

*Low cost, low power, input/output rail-to-rail operational amplifiers*

## Description

The HT321V/358/324 family (single, dual, and quad) answers the need for low cost, general-purpose operational amplifiers. They operate with voltages as low as 2.7 V and feature both input and output rail-to-rail, 145  $\mu$ A consumption current, and 1 MHz gain bandwidth product (GBP).

With such a low consumption and a sufficient GBP for many applications, these op amps are well suited for any kind of battery supplied and portable equipment application.

The HT321V device is housed in the space-saving 5-pin SOT23-5 package, which simplifies board design. The SOT23-5 has two pinning configurations to answer all application requirements.

## Features

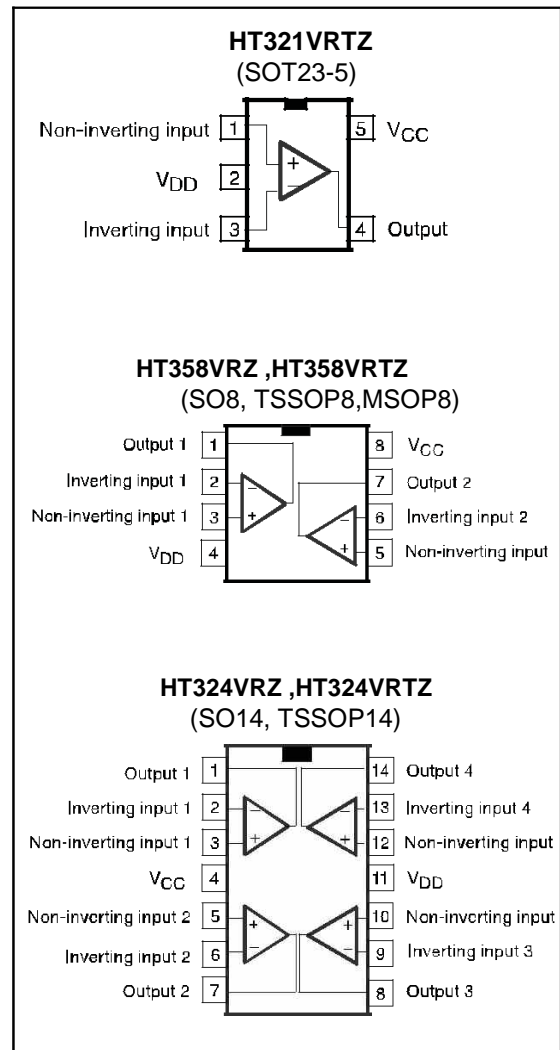
- Operating range from  $V_{CC} = 2.7$  to 6 V
- Rail-to-rail input and output
- Extended  $V_{icm}$  ( $V_{DD} - 0.2$  V to  $V_{CC} + 0.2$  V)
- Low supply current (145  $\mu$ A)
- Gain bandwidth product (1 MHz)
- ESD tolerance (2 kV)

## Related products

- See HT321V, HT358V, HT324V for newer technological version
- See TSV851, TSV852, TSV854 for enhanced performances

## Applications

- Battery powered electronic equipment
- Personal medical care (glucose meters)
- Laptops



## Absolute maximum ratings and operating conditions

**Table 1: Absolute maximum ratings**

Symbol	Parameter	Value	Unit	
V <sub>CC</sub>	Supply voltage <sup>(1)</sup>	7	V	
V <sub>id</sub>	Differential input voltage <sup>(2)</sup>	±1		
V <sub>in</sub>	Input voltage	V <sub>DD</sub> - 0.3 to V <sub>CC</sub> + 0.3		
T <sub>oper</sub>	Operating free air temperature range	-40 to 125	°C	
T <sub>stg</sub>	Storage temperature	-65 to 150		
T <sub>j</sub>	Maximum junction temperature	150		
R <sub>thja</sub>	Thermal resistance junction-to-ambient <sup>(3)</sup>	SOT23-5	250	°C/W
		SO8	125	
		TSSOP8	120	
		SO14	103	
		TSSOP14	100	
R <sub>thjc</sub>	Thermal resistance junction-to-case <sup>(3)</sup>	SOT23-5	81	
		SO8	40	
		TSSOP8	37	
		SO14	31	
		TSSOP14	32	
ESD	HBM: human body model <sup>(4)</sup>	2	kV	
	MM: machine model <sup>(5)</sup>	200	V	
	CDM: charged device model <sup>(6)</sup>	1.5	kV	
	Lead temperature (soldering, 10 s)	250	°C	
	Output short-circuit duration	See <sup>(7)</sup>		

**Notes:**

(1) All voltage values, except differential voltage are with respect to network terminal.

(2) The differential voltage is the non-inverting input terminal with respect to the inverting input terminal. If V<sub>id</sub> > ±1 V, the maximum input current must not exceed ±1 mA. In this case (V<sub>id</sub> > ±1 V), 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-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. No value specified for CDM on SOT23-5 package. The value is given for SO8 and TSSOP packages.

(7) Short-circuits from the output to V<sub>CC</sub> can cause excessive heating. The maximum output current is approximately 48 mA, independent of the magnitude of V<sub>CC</sub>. Destructive dissipation can result from simultaneous short-circuits on all amplifiers.

