TS971-TS972-TS974

Output Rail-to-Rail Very Low Noise Operational Amplifier

- Rail-to-rail output voltage swing ±2.4V @ V_{CC} = ±2.5V
- Very low noise level: 4nV/√Hz
- Ultra low distortion: 0.003%
- High dynamic features: 12MHz, 4V/µs
- Operating range: 2.7V to 10V
- ESD protection (2kV)
- Latch-up immunity (class A)
- Available in:
  - SOT23-5
  - QFN8 (3x3) micropackage

Description

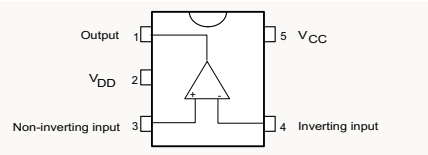
The TS97x family of operational amplifiers is able to operate with voltages as low as ±1.35V and featuring output rail-to-rail signal swing. The TS97x boasts characteristics that make them particularly well suited for portable and battery-supplied equipment. Very low noise and low distortion characteristics make them ideal for audio pre-amplification.

The TS971 is housed in the space-saving 5 pins SOT23 package which simplifies the board design because of the ability to be placed everywhere (outside dimensions are 2.8mm x 2.9mm).

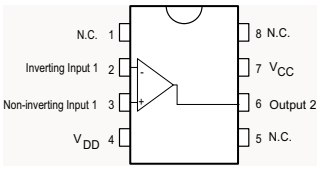
Applications

- Portable equipment (CD players, PDA)
- Portable communications (cell phones, pagers)
- Instrumentation & sensoring
- Professional audio circuits

TS971ILT



TS971ID-TS971IDT



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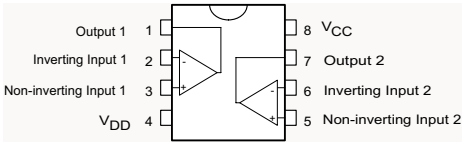
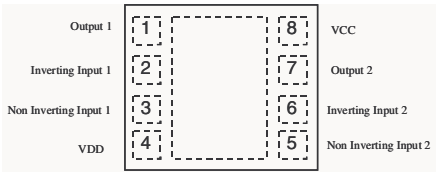
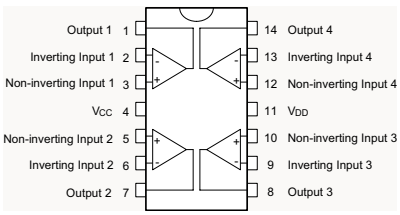


TS972IQT: QFN8



TS974IN-TS974ID-TS974IDT-TS974IPT



1 Order Codes

Part Number	Temperature Range	Package	Packing	Marking
TS971ID/IDT	-40°C, +125°C	SO-8	Tube or Tape & Reel	971I
TS971ILT		SOT23-5L	Tape & Reel	K120
TS971IYLT		SOT23-5L (automotive grade level)		K121
TS971IYD/IYDT		SO-8 (automotive grade level)	Tube or Tape & Reel	971Y
TS972IN		DIP8	Tube	TS972IN
TS972ID/IDT		SO-8	Tube or Tape & Reel	972I
TS972IPT		TSSOP8 (Thin Shrink Outline Package)	Tape & Reel	
TS972IQT		DFN8 (dual micro lead frame package)		
TS972IYD/IYDT		SO-8 (automotive grade level)	Tube or Tape & Reel	972Y
TS972IYPT		TSSOP8 (automotive grade level)	Tape & Reel	972IY
TS974IN		DIP14	Tube	TS974IN
TS974ID/IDT		SO-14	Tube or Tape & Reel	974I
TS974IPT		TSSOP14 (Thin Shrink Outline Package)	Tape & Reel	
TS974IYD/IYDT		SO-14 (automotive grade level)		974Y
TS974IYPT		TSSOP14 (automotive grade level)		974IY

