TS951-TS952-TS954

Input/Output Rail-to-Rail Low Power Operational Amplifier

- **Rail-to-rail input common-mode voltage range**
- **Rail-to-rail output voltage swing**
- **Operating from 2.7V to 12V**
- **High-speed (3MHz, 1V/µs)**
- **Low consumption (0.9mA @ 3V)**
- **Supply voltage rejection ratio: 80dB**
- **Latch-up immunity**
- **Available in SOT23-5 micropackage**

Description

The TS95x family are rail-to-rail BiCMOS operational amplifiers optimized and fully specified for 3V and 5V operation.

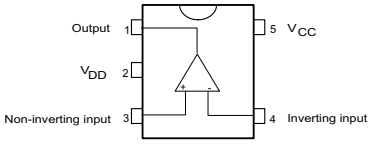
The TS951 is housed in the space-saving 5 pins SOT23 package that makes it well suited for battery-powered systems. This micropackage simplifies the PC board design because of it's ability to be placed in tight spaces (outside dimensions are: 2.8mm x 2.9mm)

Applications

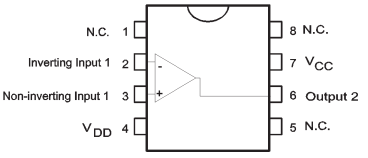
- **Set-top boxes**
- **Laptop/notebook computers**
- **Transformer/line drivers**
- **Personal entertainments (CD players)**
- **Portable communication (cell phones, pagers)**
- **Instrumentation & sensoring**
- **Digital to analog converter buffers**
- **Portable headphone speaker drivers**

Pin Connections (top view)

TS951ILT



TS951ID



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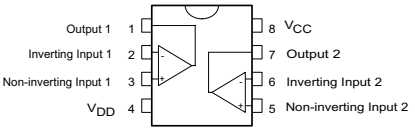

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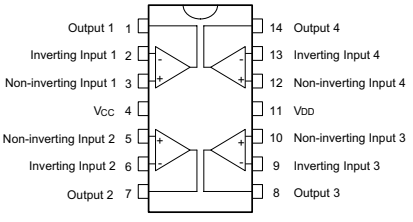


Order Codes

Part Number	Temperature Range	Package	Packaging	Marking
TS951IN	-40°C, +125°C	DIP	Tube	
TS951ILT		SOT23-5L	Tape & Reel	K101
TS952IN		DIP	Tube	
TS952ID/IDT		SO	Tube or Tape & Reel	
TS952IPT		TSSOP (Thin Shrink Outline Package)	Tape & Reel	
TS954IN		DIP	Tube	
TS954ID/IDT		SO	Tube or Tape & Reel	
TS954IPT		TSSOP (Thin Shrink Outline Package)	Tape & Reel	

1 Absolute Maximum Ratings

Table 1: Key parameters and their absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage [1]	14	V
V_{id}	Differential Input Voltage [2]	±1	V
V_{in}	Input Voltage	V_{DD}-0.3 to V_{CC}+0.3	V
Tstg	Storage Temperature Range	-65 to +150	
T_j	Maximum Junction Temperature	150	°C
Rthja	Thermal Resistance Junction to Ambient [3] SOT23-5 SO8 SO14 TSSOP8 TSSOP14	 250 125 103 120 100	°C/W
ESD	Human Body Model	2	kV
ESD	HBM: Human Body Model[4] TS951 TS952 TS954	 1 2 3	kV
	MM: Machine Model[5]	100	V
	CDM: Charged Device Model	1.5	kV
	Latch-up Immunity	200	mA
	Lead Temperature (soldering, 10sec)	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. If Vid > ±1V, the maximum input current must not exceed ±1mA. In this case (Vid > ±1V) an input serie resistor must be added to limit input current.

3) Short-circuits can cause excessive heating and destructive dissipation.

4) Human body model, 100pF discharged through a 1.5kΩ resistor into pin of device.

5) 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.