**Table 2: Operating conditions**

Symbol	Parameter	Value	Unit
V <sub>CC</sub>	Supply voltage	2.7 to 6	V
V <sub>icm</sub>	Common mode input voltage range <sup>(1)</sup>	V <sub>DD</sub> - 0.2 to V <sub>CC</sub> + 0.2	
V <sub>icm</sub>	Common mode input voltage range <sup>(2)</sup>	V <sub>DD</sub> to V <sub>CC</sub>	
T <sub>oper</sub>	Operating free air temperature range	-40 to 125	°C

**Notes:**

<sup>(1)</sup> At 25 °C, for  $2.7 \leq V_{CC} \leq 6$  V, V<sub>icm</sub> is extended to V<sub>DD</sub> - 0.2 V, V<sub>CC</sub> + 0.2 V.

<sup>(2)</sup> In full temperature range, both rails can be reached when V<sub>CC</sub> does not exceed 5.5 V.

## Electrical characteristics

**Table 3: Electrical characteristics at VCC = 2.7 V, VDD = 0 V, CL and RL connected to VCC/2, Tamb = 25 °C (unless otherwise specified)**

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V <sub>io</sub>	Input offset voltage	V <sub>icm</sub> = V <sub>out</sub> = V <sub>CC</sub> /2		0.1	3	mV
		T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>			6	
ΔV <sub>io</sub> /ΔT	Input offset voltage drift			2		μV/°C
I <sub>io</sub>	Input offset current	V <sub>icm</sub> = V <sub>out</sub> = V <sub>CC</sub> /2 <sup>(1)</sup>		1	9	nA
		T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>			25	
I <sub>ib</sub>	Input bias current	V <sub>icm</sub> = V <sub>out</sub> = V <sub>CC</sub> /2 <sup>(1)</sup>		10	50	nA
		T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>			85	
CMR	Common mode rejection ratio	0 ≤ V <sub>icm</sub> ≤ V <sub>CC</sub>	55	85		dB
SVR	Supply voltage rejection ratio	V <sub>icm</sub> = V <sub>CC</sub> /2	70	80		
A <sub>vd</sub>	Large signal voltage gain	V <sub>out</sub> = 0.5 V to 2.2 V, R <sub>L</sub> = 10 kΩ	80	100		
		V <sub>out</sub> = 0.5 V to 2.2 V, R <sub>L</sub> = 2 kΩ	70	88		
V <sub>OH</sub>	High level output voltage	V <sub>id</sub> = 100 mV, T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub> , R <sub>L</sub> = 10 kΩ	2.6	2.65		V
		V <sub>id</sub> = 100 mV, T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub> , R <sub>L</sub> = 2 kΩ	2.55	2.6		
V <sub>OL</sub>	Low level output voltage	V <sub>id</sub> = -100 mV, T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub> , R <sub>L</sub> = 10 kΩ		15	90	mV
		V <sub>id</sub> = -100 mV, T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub> , R <sub>L</sub> = 2 kΩ		50	100	
I <sub>o</sub>	Output current	Output source current, V <sub>id</sub> = 100 mV, V <sub>O</sub> = V <sub>DD</sub>	5	46		mA
		Output sink current, V <sub>id</sub> = -100 mV, V <sub>O</sub> = V <sub>CC</sub>	5	46		
I <sub>CC</sub>	Supply current (per amplifier)	V <sub>out</sub> = V <sub>CC</sub> /2, A <sub>VCL</sub> = 1, no load		145	200	μA
		T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>			230	
GBP	Gain bandwidth product	R <sub>L</sub> = 10 kΩ, C <sub>L</sub> = 100 pF, f = 100 kHz		1		MHz
SR	Slew rate	R <sub>L</sub> = 600 Ω, C <sub>L</sub> = 100 pF, A <sub>v</sub> = 1		0.35		V/μs
φ <sub>m</sub>	Phase margin	R <sub>L</sub> = 600 Ω, C <sub>L</sub> = 100 pF		44		Degrees
e <sub>n</sub>	Input voltage noise			40		nV/√Hz
THD	Total harmonic distortion			0.01		%

**Notes:**

(1) Maximum values include unavoidable inaccuracies of the industrial tests.

**Table 4: Electrical characteristics at VCC = 5 V, VDD = 0 V, CL and RL connected to VCC/2, Tamb = 25 °C (unless otherwise specified)**