2 Absolute Maximum Ratings

Table 1. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage (1)	12	V
V_{id}	Differential Input Voltage (2)	±1	V
V_{in}	Input Voltage (3)	V_{DD}-0.3 to V_{CC}+0.3	V
T_{oper}	Operating Free Air Temperature Range	-40 to +125	°C
T_{stg}	Storage Temperature Range	-65 to +150	
T_j	Maximum Junction Temperature	150	°C
R_{thja}	Thermal Resistance Junction to Ambient (4) SOT23-5 QFN8 SO8 SO14 TSSOP8 TSSOP14	 250 50 125 103 120 100	°C/W
R_{thjc}	Thermal Resistance Junction to Case SOT23-5 QFN8 SO8 SO14 TSSOP8 TSSOP14	 81 5.2 40 31 37 32	°C/W
ESD	HBM: Human Body Model(5)	2	kV
	MM: Machine Model(6)	200	V
	CDM: Charged Device Model	1.5	kV
	Lead Temperature (soldering, 10sec) (7)	260	°C

1. All voltage values, except differential voltage are with respect to network ground terminal.
2. Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
3. The magnitude of input and output voltages must never exceed V_{CC} +0.3V.
4. Short-circuits can cause excessive heating and destructive dissipation. Values are typical.
5. Human body model, 100pF discharged through a 1.5kΩ resistor into pin of device.
6. Machine model ESD, a 200pF cap is charged to the specified voltage, then discharged directly into the IC with no external series resistor (internal resistor < 5Ω), into pin to pin of device.
7. No value specified for CDM on SOT23-5 package.

Table 2. Operating conditions

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage	2.7 to 10	V
V_{icm}	Common Mode Input Voltage Range	V_{DD} +1.15 to V_{CC} -1.15	V
T_{oper}	Operating Free Air Temperature Range	-40 to +125	°C

3 Electrical Characteristics

Table 3. V_{CC} = +2.5V, V_{DD} = -2.5V, T_{amb} = 25°C (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_{io}	Input Offset Voltage	 $T_{min} \le T_{amb} \le T_{max}$		1	5 7	mV
DV_{io}	Input Offset Voltage Drift	V_{icm} = 0V, V_o = 0V		5		µV/°C
I_{io}	Input Offset Current	V_{icm} = 0V, V_o = 0V		10	150	nA
I_{ib}	Input Bias Current	V_{icm} = 0V, V_o = 0V $T_{min} \le T_{amb} \le T_{max}$		200 200	750 1000	nA
V_{icm}	Common Mode Input Voltage Range		-1.35		1.35	V
CMR	Common Mode Rejection Ratio	V_{icm} = ±1.35V	60	85		dB
SVR	Supply Voltage Rejection Ratio	V_{CC} = ±2V to ±3V	60	70		dB
A_{vd}	Large Signal Voltage Gain	R_L = 2kΩ	70	80		dB
V_{OH}	High Level Output Voltage	R_L = 2kΩ	2	2.4		V
V_{OL}	Low Level Output Voltage	R_L = 2kΩ		-2.4	-2	V
I_{source}	Output Source Current			1.5		mA
I_{sink}	Output Sink Current			100		mA
I_{CC}	Supply Current - per amplifier	Unity gain - No load		2	2.8	mA
GBP	Gain Bandwidth Product	f = 100kHz, R_L = 2kΩ, C_L = 100pF	8.5	12		MHz
SR	Slew Rate	A_V = 1, V_{in} = ±1V	2.8	4		V/µs
∅m	Phase Margin at Unit Gain	R_L = 2kΩ, C_L =100pF		60		Degrees
Gm	Gain Margin	R_L = 2kΩ, C_L =100pF		10		dB
e_n	Equivalent Input Noise Voltage	f = 100kHz		4		nV/√Hz
THD	Total Harmonic Distortion	f = 1KHz, A_v = -1, R_L =10kΩ		0.003		%