Table 2: Operating Conditions

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage	2.7 to 12	V
V_{icm}	Common Mode Input Voltage Range	V_{DD} -0.2 to V_{CC} +0.1	V
T_{oper}	Operating Free Air Temperature Range	-40 to +125	°C

2 Electrical Characteristics

Table 3: V_{CC} = +3V, V_{DD} = 0V, R_L connected to $V_{cc}/2$, T_{amb} = 25°C (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{io}	Input Offset Voltage $T_{min} \le T_{amb} \le T_{max}$			6 8	mV
DV_{io}	Input Offset Voltage Drift		2		µV/°C
I_{io}	Input Offset Current $T_{min} \le T_{amb} \le T_{max}$		1	30 80	nA
I_{ib}	Input Bias Current $V_{icm} = V_{cc/2}$ $T_{min} \le T_{amb} \le T_{max}$		35	100 200	nA
V_{icm}	Common Mode Input Voltage Range	V_{DD} -0.2 to V_{CC} +0.2V			V
CMR	Common Mode Rejection Ratio	50	80		dB
SVR	Supply Voltage Rejection Ratio Vcc = 2.7V to 3.3V	60	80		dB
A_{vd}	Large Signal Voltage Gain V_o = 2Vpk-pk R_L = 600Ω		80		dB
V_{OH}	High Level Output Voltage R_L = 600Ω	2.8	2.9		V
V_{OL}	Low Level Output Voltage R_L = 600Ω		80	250	mV
I_{sc}	Output Short Circuit Current	10			mA
I_{cc}	Supply Current (per Amplifier) No load, $V_{icm} = V_{cc/2}$		0.9	1.3	mA
GBP	Gain Bandwidth Product R_L = 2kΩ		3		MHz
SR	Slew Rate		1		V/µs
∅m	Phase Margin at Unit Gain R_L = 600Ω, C_L =100pF		60		Degrees
Gm	Gain Margin R_L = 600Ω, C_L =100pF		10		dB
e_n	Equivalent Input Noise Voltage f = 1kHz		25		$\frac{nV}{\sqrt{Hz}}$
THD	Total Harmonic Distortion V_{out} = 4Vpk-pk, F = 10kHz, A_V = 2, R_L =10kΩ		0.01		%

Table 4: V_{CC} = +5V, V_{DD} = 0V, R_L connected to $V_{cc}/2$, T_{amb} = 25°C (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{io}	Input Offset Voltage $T_{min} \le T_{amb} \le T_{max}$			6 8	mV
DV_{io}	Input Offset Voltage Drift		2		µV/°C
I_{io}	Input Offset Current $V_{icm} = V_{cc/2}$ $T_{min} \le T_{amb} \le T_{max}$		1	30 80	nA
I_{ib}	Input Bias Current $V_{icm} = V_{cc/2}$ $T_{min} \le T_{amb} \le T_{max}$		35	100 200	nA
V_{icm}	Common Mode Input Voltage Range	V_{DD}^- -0.2 to V_{CC}^+ +0.2V			V
CMR	Common Mode Rejection Ratio	50	80		dB
SVR	Supply Voltage Rejection Ratio Vcc = 2.7V to 3.3V	60	80		dB
A_{vd}	Large Signal Voltage Gain V_o = 2Vpk-pk R_L = 600Ω		86		dB
V_{OH}	High Level Output Voltage R_L = 600Ω	4.7	4.8		V
V_{OL}	Low Level Output Voltage R_L = 600Ω		80	300	mV
I_{sc}	Output Short Circuit Current	10			mA
I_{cc}	Supply Current (per Amplifier) No load, $V_{icm} = V_{cc/2}$		0.95	1.4	mA
GBP	Gain Bandwidth Product R_L = 2kΩ		3		MHz
SR	Slew Rate		1		V/µs
∅m	Phase Margin at Unit Gain R_L = 600Ω, C_L =100pF		60		Degrees
Gm	Gain Margin R_L = 600Ω, C_L =100pF		10		dB
e_n	Equivalent Input Noise Voltage f = 1kHz		25		$\frac{nV}{\sqrt{Hz}}$
THD	Total Harmonic Distortion V_{out} = 4Vpk-pk, F = 10kHz, A_V = 2, R_L =10kΩ		0.01		%

