TS321

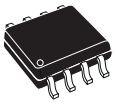
Low power single operational amplifier

Features

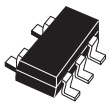
- Large output voltage swing: 0 to 3.5 V min. (V_{CC} = 5 V)
- Low supply current: 500 µA
- Low input bias current: 20 nA
- Low input offset voltage: 2 mV max.
- Wide power supply range:
  - Single supply: +3 V to +30 V
  - Dual supplies: ±1.5 V to ±15 V
- Stable with high capacitive loads

Description

The TS321 is intended for cost-sensitive applications where space saving is of great importance. This bipolar op-amp offers the benefits of a reduced component size (SOT23-5 package), with specifications that match (or are better than) industry standard devices (like the popular LM358A, LM324, etc.). The TS321 has an input common mode range (V_{icm}) that includes ground, and therefore can be employed in single supply applications.

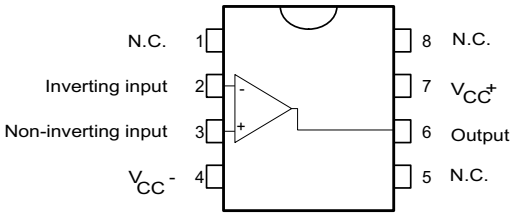


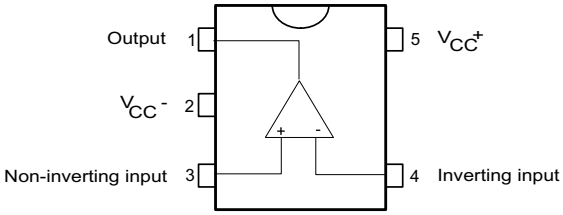
SO-8
(Plastic micropackage)



SOT23-5
(Plastic package)

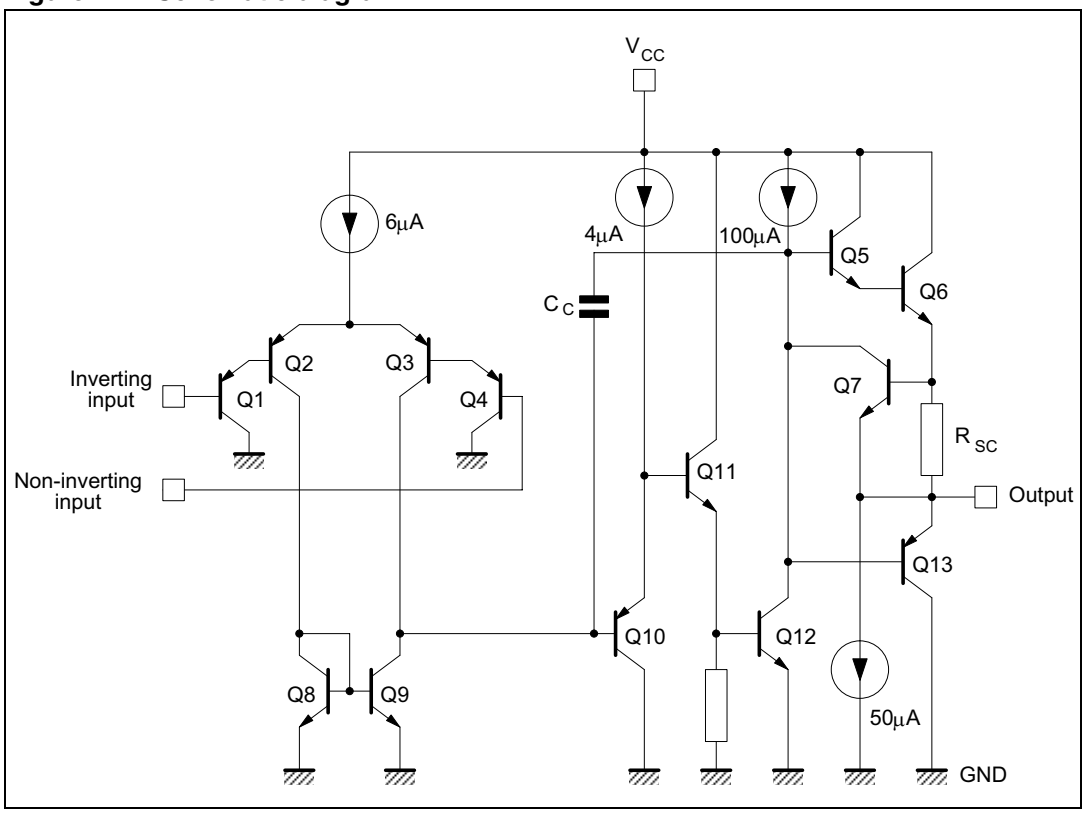
Pin connections (top view)