Figure 1. Input offset voltage distribution

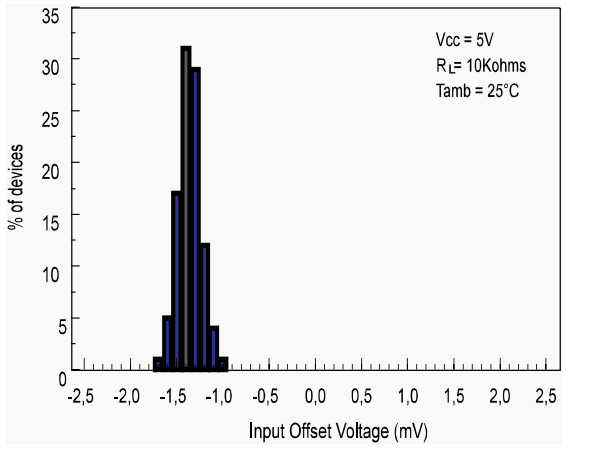


Figure 2. Voltage gain & phase vs. frequency

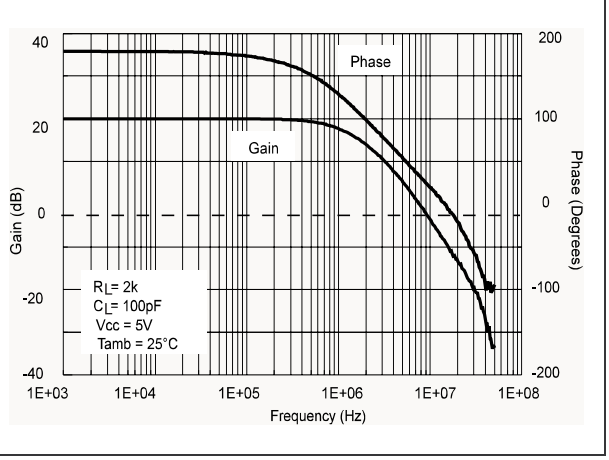


Figure 3. Voltage gain & phase vs. frequency

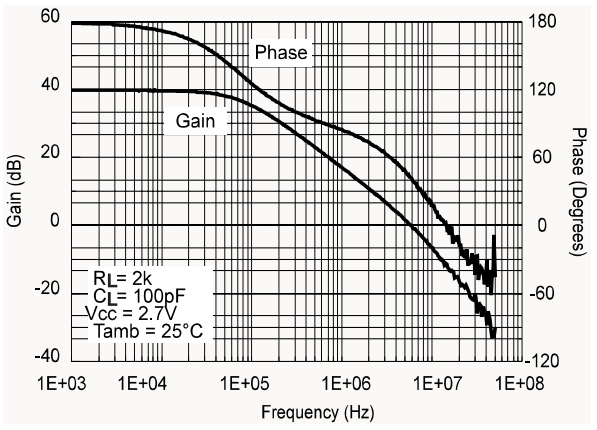


Figure 4. THS vs. Vout

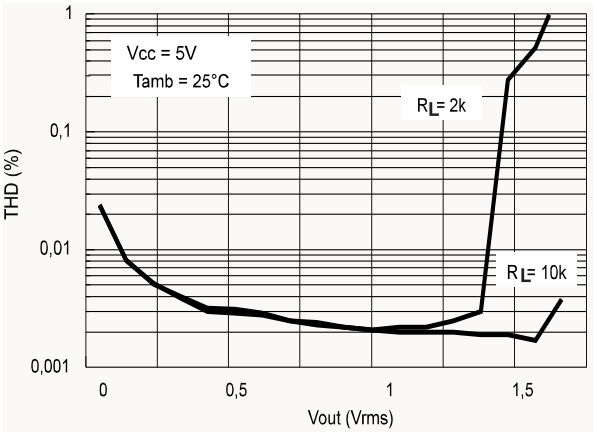


Figure 5. THD vs. Vout

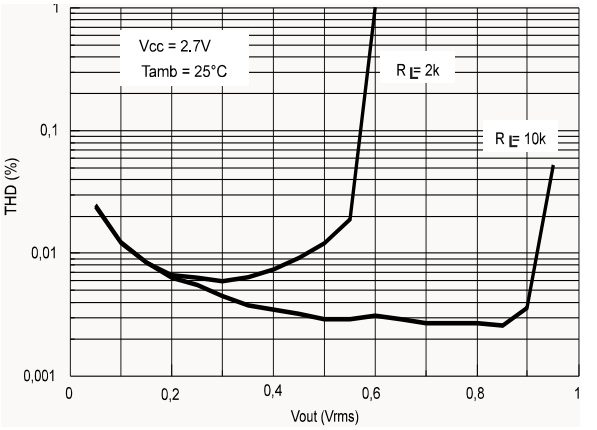


Figure 6. THD vs. frequency

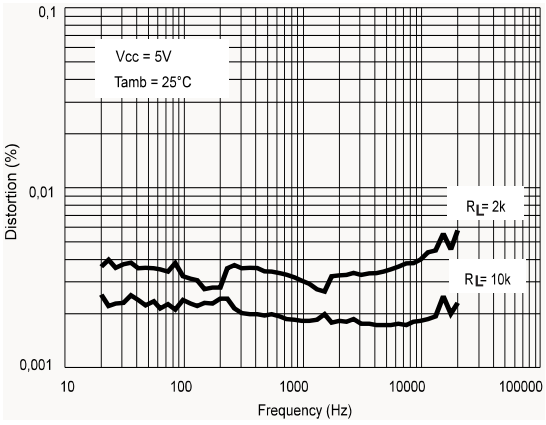


Figure 7. Noise voltage vs. frequency