Figure 1: Supply current vs. supply voltage

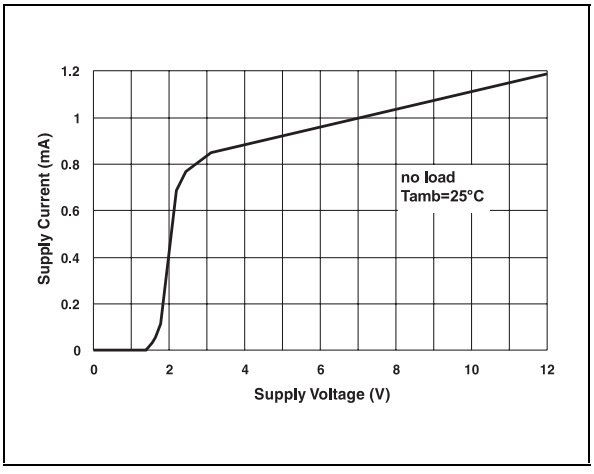


Figure 2: Output short circuit current vs. output voltage

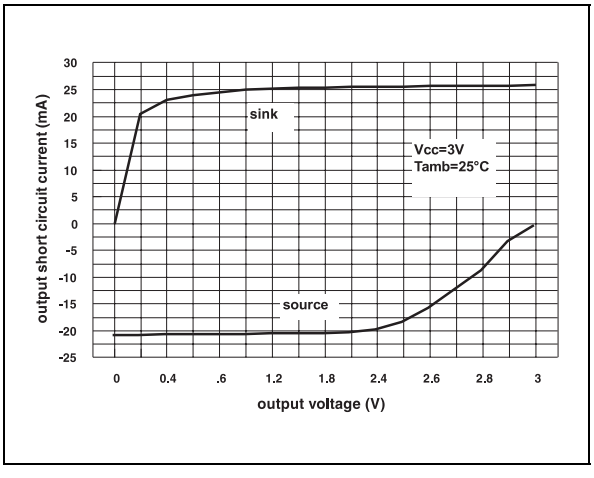


Figure 3: Voltage gain and phase vs. frequency

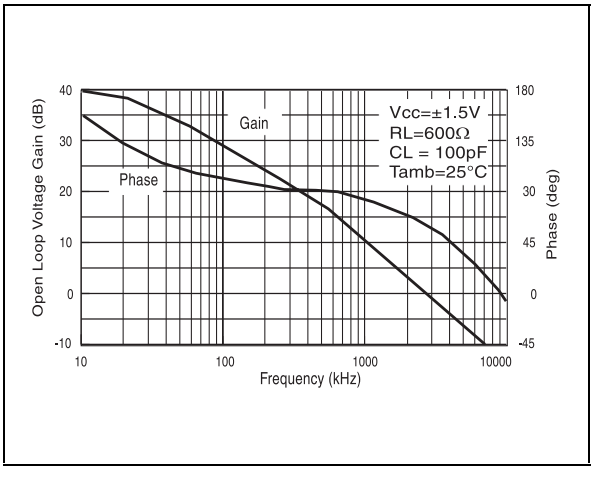


