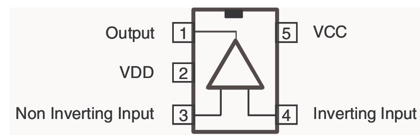
TSV321-TSV358-TSV324

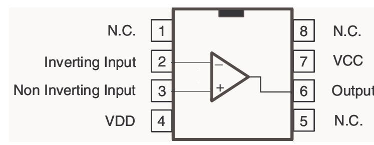
General Purpose, Input/Output Rail-to-Rail Low Power Operational Amplifiers

- Operating at V_{CC} = 2.5V to 6V
- Rail-to-rail input & output
- Extended V_{icm} (V_{DD} - 0.2V to V_{CC} + 0.2V)
- Capable of driving a 32Ω load resistor
- High stability: 500pF
- Available in SOT23-5 micropackage
- Operating temperature range: -40, +125°C

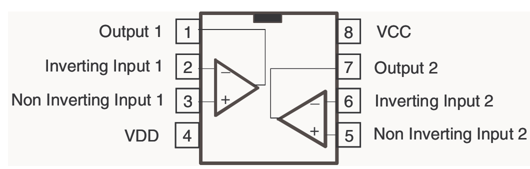
TSV321RILT



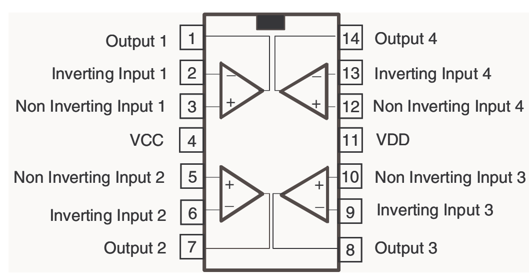
TSV321ID-TSV321IDT



TSV358IST-TSV358ID-TSV358IDT-TSV358IPT



TSV324ID-TSV324IDT-TSV324IPT



Description

The TSV358 and TSV324 (dual & quad) are low voltage versions of LM358 and LM324 commodity operational amplifiers. TSV321 is the single version. The TSV321/358/324 are able to operate with voltage as low as 2.5V and features both I/O rail-to-rail.

The common mode input voltage extends 200mV at 25°C beyond the supply voltages while the output voltage swing is within 100mV of each rail with 600 Ohm load resistor. These devices offer 1.3MHz of gain-bandwidth product and provide high output drive capability typically at 65mA-load.

These performances make the TSV3xx family ideal for active filters, general purpose low-voltage applications, general purpose portable devices.

Applications

- Battery-powered applications
- Audio driver (headphone driver)
- Sensor signal conditioning
- Laptop/notebook computers

1 Order Codes

Part Number	Temperature Range	Package	Packaging	Marking
TSV321RILT	-40°C to +125°C	SOT23-5L	Tape & Reel	K174
TSV321RAILT		SOT23-5L	Tape & Reel	K178
TSV321ID/IDT		SO-8	Tube or Tape & Reel	V321ID
TSV358ID/IDT				V358ID
TSV358IPT		TSSOP8 (Thin Shrink Outline Package)	Tape & Reel	V358I
TSV358IST		MiniSO-8		K175
TSV358IYD/IYDT		SO-8 (automotive grade level)	Tube or Tape & Reel	
TSV358IYPT		TSSOP8 (automotive grade level)	Tape & Reel	V358Y
TSV324ID/IDT		SO-14	Tube or Tape & Reel	V324ID
TSV324IPT		TSSOP14 (Thin Shrink Outline Package)	Tape & Reel	V324IP

2 Absolute Maximum Ratings

Table 1. Key parameters and their absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}	Supply Voltage (1)	7	V
V_{id}	Differential Input Voltage (2)	±1	V
V_i	Input Voltage	V_{DD}-0.3 to V_{CC} +0.3	V
T_{stg}	Storage Temperature	-65 to +150	°C
T_j	Maximum Junction Temperature	150	°C
R_{thja}	Thermal Resistance Junction to Ambient(3) SOT23-5 SO-8 SO-14 TSSOP8 TSSOP14 MiniSO-8	 250 125 103 120 100 190	°C/W
ESD	HBM: Human Body Model(4)	2	kV
	MM: Machine Model(5)	200	V
	CDM: Charged Device Model	1.5	kV
	Latch-up Immunity	200	mA
	Lead Temperature (soldering, 10s)	250	°C
	Output Short Circuit Duration	see note(6)	