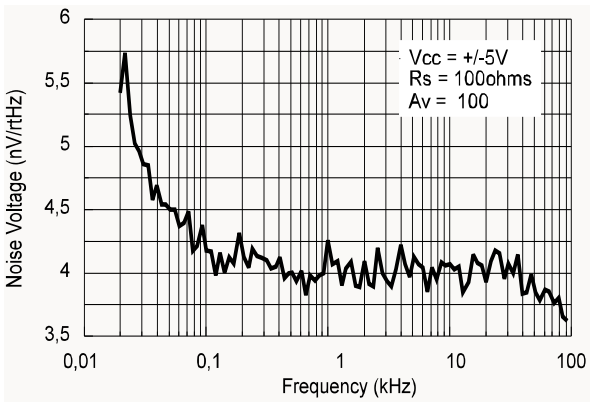


Figure 8. Gain bandwidth product vs. Iout

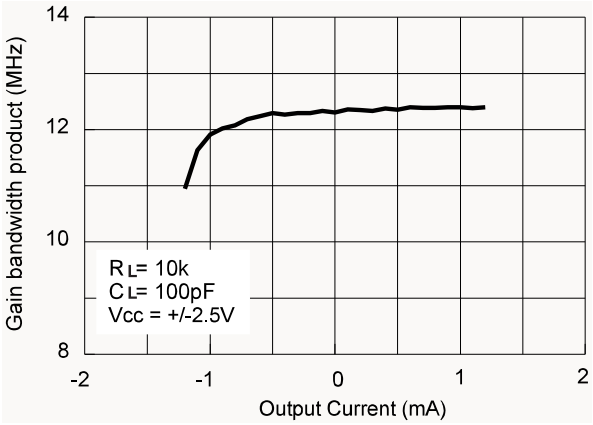


Figure 9. Phase margin vs. Iout

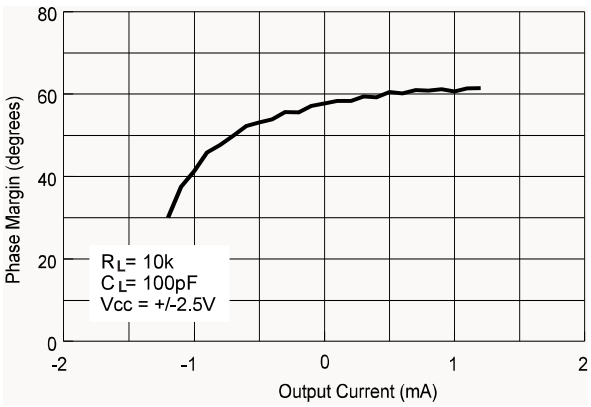


Figure 10. Phase margin vs. V_{CC}

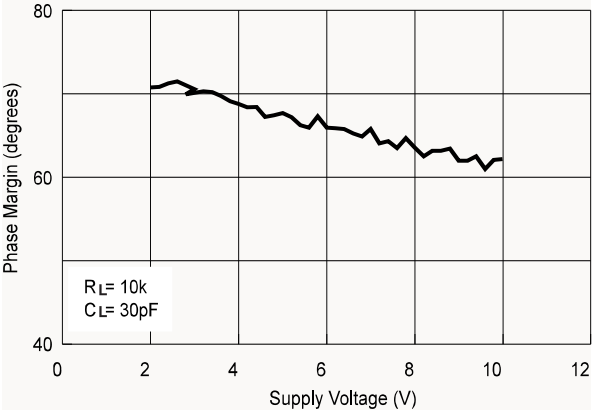


Figure 11. Phase margin vs. V_{CC}

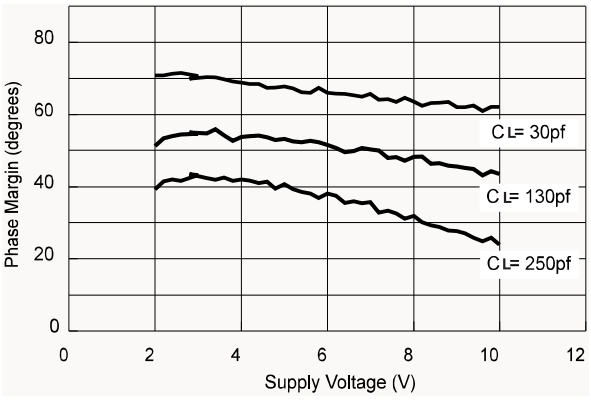
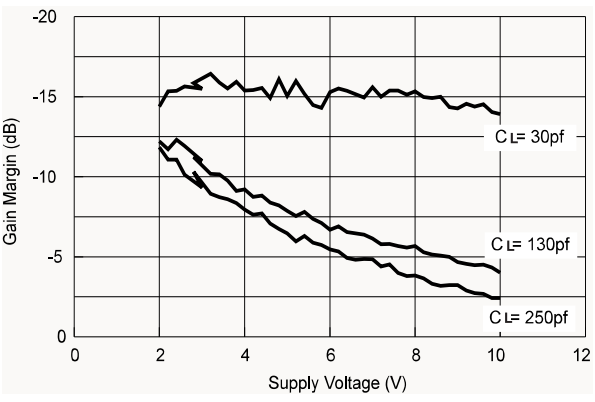


Figure 12. Gain margin vs. V_{CC}



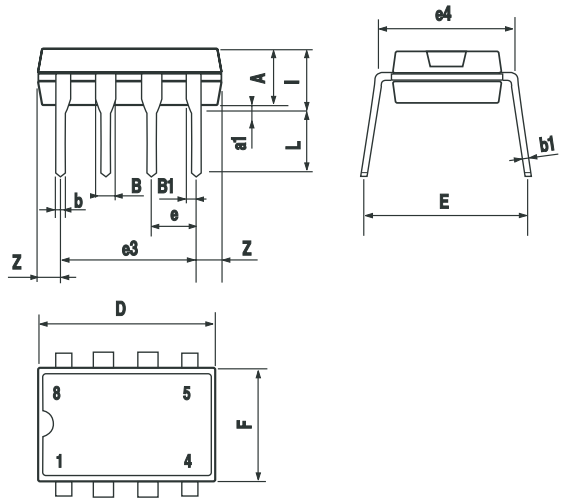