Figure 4: Supply current vs. temperature

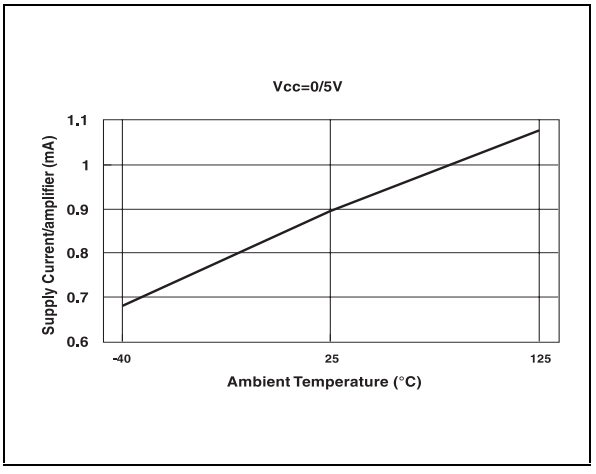


Figure 5: Output short circuit current vs. temperature

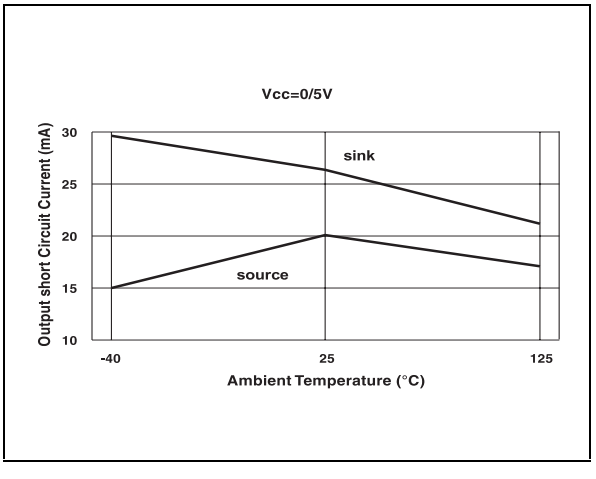


Figure 6: Slew rate vs. temperature

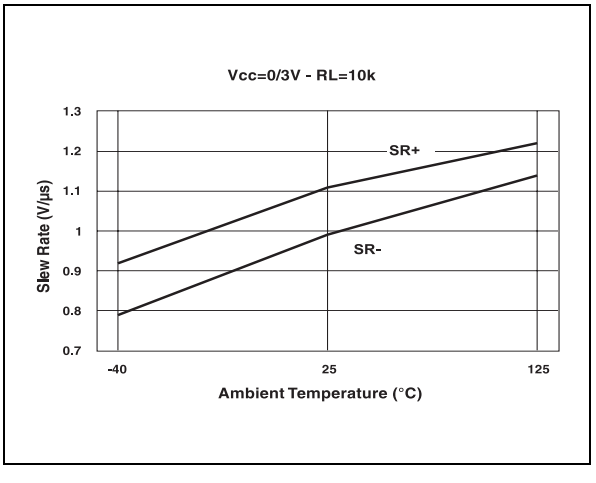