1 Circuit schematics

Figure 1. Schematic diagram



2 Absolute maximum ratings and operating conditions

Table 1. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}^+	Supply voltage	±16 to 32	V
V_i	Input voltage	-0.3 to +32	V
V_{id}	Differential input voltage	+32	V
	Output short-circuit duration (1)	Infinite	
I_{in}	Input current (2)	50	mA
T_{stg}	Storage temperature range	-65 to +150	°C
T_j	Maximum junction temperature	+150	°C
R_{thja}	Thermal resistance junction to ambient (3) SOT23-5 SO-8	 250 125	°C/W
R_{thjc}	Thermal resistance junction to case(3) SOT23-5 SO-8	 81 40	°C/W
ESD	HBM: human body model(4)	300	V
	MM: machine model(5)	200	
	CDM: charged device model(6) Sot23-5 SO-8	 1000 1500	

1. Short-circuits from the output to V_{CC} can cause excessive heating if V_{CC} > 15 V. The maximum output current is approximately 40 mA independent of the magnitude of V_{CC}.
2. This input current only exists when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistor becoming forward biased and thereby acting as input diodes clamps. In addition to this diode action, there is also NPN parasitic action on the IC chip. This transistor action can cause the output voltages of the Op-amps to go to the V_{CC} voltage level (or to ground for a large overdrive) for the time during which an input is driven negative. This is not destructive and normal output is restored when the input voltage goes back above -0.3V.
3. Short-circuits can cause excessive heating. Destructive dissipation can result from simultaneous short-circuits on all amplifiers. All values are typical.
4. Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 kΩ resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
5. Machine model: a 200 pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω). This is done for all couples of connected pin combinations while the other pins are floating.
6. Charged device model: all pins and the package are charged together to the specified voltage and then discharged directly to the ground through only one pin. This is done for all pins. The CDM value applies to SO-8 only.

Table 2. Operating conditions

Symbol	Parameter	Value	Unit
V_{CC}^+	Supply voltage	3 to 30	V
V_{icm}	Common mode input voltage range (V_{CC}^+= 30 V) T_{amb} = +25°C $T_{min} \leq T_{amb} \leq T_{max}$	 0 to V_{CC}^+ -1.5 0 to V_{CC}^+ -2	V
T_{oper}	Operating free-air temperature range	-40 to +125	°C

3 Electrical characteristics

Table 3. V_{CC}^+ = +5V, V_{CC}^- = Ground, V_o = 1.4V, T_{amb} = +25°C (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_{io}	Input offset voltage (1)	TS321 TS321A $T_{min} \le T_{amb} \le T_{max}$ TS321 TS321A		0.5	4 2 5 3	mV
I_{io}	Input offset current	$T_{min} \le T_{amb} \le T_{max}$		2	30 50	nA
I_{ib}	Input bias current (2)	$T_{min} \le T_{amb} \le T_{max}$		20	150 200	nA
A_{vd}	Large signal voltage gain	V_{CC}^+ = +15V, R_L = 2kΩ, V_o = 1.4V to 11.4V $T_{min} \le T_{amb} \le T_{max}$	50 25	100		V/mV
SVR	Supply voltage rejection ratio	Rs ≤ 10kΩ, V_{CC}^+ = 5 to 30V	65	110		dB
I_{CC}	Supply current, no load	V_{CC}^+ = +5V V_{CC}^+ = +30V $T_{min} \le T_{amb} \le T_{max}$ V_{CC}^+ = +5V V_{CC}^+ = +30V		500 600 600	800 900 900 1000	µA
CMR	Common mode rejection ratio	$R_s \le 10k\Omega$	65	85		dB
I_{source}	Output current source	V_{id} = +1V V_{CC}^+ = +15V, V_o = +2V	20	40		mA
I_{sink}	Output sink current	V_{id} = -1V V_{CC}^+ = +15V, V_o = +2V V_{CC}^+ = +15V, V_o = +0.2V	 10 12	 20 50		 mA µA
I_o	Short-circuit to ground	V_{CC}^+ = +15V		40	60	mA
V_{OH}	High level output voltage	V_{CC}^+ = +30V, R_L = 2kΩ $T_{min} \le T_{amb} \le T_{max}$ V_{CC}^+ = +30V, R_L = 10kΩ $T_{min} \le T_{amb} \le T_{max}$ V_{CC}^+ = +5V, R_L = 2kΩ $T_{min} \le T_{amb} \le T_{max}$	26 25.5 27 26.5 3.5 3	27 28 		V
V_{OL}	Low level output voltage	R_L = 10kΩ $T_{min} \le T_{amb} \le T_{max}$		5	15 20	mV
SR	Slew rate	V_{CC}^+ = +15V, V_i = 0.5 to 3V, R_L = 2kΩ, C_L = 100pF, unity gain		0.4		V/µs
GBP	Gain bandwidth product	V_{CC}^+ = 30V, f = 100kHz, V_{in} = 10mV, R_L = 2kΩ, C_L = 100pF		0.8		MHz
ϕm	Phase margin			60		Degrees

