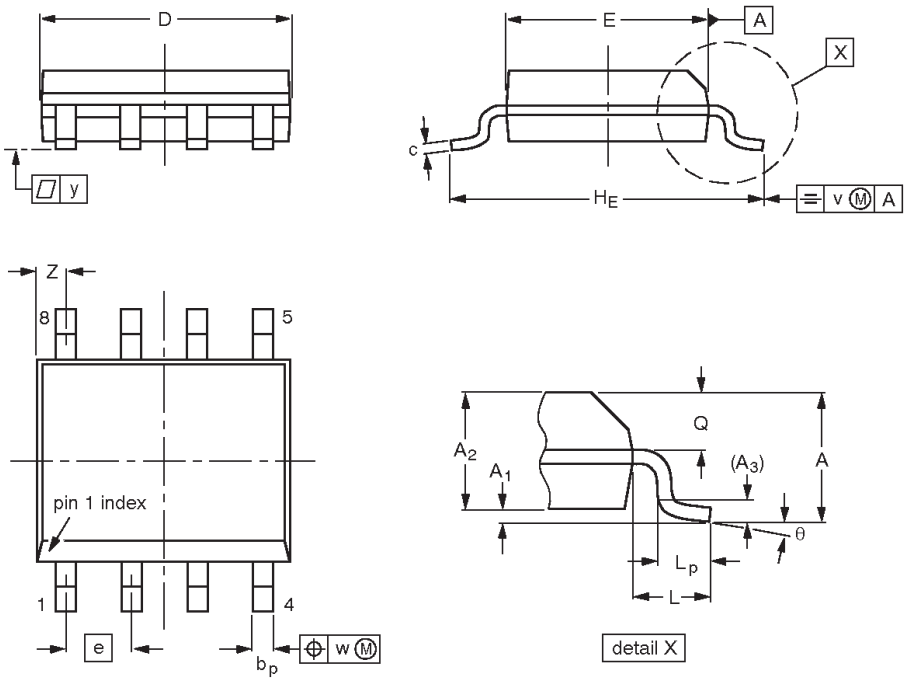
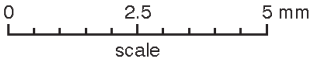


Figure 23. Constant Current Sink

SO8: plastic small outline package; 8 leads; body width 3.9 mm **SOT96-1**





DIMENSIONS (inch dimensions are derived from the original mm dimensions)

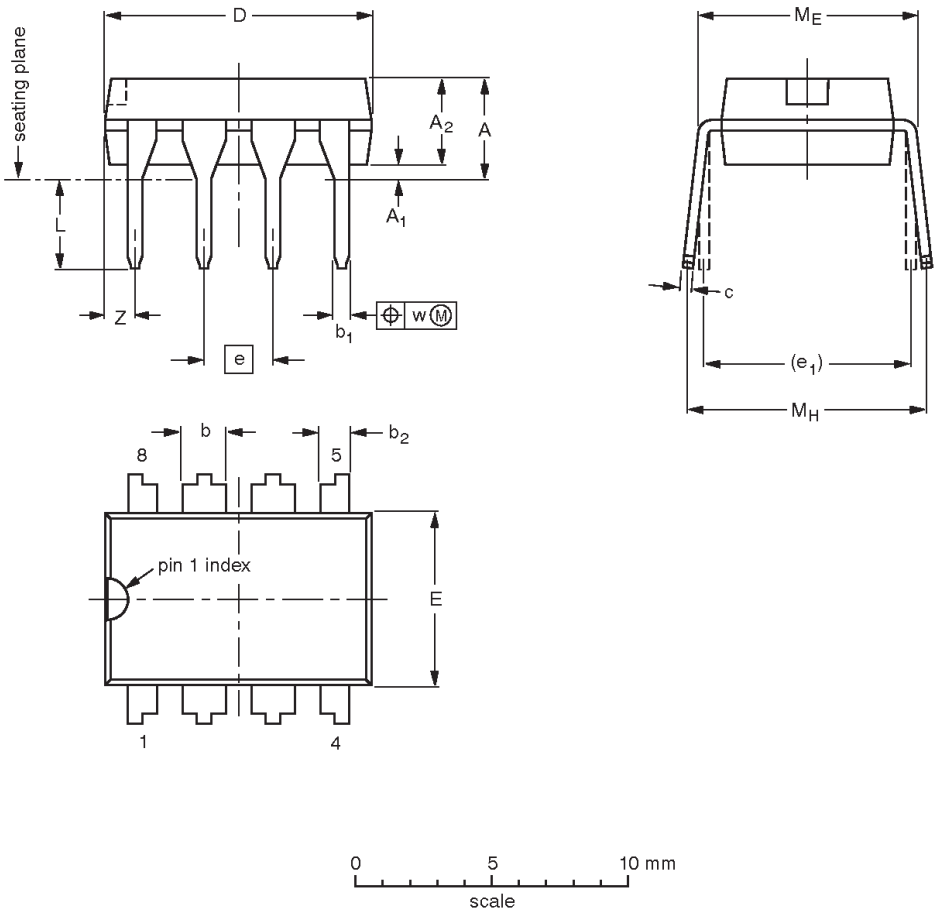
UNIT	A max.	A_1	A_2	A_3	b_p	c	$D^{(1)}$	$E^{(2)}$	e	H_E	L	L_p	Q	v	w	y	$Z^{(1)}$	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	5.0 4.8	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8^o 0^o
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.20 0.19	0.16 0.15	0.050	0.244 0.228	0.041	0.039 0.016	0.028 0.024	0.01	0.01	0.004	0.028 0.012	