4 Package Mechanical Data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: www.st.com.

4.1 DIP8 Package

Plastic DIP-8 MECHANICAL DATA

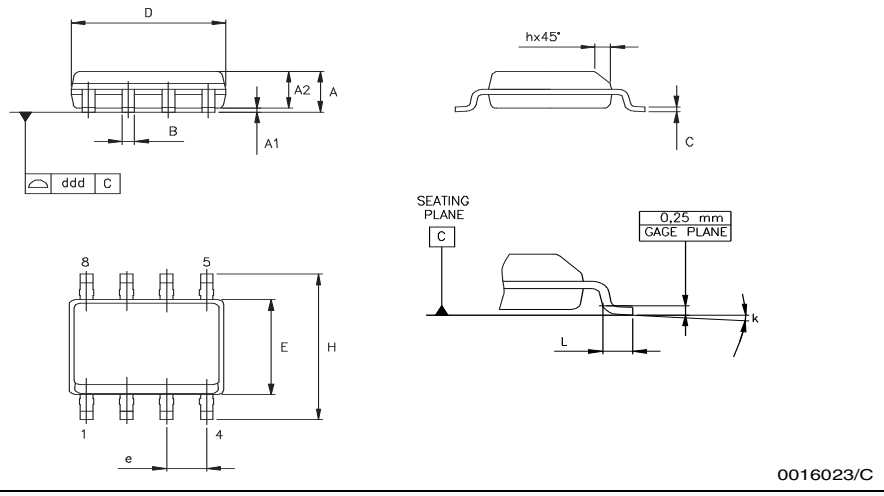
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A		3.3			0.130	
a1	0.7			0.028		
B	1.39		1.65	0.055		0.065
B1	0.91		1.04	0.036		0.041
b		0.5			0.020	
b1	0.38		0.5	0.015		0.020
D			9.8			0.386
E		8.8			0.346	
e		2.54			0.100	
e3		7.62			0.300	
e4		7.62			0.300	
F			7.1			0.280
I			4.8			0.189
L		3.3			0.130	
Z	0.44		1.6	0.017		0.063