Table 3. V_{CC}^+ = +5V, V_{CC}^- = Ground, V_o = 1.4V, T_{amb} = +25°C (unless otherwise specified) (continued)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
THD	Total harmonic distortion	f = 1kHz, A_V = 20dB, R_L = 2kΩ, V_o = $2V_{pp}$, C_L = 100pF, V_{CC}^+ = +30V		0.015		%
en	Equivalent input noise voltage	f = 1kHz, R_s = 100Ω, V_{CC}^+ = +30V		40		$\frac{nV}{\sqrt{Hz}}$

1. V_o = 1.4 V, R_s = 0 Ω, 5 V < V_{CC}^+ < 30 V, 0 < V_{icm} < V_{CC}^+ - 1.5 V.
2. The direction of the input current is out of the IC. This current is essentially constant and independent of the state of the output, therefore there is no change in the load on the input lines.

Figure 2. Current consumption versus temperature

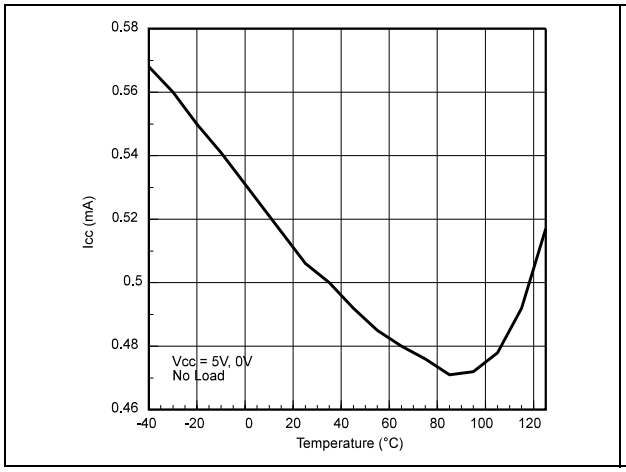


Figure 3. AC coupled inverting amplifier

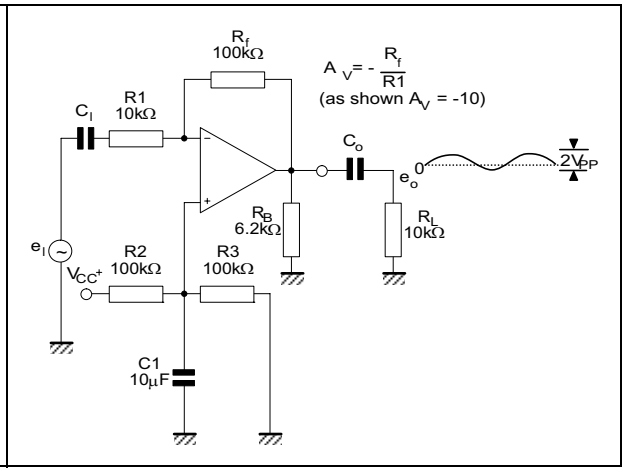


Figure 4. Non-inverting DC gain

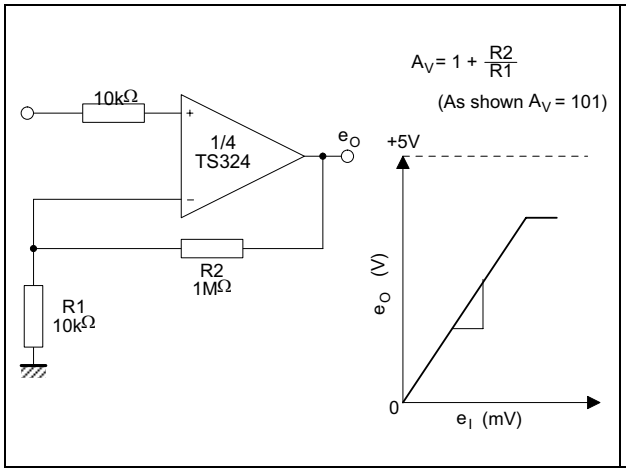


Figure 5. AC coupled non-inverting amplifier

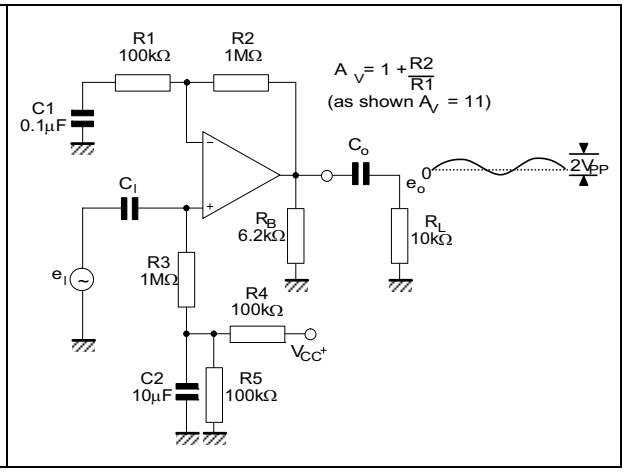
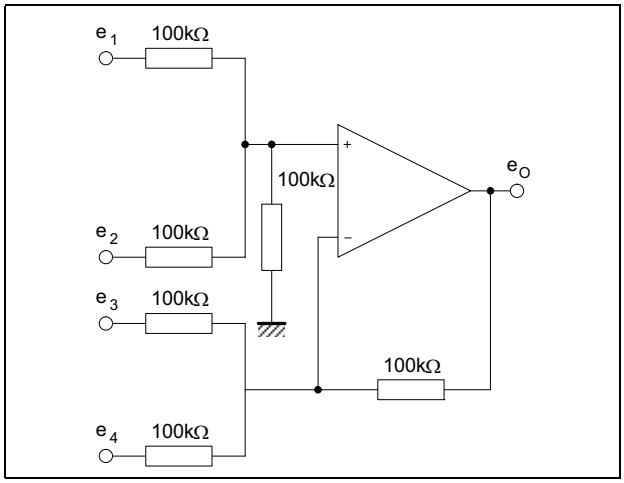


Figure 6. DC summing amplifier



4 Macromodel

4.1 Important note concerning this macromodel

Please consider the following remarks before using this macromodel.

- All models are a trade-off between accuracy and complexity (i.e. simulation time).
- Macromodels are not a substitute to breadboarding; rather, they confirm the validity of a design approach and help to select surrounding component values.