1. All voltages values, except differential voltage are with respect to network 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 series resistor must be added to limit input current.
3. Short-circuits can cause excessive heating. Destructive dissipation can result from simultaneous short-circuit on all amplifiers.
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.
6. Short-circuits from the output to V_{CC} can cause excessive heating. The maximum output current is approximately 80mA, independent of the magnitude of V_{CC}. Destructive dissipation can result from simultaneous short-circuits on all amplifiers.

Table 2. Operating conditions

Symbol	Parameter	Value	Unit
V_{CC}	Supply Voltage	2.5 to 6	V
V_{icm}	Common Mode Input Voltage Range (1)	V_{DD} - 0.2 to V_{CC} + 0.2	V
V_{icm}	Common Mode Input Voltage Range (2)	V_{DD} to V_{CC}	V
T_{oper}	Operating Free Air Temperature Range	-40 to + 125	°C

1. At 25°C, for $2.5 \le V_{CC} \le 6V$, V_{icm} is extended to V_{DD} - 0.2V, V_{CC} + 0.2V.
2. In full temperature range, both Rails can be reached when V_{CC} does not exceed 5.5V.

3 Electrical Characteristics

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

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_{io}	Input Offset Voltage	**$V_{icm} = V_{out} = V_{CC}/2$** TSV321/358/324 TSV321A/358A/324A		 0.2 0.1	 3 1	mV
ΔV_{io}	Input Offset Voltage Drift			2		µV/°C
I_{io}	Input Offset Current (1)	$V_{icm} = V_{out} = V_{CC}/2$		3	30	nA
I_{ib}	Input Bias Current 1)	$V_{icm} = V_{out} = V_{CC}/2$		4	125	nA
CMR	Common Mode Rejection Ratio	$0 \leq V_{icm} \leq V_{CC}$, $V_{out} = V_{CC}/2$	60	80		dB
SVR	Supply Voltage Rejection Ratio		70	85		dB
A_{vd}	Large Signal Voltage Gain	**V_{out} = 0.5V to 2.5V** R_L = 2kΩ R_L = 600Ω	 80 74	 92 95		dB
V_{OH}	High Level Output Voltage	**V_{id} = 100mV** R_L = 2kΩ R_L = 600Ω	 2.82 2.80	 2.95 2.95		V
V_{OL}	Low Level Output Voltage	**V_{id} = -100mV** R_L = 2kΩ R_L = 600Ω		 88 115	 120 160	mV
I_o	Output Source Current	V_{ID} = 100mV, $V_O = V_{DD}$	20	80		mA
	Output Sink Current	V_{ID} = -100mV, $V_O = V_{CC}$	20	80		
I_{CC}	Supply Current (per amplifier)	A_{VCL} = 1, no load		420	650	µA
GBP	Gain Bandwidth Product	R_L = 10kΩ, C_L = 100pF, f = 100kHz	1	1.3		MHz
SR	Slew Rate	R_L = 10kΩ, C_L = 100pF, AV = 1	0.42	0.6		V/µs
ϕm	Phase Margin	C_L = 100pF		53		Degrees
en	Input Voltage Noise			27		nV/√Hz
THD	Total Harmonic Distortion			0.01		%