4.2 SO-8 Package

SO-8 MECHANICAL DATA

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	1.35		1.75	0.053		0.069
A1	0.10		0.25	0.04		0.010
A2	1.10		1.65	0.043		0.065
B	0.33		0.51	0.013		0.020
C	0.19		0.25	0.007		0.010
D	4.80		5.00	0.189		0.197
E	3.80		4.00	0.150		0.157
e		1.27			0.050	
H	5.80		6.20	0.228		0.244
h	0.25		0.50	0.010		0.020
L	0.40		1.27	0.016		0.050
k	8° (max.)					
ddd			0.1			0.04

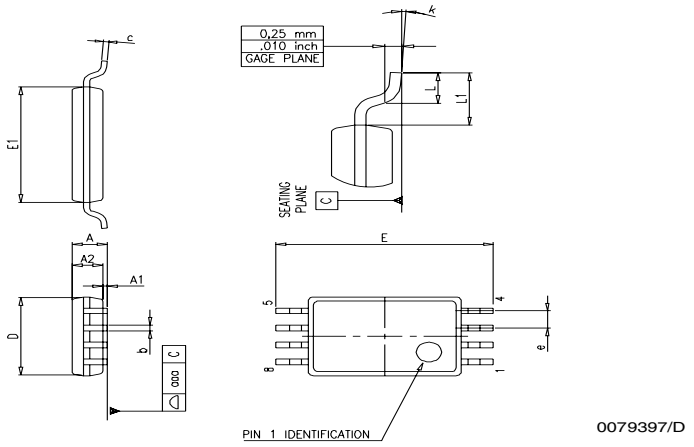


0016023/C

4.3 TSSOP8 Package

TSSOP8 MECHANICAL DATA

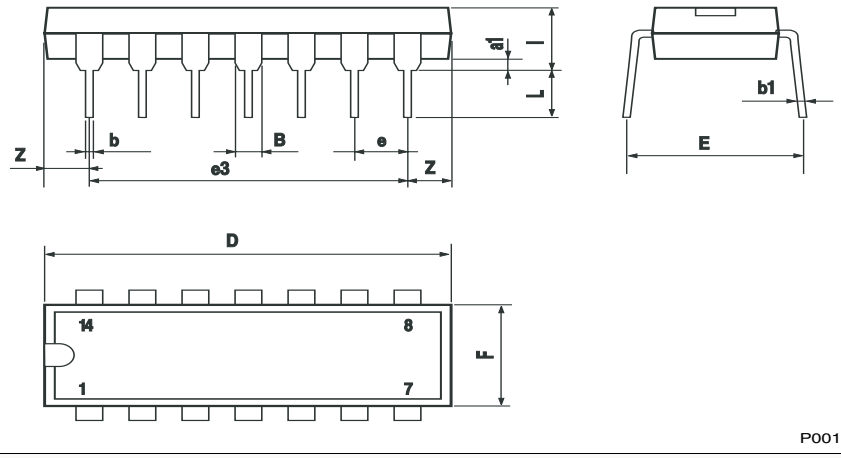
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			1.2			0.047
A1	0.05		0.15	0.002		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.012
c	0.09		0.20	0.004		0.008
D	2.90	3.00	3.10	0.114	0.118	0.122
E	6.20	6.40	6.60	0.244	0.252	0.260
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.0256	
K	0°		8°	0°		8°
L	0.45	0.60	0.75	0.018	0.024	0.030
L1		1			0.039	