- A macromodel emulates the **nominal** performance of a **typical** device within **specified operating conditions** (temperature, supply voltage, for example). Thus the macromodel is often not as exhaustive as the datasheet, its purpose is to illustrate the main parameters of the product.

Data derived from macromodels used outside of the specified conditions (V_{CC}, temperature, for example) or even worse, outside of the device operating conditions (V_{CC}, V_{icm}, for example), is not reliable in any way.

4.2 Macromodel code

```
** Standard Linear Ics Macromodels, 1993.
** CONNECTIONS :
* 1 INVERTING INPUT
* 2 NON-INVERTING INPUT
* 3 OUTPUT
* 4 POSITIVE POWER SUPPLY
* 5 NEGATIVE POWER SUPPLY
.SUBCKT TS321 1 2 3 4 5
****************************
.MODEL MDTH D IS=1E-8 KF=3.104131E-15 CJO=10F
* INPUT STAGE
CIP 2 5 1.000000E-12
CIN 1 5 1.000000E-12
EIP 10 5 2 5 1
EIN 16 5 1 5 1
RIP 10 11 2.600000E+01
RIN 15 16 2.600000E+01
RIS 11 15 2.003862E+02
DIP 11 12 MDTH 400E-12
DIN 15 14 MDTH 400E-12
VOFP 12 13 DC 0
VOFN 13 14 DC 0
IPOL 13 5 1.000000E-05
CPS 11 15 3.783376E-09
DINN 17 13 MDTH 400E-12
VIN 17 5 0.000000e+00
DINR 15 18 MDTH 400E-12
VIP 4 18 2.000000E+00
FCP 4 5 VOFP 3.400000E+01
FCN 5 4 VOFN 3.400000E+01
FIBP 2 5 VOFN 2.000000E-03
```

```
FIBN 5 1 VOFP 2.000000E-03
* AMPLIFYING STAGE
FIP 5 19 VOFP 3.600000E+02
FIN 5 19 VOFN 3.600000E+02
RG1 19 5 3.652997E+06
RG2 19 4 3.652997E+06
CC 19 5 6.000000E-09
DOPM 19 22 MDTH 400E-12
DONM 21 19 MDTH 400E-12
HOPM 22 28 VOUT 7.500000E+03
VIPM 28 4 1.500000E+02
HONM 21 27 VOUT 7.500000E+03
VINM 5 27 1.500000E+02
EOUT 26 23 19 5 1
VOUT 23 5 0
ROUT 26 3 20
COUT 3 5 1.000000E-12
DOP 19 25 MDTH 400E-12
VOP 4 25 2.242230E+00
DON 24 19 MDTH 400E-12
VON 24 5 7.922301E-01
.ENDS
```