1. Maximum values including unavoidable inaccuracies of the industrial test.

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

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_{io}	Input Offset Voltage	**$V_{icm} = V_{out} = V_{CC}/2$** TSV321/358/324 TSV321A/358A/324A		 0.2 0.1	 3 1	mV
ΔV_{io}	Input Offset Voltage Drift			2		µV/°C
I_{io}	Input Offset Current (1)	$V_{icm} = V_{out} = V_{CC}/2$		3	30	nA
I_{ib}	Input Bias Current 1)	$V_{icm} = V_{out} = V_{CC}/2$		70	130	nA
CMR	Common Mode Rejection Ratio	$0 \le V_{icm} \le V_{CC}$, $V_{out} = V_{CC}/2$	65	85		dB
SVR	Supply Voltage Rejection Ratio		70	90		dB
A_{vd}	Large Signal Voltage Gain	**V_{out} = 0.5V to 2.5V** R_L = 2kΩ R_L = 600Ω	 83 77	 92 85		dB
V_{OH}	High Level Output Voltage	**V_{id} = 100mV** R_L = 2kΩ R_L = 600Ω	 4.80 4.75	 4.95 4.90		V
V_{OL}	Low Level Output Voltage	**V_{id} = -100mV** R_L = 2kΩ R_L = 600Ω		 88 115	 130 188	mV
I_o	Output Source Current	V_{ID} = 100mV, $V_O = V_{DD}$	20	80		mA
	Output Sink Current	V_{ID} = -100mV, $V_O = V_{CC}$	20	80		
I_{CC}	Supply Current (per amplifier)	A_{VCL} = 1, no load		500	835	µA
GBP	Gain Bandwidth Product	R_L = 10kΩ, C_L = 100pF, f = 100kHz	1	1.4		MHz
SR	Slew Rate	R_L = 10kΩ, C_L = 100pF, AV = 1	0.42	0.6		V/µs
ϕm	Phase Margin	C_L = 100pF		55		Degrees
en	Input Voltage Noise			27		nV/√Hz
THD	Total Harmonic Distortion			0.01		%