Figure 7: THD + noise vs. Vout

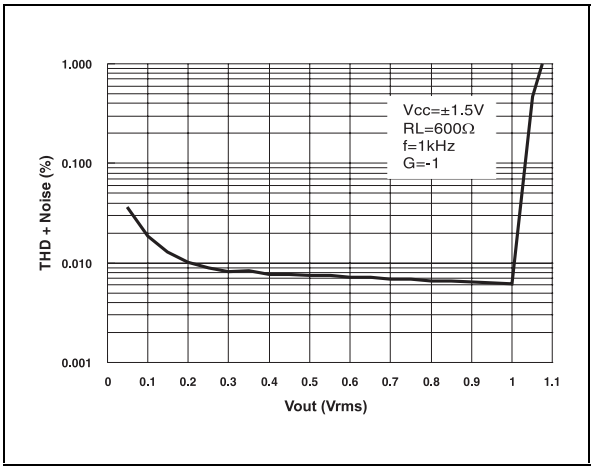


Figure 8: THD + noise vs. frequency

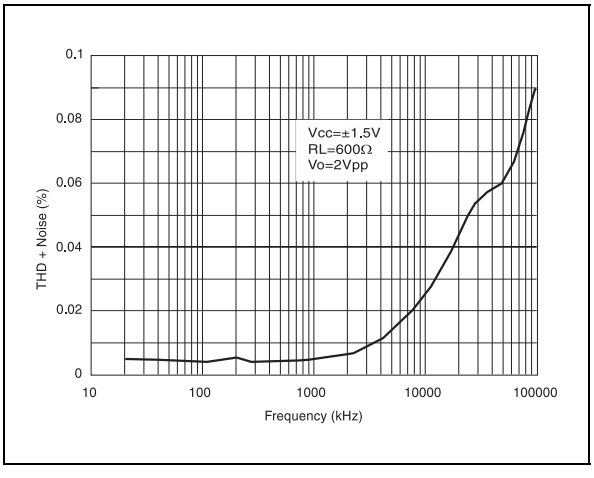


Figure 9: THD + noise vs. Vout

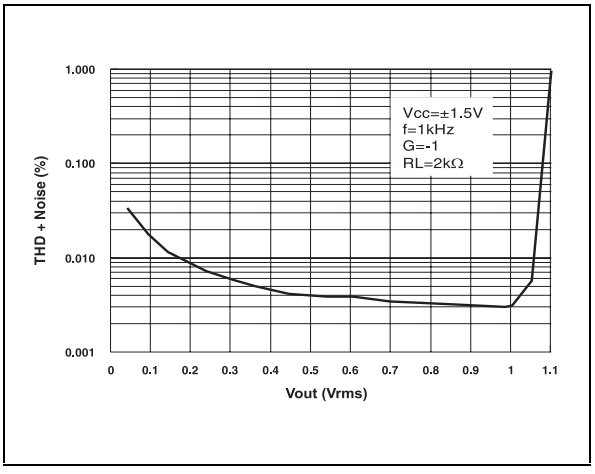
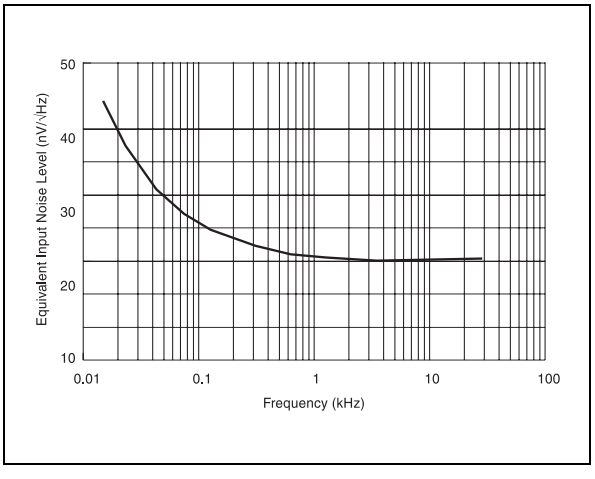