4.3 Macromodel electrical characteristics

Table 4. V_{CC}^+ = +3V, V_{CC}^- = 0V, R_L, C_L connected to $V_{CC}/2$, T_{amb} = 25°C (unless otherwise specified)

Symbol	Conditions	Value	Unit
V_{io}		0	mV
A_{vd}	R_L = 2 kΩ	100	V/mV
I_{CC}	No load, per operator	300	µA
V_{icm}		0 to +3.5	V
V_{OH}	R_L = 2 kΩ	3.5	V
V_{OL}	R_L = 2 kΩ	5	mV
I_{os}	V_o = 0 V	40	mA
GBP	R_L = 2 kΩ, C_L = 100 pF	0.8	MHz
SR	R_L = 2 kΩ, C_L = 100 pF	0.4	V/µs
∅m	R_L = 2 kΩ, C_L = 100 pF	60	Degrees

5 Package information

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.

5.1 SOT23-5 package information

Figure 7. SOT23-5 package mechanical drawing

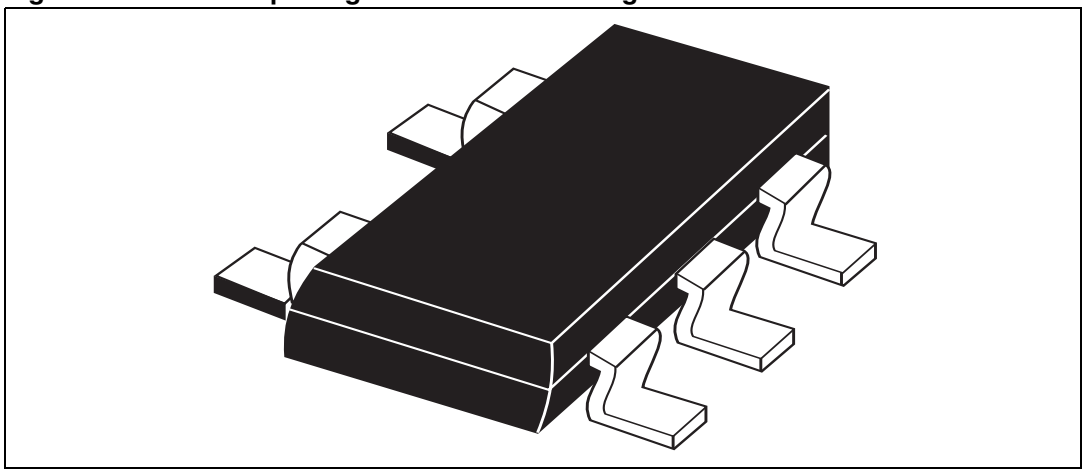


Table 5. SOT23-5 package mechanical data

Ref.	Dimensions					
	Millimeters			Mils		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.90		1.45	35.4		57.1
A1	0.00		0.15	0.00		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