1. Maximum values including unavoidable inaccuracies of the industrial test.

Figure 1. Supply current/amplifier vs. supply voltage

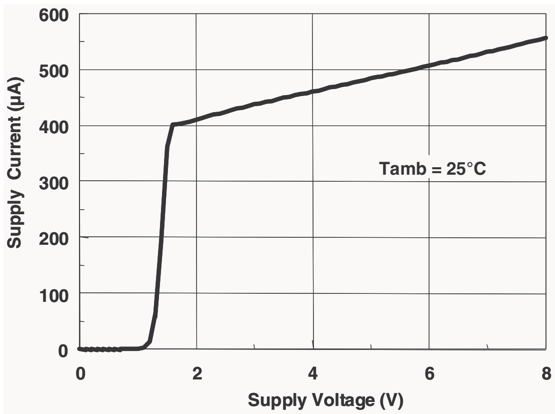


Figure 2. Supply current/amplifier vs. temperature

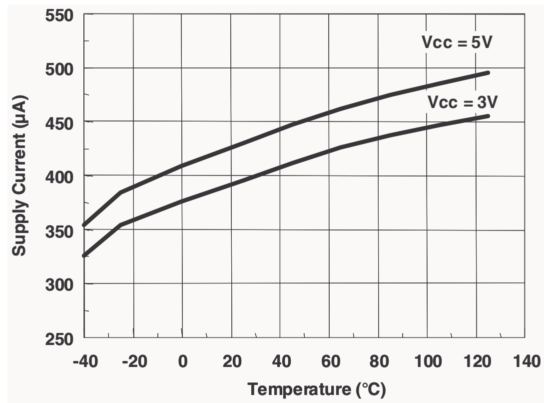


Figure 3. Output power vs. supply voltage

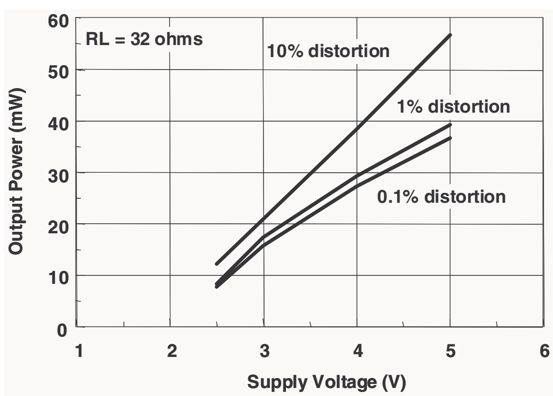


Figure 4. Input offset voltage drift vs. temperature

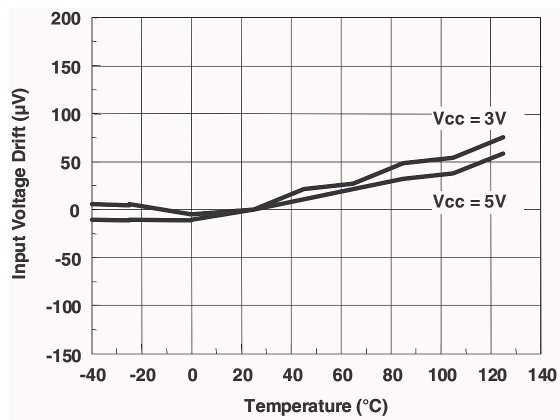


Figure 5. Input bias current vs. temperature

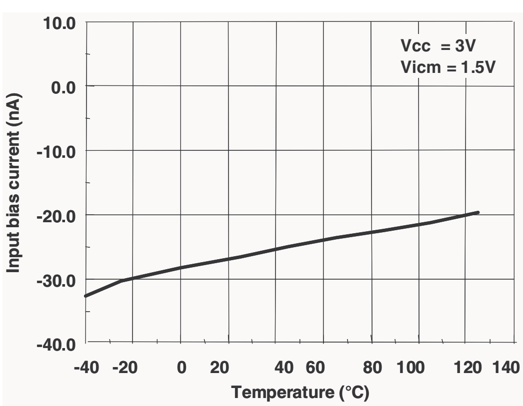


Figure 6. Open loop gain vs. temperature

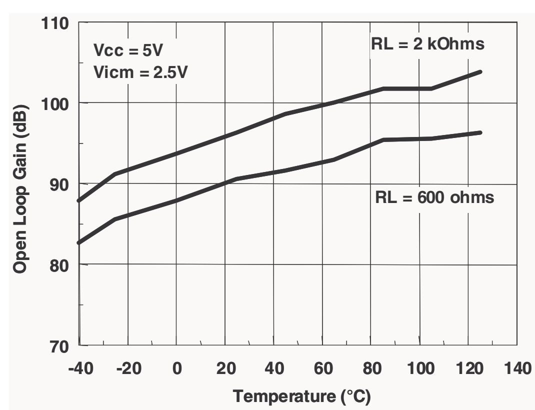