4.4 DIP14 Package

Plastic DIP-14 MECHANICAL DATA

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
a1	0.51			0.020		
B	1.39		1.65	0.055		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		15.24			0.600	
F			7.1			0.280
I			5.1			0.201
L		3.3			0.130	
Z	1.27		2.54	0.050		0.100

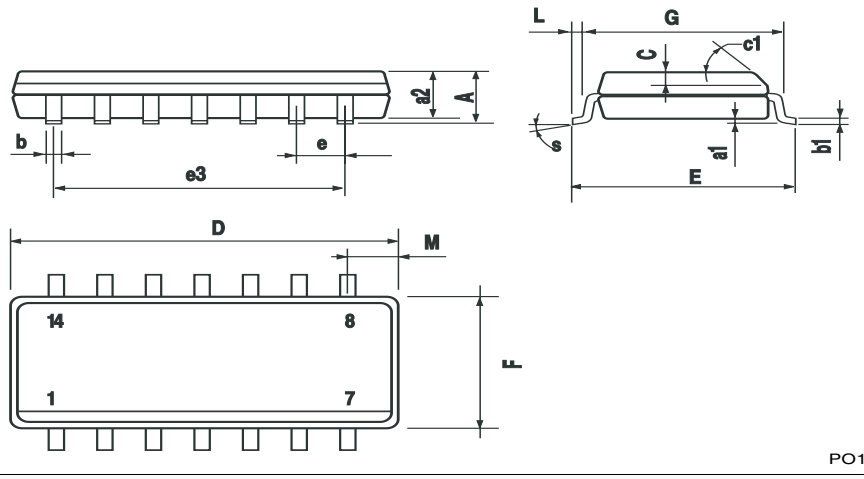


P001A

4.5 SO-14 Package

SO-14 MECHANICAL DATA

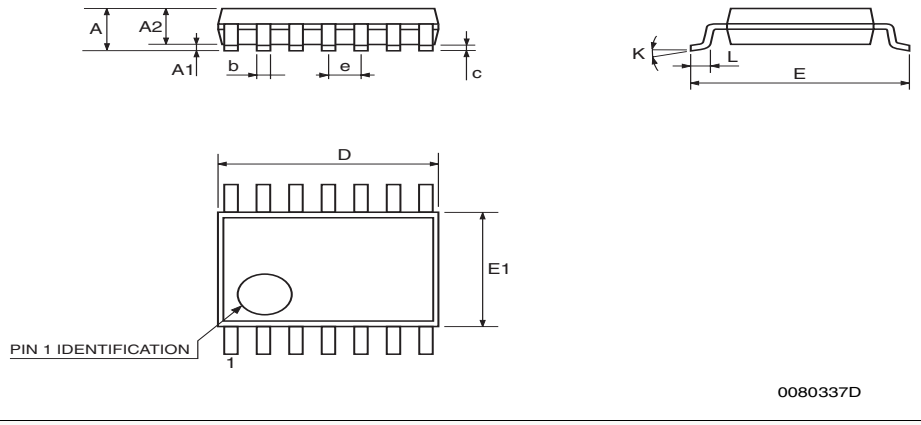
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			1.75			0.068
a1	0.1		0.2	0.003		0.007
a2			1.65			0.064
b	0.35		0.46	0.013		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.019	
c1	45° (typ.)					
D	8.55		8.75	0.336		0.344
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F	3.8		4.0	0.149		0.157
G	4.6		5.3	0.181		0.208
L	0.5		1.27	0.019		0.050
M			0.68			0.026
S	8° (max.)					