5.2 SO-8 package information

Figure 8. SO-8 package mechanical drawing

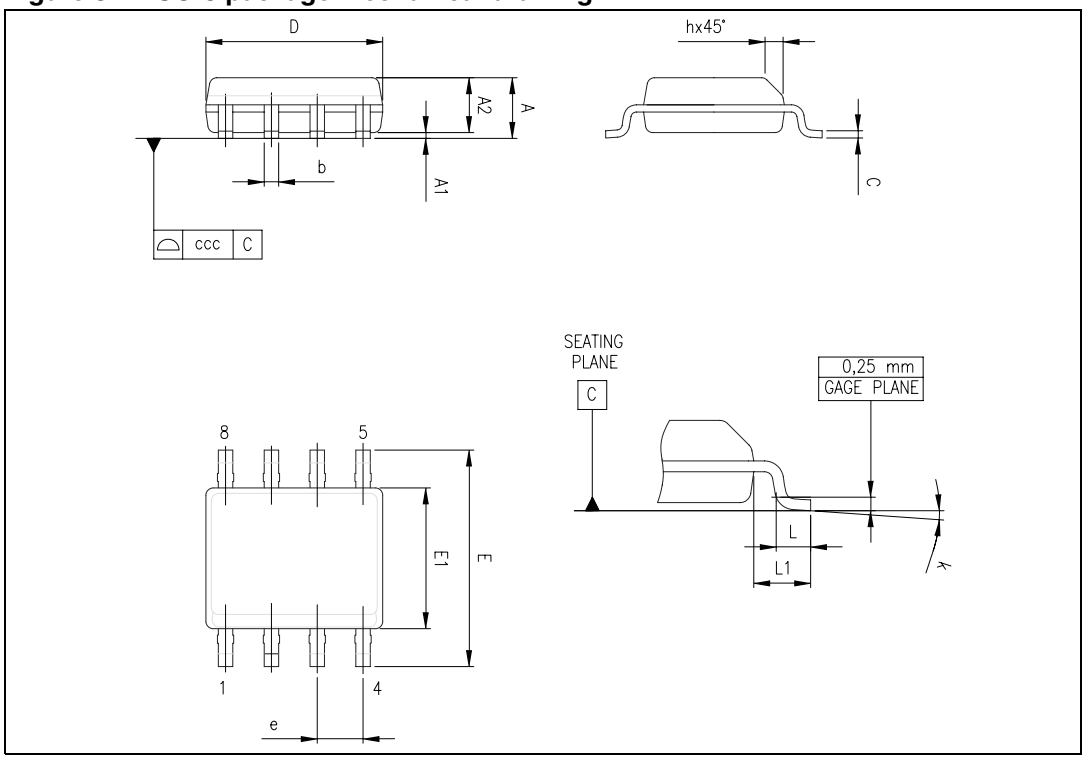


Table 6. SO-8 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
A1	0.10		0.25	0.004		0.010
A2	1.25			0.049		
b	0.28		0.48	0.011		0.019
c	0.17		0.23	0.007		0.010
D	4.80	4.90	5.00	0.189	0.193	0.197
H	5.80	6.00	6.20	0.228	0.236	0.244
E1	3.80	3.90	4.00	0.150	0.154	0.157
e		1.27			0.050	
h	0.25		0.50	0.010		0.020
L	0.40		1.27	0.016		0.050
k	1°		8°	1°		8°
ccc			0.10			0.004

6 Ordering information

Table 7. Order codes

Part number	Temperature range	Package	Packaging	Marking
TS321ILT	-40°C, +125°C	SOT23-5L	Tape & reel	K401
TS321AILT				K402
TS321ID/IDT		SO-8	Tube or tape & reel	321I
TS321AID/AIDT				321AI
TS321IYLT(1)		SOT23-5L (Automotive grade level)	Tape & reel	K406
TS321AIYLT(1)				K407

1. Qualification and characterization according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q002 or equivalent are on-going.

7 Revision history

Table 8. Document revision history

Date	Revision	Changes
30-Jun-2001	1	Initial release.
04-Jul-2005	2	PPAP references inserted in the datasheet, see order codes table. ESD protection inserted in *Table 1: Absolute maximum ratings*.
06-Sep-2005	3	Correction of errors in package names and markings in order codes table. Minor grammatical and formatting corrections.
12-Dec-2005	4	Missing PPAP references inserted, see order codes table. Thermal resistance junction to ambient and thermal resistance junction to case information added in *Table 1: Absolute maximum ratings*. Macromodel updated see *Section 4: Macromodel*.
08-Nov-2007	5	Added CDM value for SO-8 in *Table 1: Absolute maximum ratings*. Added T_j value in *Table 1: Absolute maximum ratings*. Macromodel updated see *Section 4: Macromodel*. Reformatted package information. Added footnote in *Table 7: Order codes*. Removed TS321IYD/IYDT and TS321AIYD/AIYDT order codes.
08-Jul-2008	6	Added CDM value for SOT23-5 package in *Table 1: Absolute maximum ratings*.

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