Figure 10: Equivalent input noise voltage vs. frequency

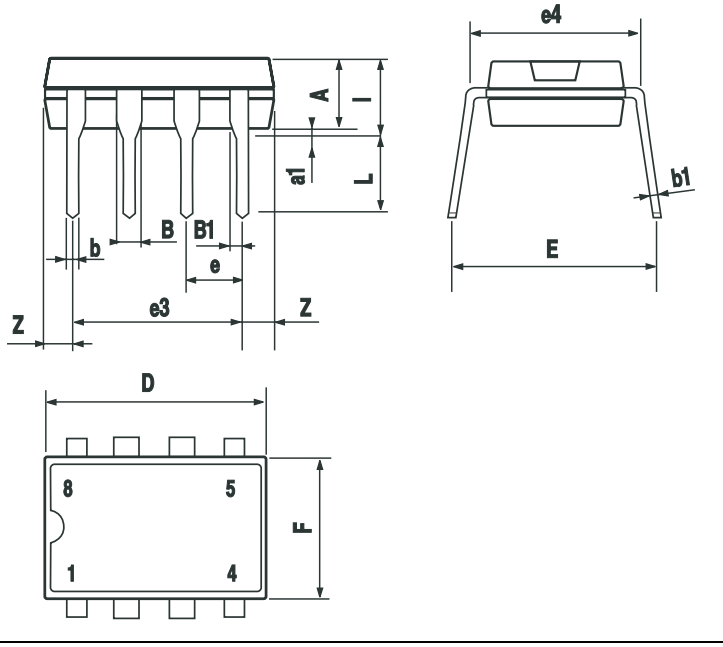


3 Package Mechanical Data

3.1 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

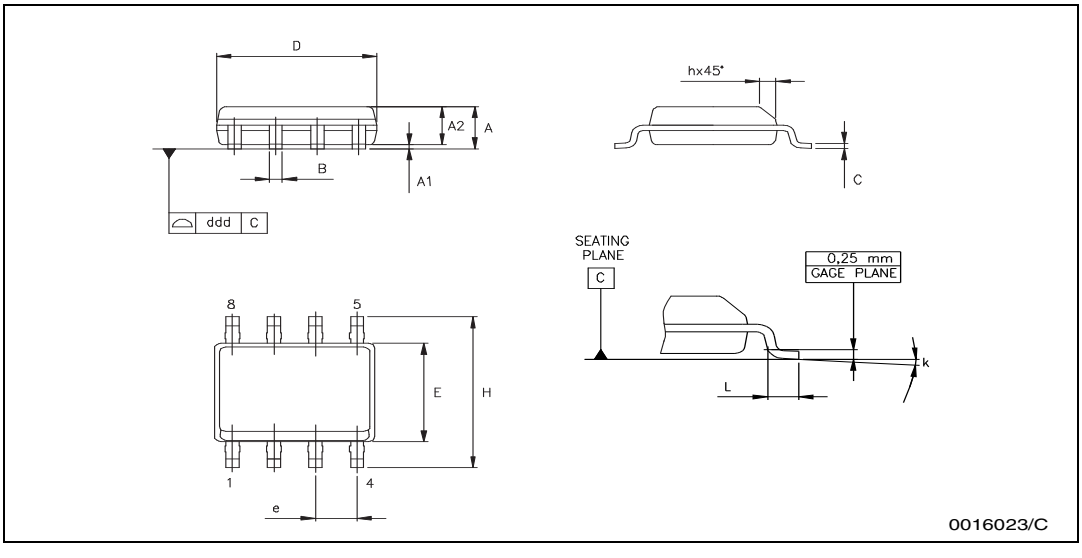


P001F

3.2 SO8 package

SO-8 MECHANICAL DATA

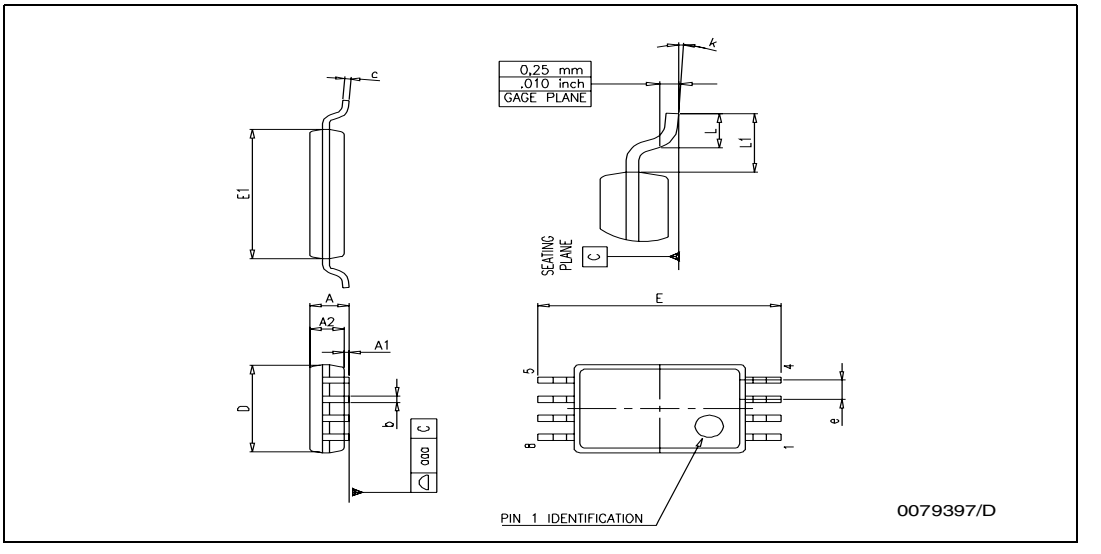
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	1.35		1.75	0.053		0.069
A1	0.10		0.25	0.04		0.010
A2	1.10		1.65	0.043		0.065
B	0.33		0.51	0.013		0.020
C	0.19		0.25	0.007		0.010
D	4.80		5.00	0.189		0.197
E	3.80		4.00	0.150		0.157
e		1.27			0.050	
H	5.80		6.20	0.228		0.244
h	0.25		0.50	0.010		0.020
L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