Figure 7. Open loop gain vs. temperature

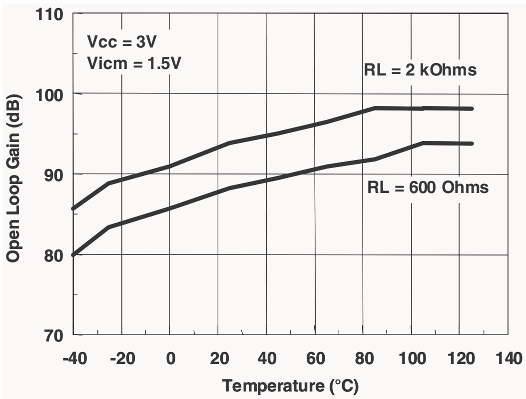


Figure 8. High level output voltage vs. temperature

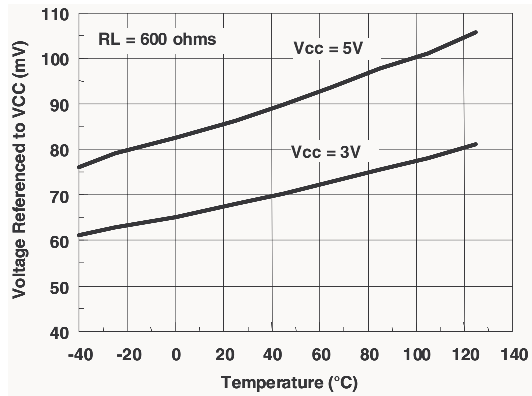


Figure 9. Low level output voltage vs. temperature

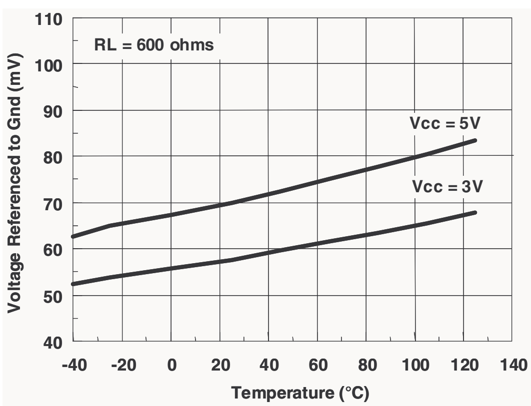


Figure 10. Output current vs. temperature

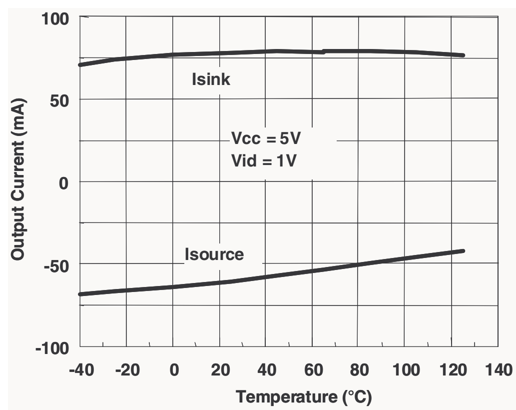


Figure 11. Output current vs. temperature

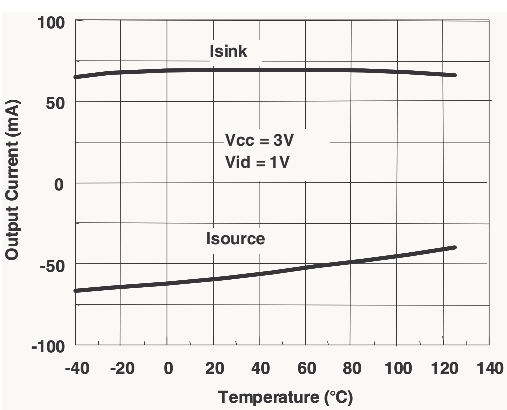


Figure 12. Output current vs. temperature

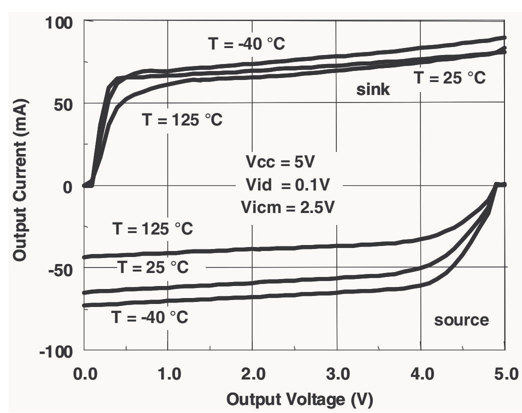


Figure 13. Output current vs. temperature