Notes

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT96-1	076E03	MS-012				~~97-05-22~~ 99-12-27

DIP8: plastic dual in-line package; 8 leads (300 mil) **SOT97-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

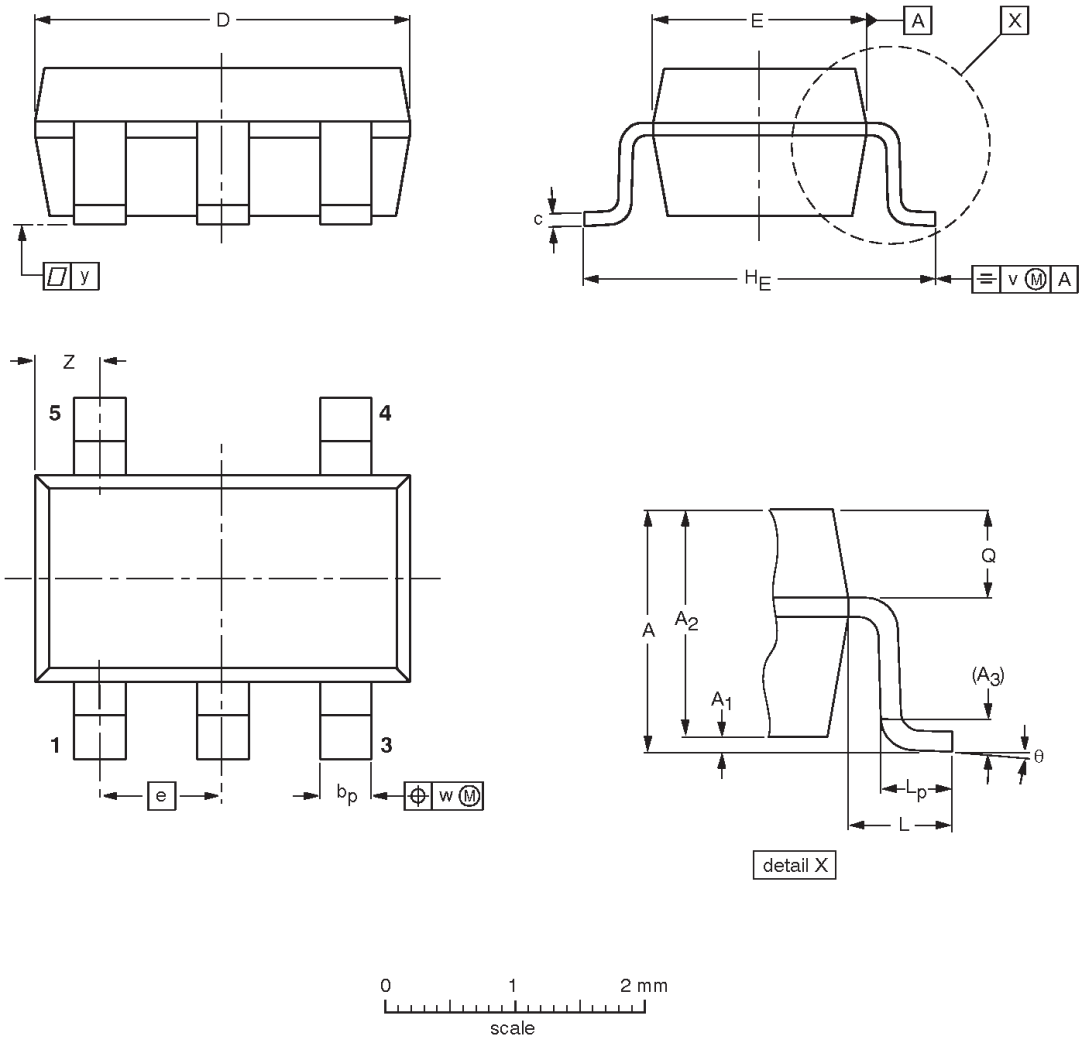
UNIT	A max.	A_1 min.	A_2 max.	b	b_1	b_2	c	D (1)	E (1)	e	e_1	L	M_E	M_H	w	Z (1) max.
mm	4.2	0.51	3.2	1.73 1.14	0.53 0.38	1.07 0.89	0.36 0.23	9.8 9.2	6.48 6.20	2.54	7.62	3.60 3.05	8.25 7.80	10.0 8.3	0.254	1.15
inches	0.17	0.020	0.13	0.068 0.045	0.021 0.015	0.042 0.035	0.014 0.009	0.39 0.36	0.26 0.24	0.10	0.30	0.14 0.12	0.32 0.31	0.39 0.33	0.01	0.045

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT97-1	050G01	MO-001	SC-504-8			~~95-02-04~~ 99-12-27

SO5: plastic small outline package; 5 leads; body width 1.6 mm **SOT680-1**



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	$D^{(1)}$	$E^{(1)}$	e	H_E	L	L_p	Q	v	w	y	$Z^{(1)}$	θ
mm	1.45	0.15 0.05	1.3 0.9	0.2	0.5 0.3	0.22 0.08	3.05 2.75	1.75 1.45	0.95	3.0 2.6	0.6	0.6 0.3	0.45 0.35	0.2	0.2	0.1	0.75 0.25	8^o 0^o

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT680-1		MO-178				~~01-03-22~~ 01-11-15

Data sheet status

Data sheet status[1]	Product status[2]	Definitions
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Contact information

For additional information please visit
http://www.semiconductors.philips.com. Fax: **+31 40 27 24825**

For sales offices addresses send e-mail to:
sales.addresses@www.semiconductors.philips.com.

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