4.6 TSSOP14 Package

TSSOP14 MECHANICAL DATA

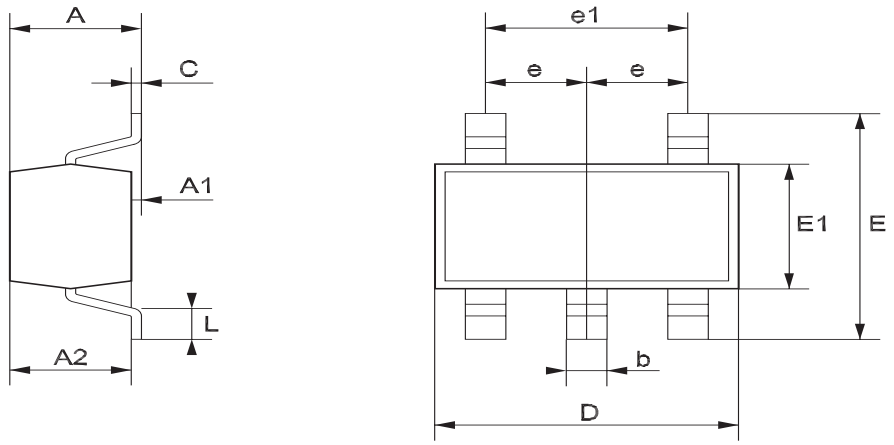
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			1.2			0.047
A1	0.05		0.15	0.002	0.004	0.006
A2	0.8	1	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.012
c	0.09		0.20	0.004		0.0089
D	4.9	5	5.1	0.193	0.197	0.201
E	6.2	6.4	6.6	0.244	0.252	0.260
E1	4.3	4.4	4.48	0.169	0.173	0.176
e		0.65 BSC			0.0256 BSC	
K	0°		8°	0°		8°
L	0.45	0.60	0.75	0.018	0.024	0.030



4.7 SOT23-5 Package

SOT23-5L MECHANICAL DATA

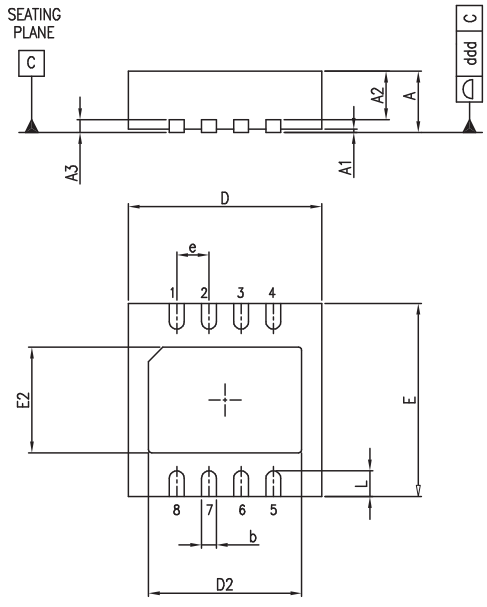
DIM.	mm.			mils		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	0.90		1.45	35.4		57.1
A1	0.00		0.15	0.0		5.9
A2	0.90		1.30	35.4		51.2
b	0.35		0.50	13.7		19.7
C	0.09		0.20	3.5		7.8
D	2.80		3.00	110.2		118.1
E	2.60		3.00	102.3		118.1
E1	1.50		1.75	59.0		68.8
e		0.95			37.4	
e1		1.9			74.8	
L	0.35		0.55	13.7		21.6



4.8 DFN8 Package

DFN8 (3x3) MECHANICAL DATA

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	0.80	0.90	1.00	31.5	35.4	39.4
A1		0.02	0.05		0.8	2.0
A2		0.70			27.6	
A3		0.20			7.9	
b	0.18	0.23	0.30	7.1	9.1	11.8
D	2.875	3.00	3.125		118.1	
D2	2.23	2.38	2.48	87.8	93.7	97.7
E	2.875	3.00	3.125		118.1	
E2	1.49	1.64	1.74	58.7	64.6	68.5
e		0.50			19.7	
L	0.30	0.40	0.50	11.8	15.7	19.7



5 Revision history

Date	Revision	Changes
Nov. 2002	1	First Release
May 2005	2	Modifications on AMR *Table 1 on page 3* (explanation of Vid and Vi limits)
Aug. 2005	3	PPAP references inserted in the datasheet see *Table 1 on page 2*.
Dec. 2005	4	– Thermal Resistance Junction to Case data added in *Table 1. on page 3* – Missing PPAP references inserted in the datasheet see *Table 1 on page 2*.

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