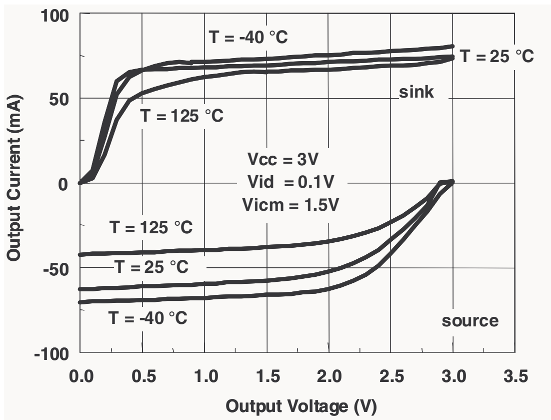


Figure 14. Gain & phase vs. frequency

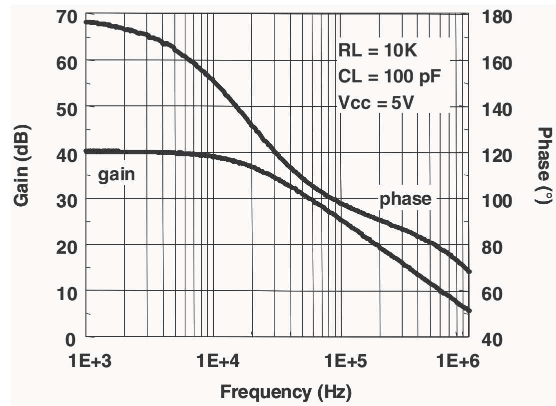


Figure 15. Gain & phase vs. frequency

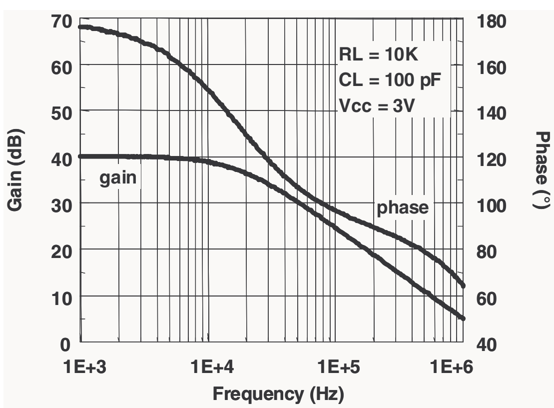


Figure 16. Slew rate vs. temperature

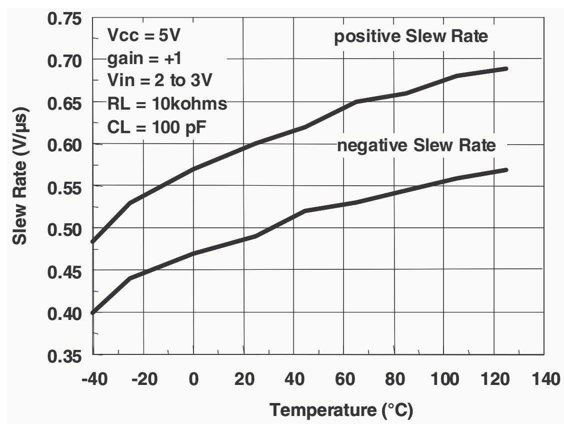


Figure 17. Slew rate vs. temperature

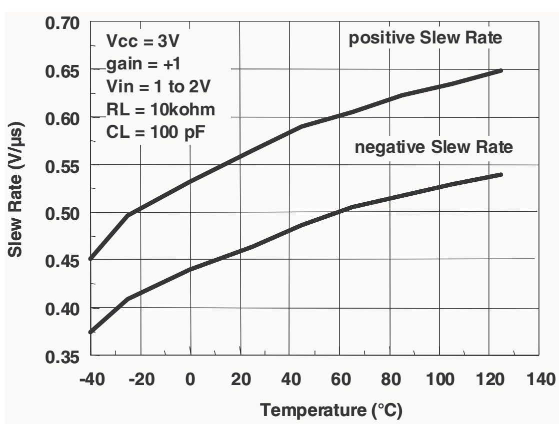
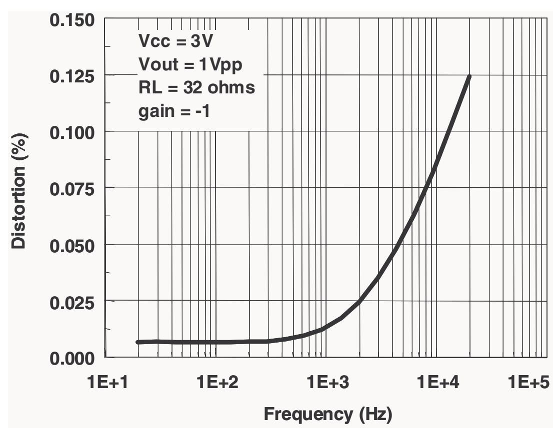


Figure 18. Distortion vs. frequency



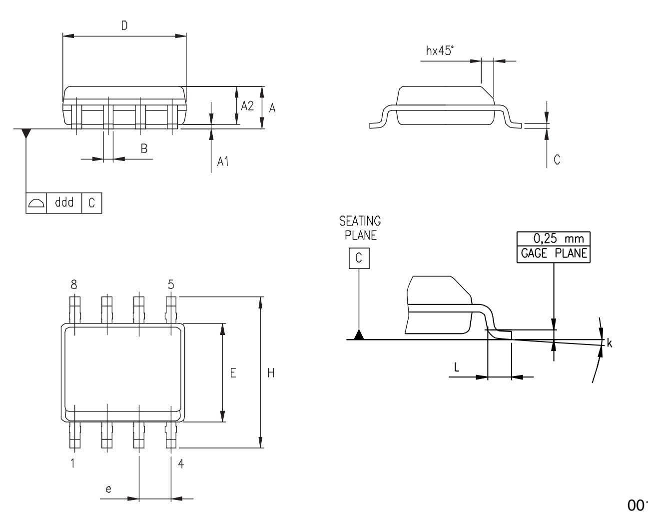
4 Package Mechanical Data

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 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