3.3 TSSOP8 package

TSSOP8 MECHANICAL DATA

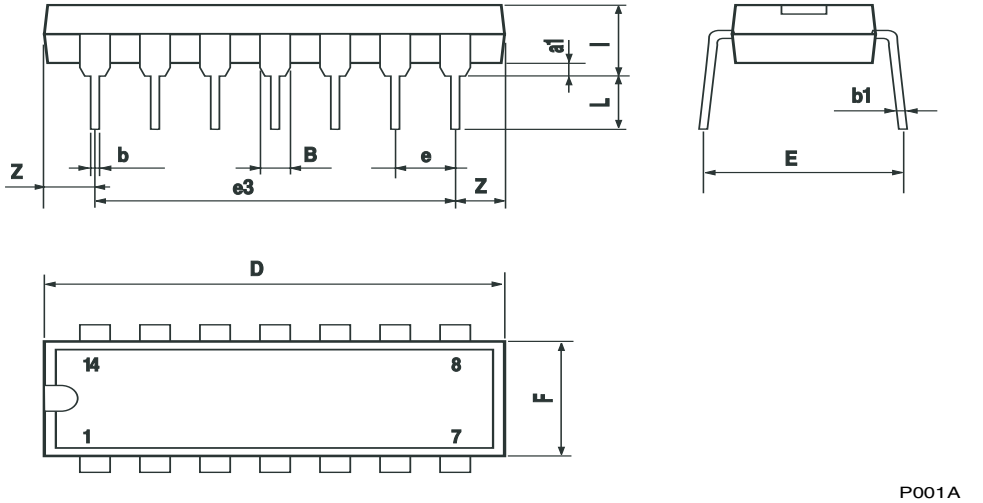
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			1.2			0.047
A1	0.05		0.15	0.002		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.012
c	0.09		0.20	0.004		0.008
D	2.90	3.00	3.10	0.114	0.118	0.122
E	6.20	6.40	6.60	0.244	0.252	0.260
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.0256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



3.4 DIP14 package

Plastic DIP-14 MECHANICAL DATA

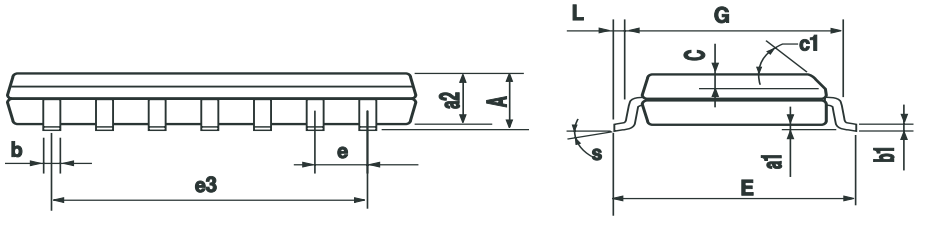
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
a1	0.51			0.020		
B	1.39		1.65	0.055		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		15.24			0.600	
F			7.1			0.280
I			5.1			0.201
L		3.3			0.130	
Z	1.27		2.54	0.050		0.100



3.5 SO14 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.)					

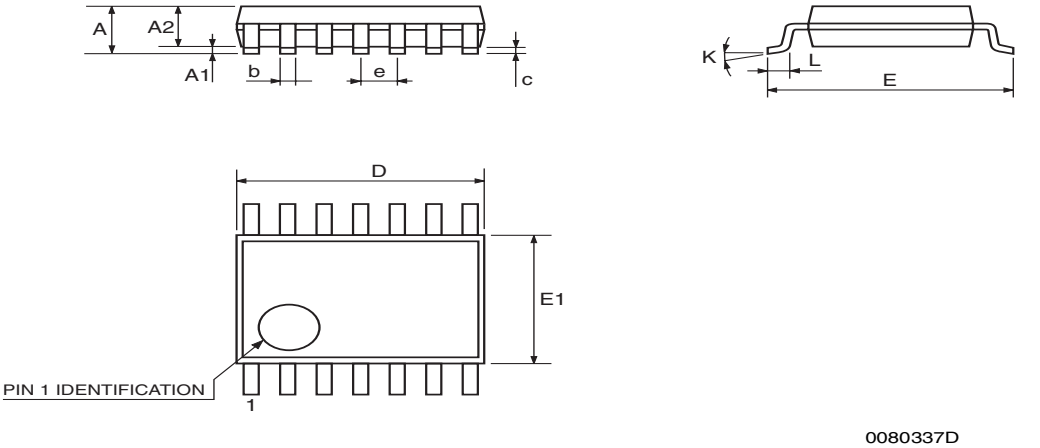


PO13G

3.6 TSSOP14 package

TSSOP14 MECHANICAL DATA

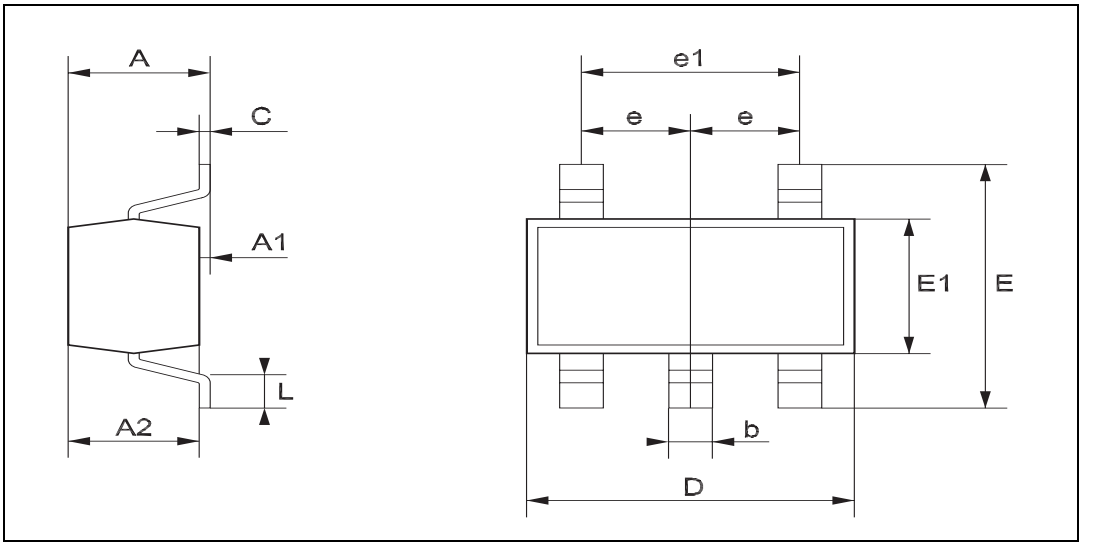
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			1.2			0.047
A1	0.05		0.15	0.002	0.004	0.006
A2	0.8	1	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.012
c	0.09		0.20	0.004		0.0089
D	4.9	5	5.1	0.193	0.197	0.201
E	6.2	6.4	6.6	0.244	0.252	0.260
E1	4.3	4.4	4.48	0.169	0.173	0.176
e		0.65 BSC			0.0256 BSC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



3.7 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 Summary of Changes

Date	Revision	Description of Changes
01 May 2001	1	First Release
01 Jan. 2005	2	Modifications on AMR *Table 1 on page 2* (explanation of Vid and Vi limits, ESD MM and CDM values added, Rthja added)