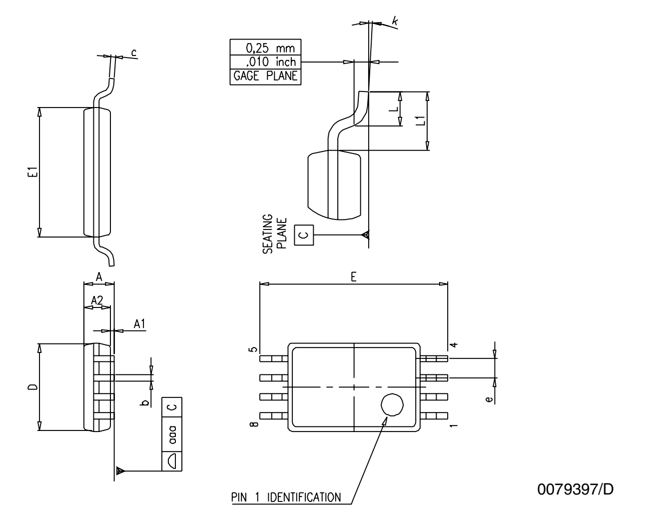


0016023/C

4.2 TSSOP8 Package

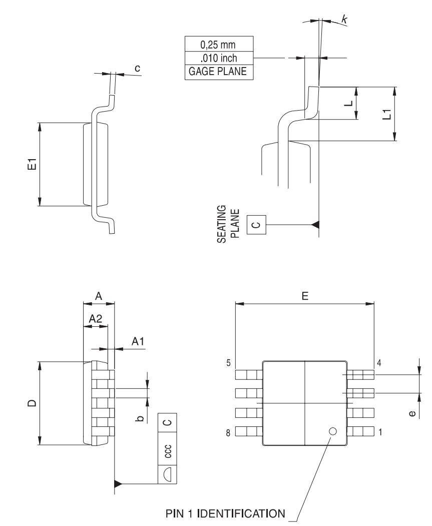
TSSOP8 MECHANICAL DATA

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	



4.3 MiniSO-8 Package

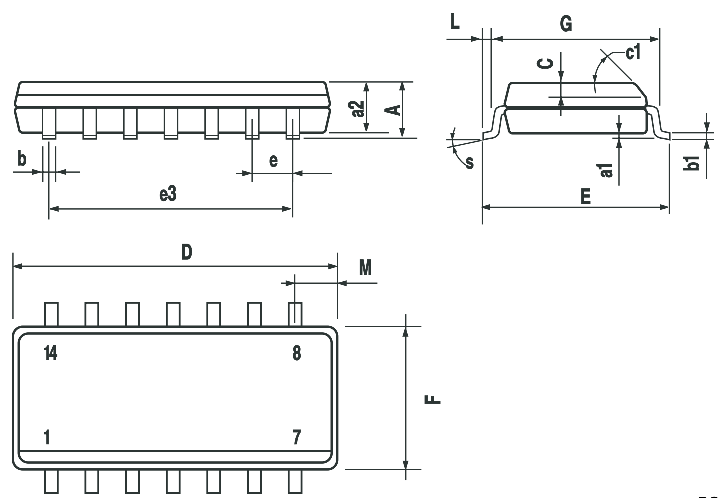
miniSO-8 MECHANICAL DATA						
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			1.1			0.043
A1	0.05	0.10	0.15	0.002	0.004	0.006
A2	0.78	0.86	0.94	0.031	0.031	0.037
b	0.25	0.33	0.40	0.010	0.13	0.013
c	0.13	0.18	0.23	0.005	0.007	0.009
D	2.90	3.00	3.10	0.114	0.118	0.122
E	4.75	4.90	5.05	0.187	0.193	0.199
E1	2.90	3.00	3.10	.0114	0.118	0.122
e		0.65			0.026	
K	0°		6°	0°		6°
L	0.40	0.55	0.70	0.016	0.022	0.028
L1			0.10			0.004



4.4 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.)					

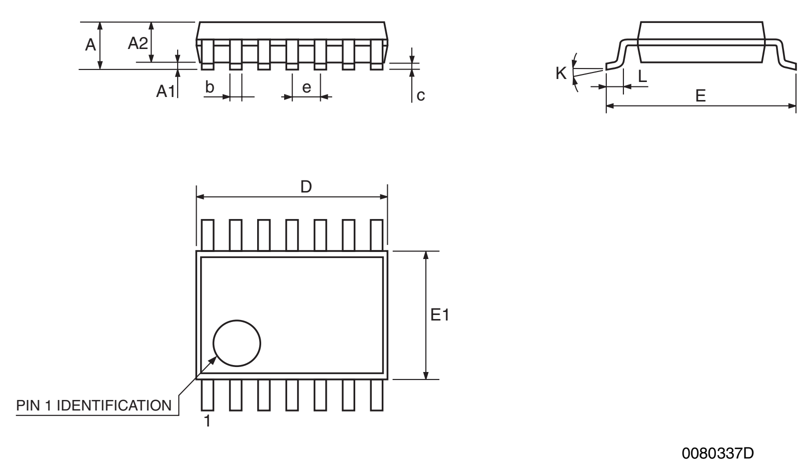


PO13G

4.5 TSSOP14 Package

TSSOP14 MECHANICAL DATA

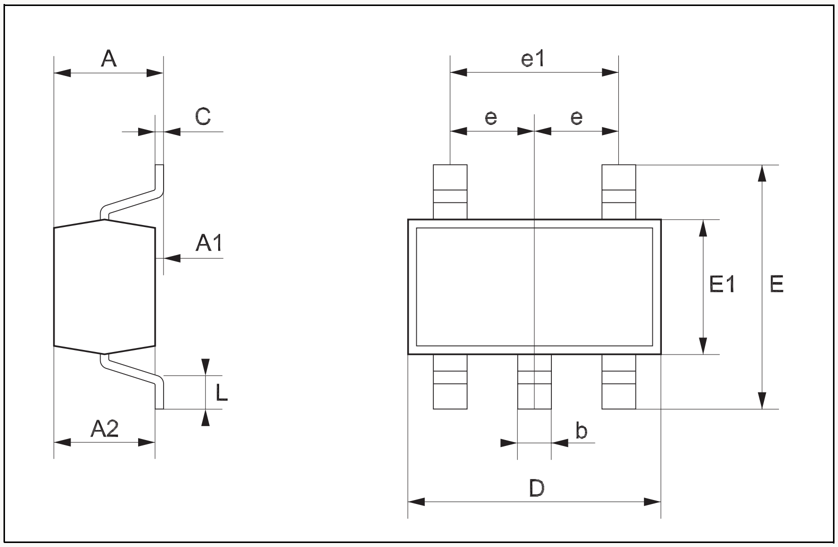
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A			1.2			0.047
A1	0.05		0.15	0.002	0.004	0.006
A2	0.8	1	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.012
c	0.09		0.20	0.004		0.0089
D	4.9	5	5.1	0.193	0.197	0.201
E	6.2	6.4	6.6	0.244	0.252	0.260
E1	4.3	4.4	4.48	0.169	0.173	0.176
e		0.65 BSC			0.0256 BSC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



4.6 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



5 Revision History

Table 5. **Document revision history**

Date	Revision	Changes
Aug. 2005	1	– First Release - Products in full production
Sept. 2005	2	– Addition of TS321A/TS324A/TS358A data in tables in *Chapter 3: Electrical Characteristics on page 4*. – Minor formatting and grammatical changes.
Dec. 2005	3	– Missing PPAP references inserted see *Table 1: Order Codes on page 2*.