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V <sub>io</sub>	Input offset voltage	V <sub>icm</sub> = V <sub>out</sub> = V <sub>CC</sub> /2		0.1	3	mV
		T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>			6	
ΔV <sub>io</sub> /ΔT	Input offset voltage drift			2		μV/°C
I <sub>io</sub>	Input offset current	V <sub>icm</sub> = V <sub>out</sub> = V <sub>CC</sub> /2 <sup>(1)</sup>		1	9	nA
		T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>			25	
I <sub>ib</sub>	Input bias current	V <sub>icm</sub> = V <sub>out</sub> = V <sub>CC</sub> /2 <sup>(1)</sup>		16	63	
		T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>			95	
CMR	Common mode rejection ratio	0 ≤ V <sub>icm</sub> ≤ V <sub>CC</sub>	65	95		dB
SVR	Supply voltage rejection ratio	V <sub>icm</sub> = V <sub>CC</sub> /2	70	90		
A <sub>vd</sub>	Large signal voltage gain	V <sub>out</sub> = 0.5 V to 4.5 V, R <sub>L</sub> = 10 kΩ	85	97		
		V <sub>out</sub> = 0.5 V to 4.5 V, R <sub>L</sub> = 2 kΩ	77	93		
V <sub>OH</sub>	High level output voltage	V <sub>id</sub> = 100 mV, T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub> , R <sub>L</sub> = 10 kΩ	4.85	4.95		V
		V <sub>id</sub> = 100 mV, T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub> , R <sub>L</sub> = 2 kΩ	4.8	4.91		
V <sub>OL</sub>	Low level output voltage	V <sub>id</sub> = -100 mV, T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub> , R <sub>L</sub> = 10 kΩ		40	180	mV
		V <sub>id</sub> = -100 mV, T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub> , R <sub>L</sub> = 2 kΩ		80	200	
I <sub>o</sub>	Output current	Output source current, V <sub>id</sub> = 100 mV, V <sub>o</sub> = V <sub>DD</sub>	7	48		mA
		Output sink current, V <sub>id</sub> = -100 mV, V <sub>o</sub> = V <sub>CC</sub>	7	48		
I <sub>cc</sub>	Supply current (per amplifier)	V <sub>out</sub> = V <sub>CC</sub> /2, A <sub>VCL</sub> = 1, no load		162	220	μA
		T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>			250	
GBP	Gain bandwidth product	R <sub>L</sub> = 10 kΩ, C <sub>L</sub> = 100 pF, f = 100 kHz		1.3		MHz
SR	Slew rate	R <sub>L</sub> = 600 Ω, C <sub>L</sub> = 100 pF, A <sub>v</sub> = 1		0.45		V/μs
φ <sub>m</sub>	Phase margin	R <sub>L</sub> = 600 Ω, C <sub>L</sub> = 100 pF		48		Degrees
e <sub>n</sub>	Input voltage noise			40		nV/√Hz
THD	Total harmonic distortion			0.01		%

**Notes:**

<sup>(1)</sup> Maximum values include unavoidable inaccuracies of the industrial tests.

Figure 1: Supply current/amplifier vs. supply voltage

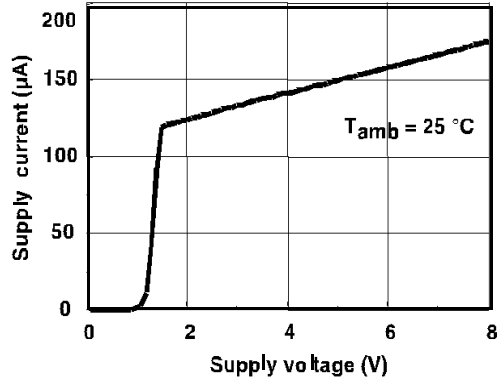
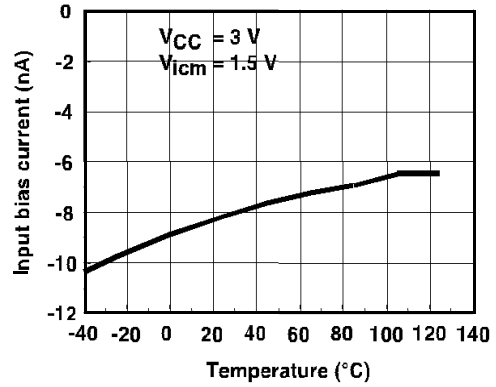
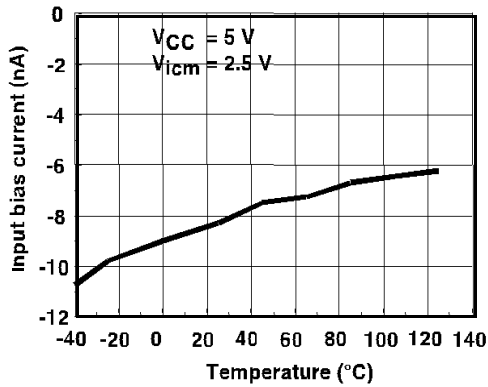
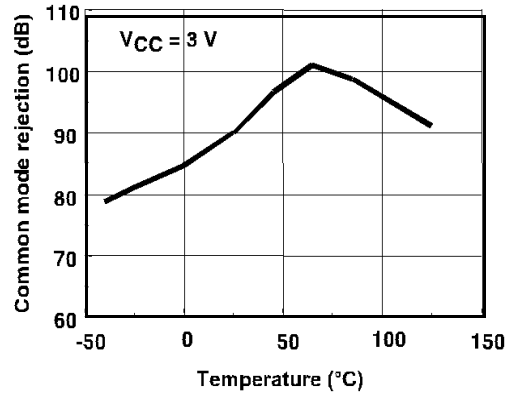
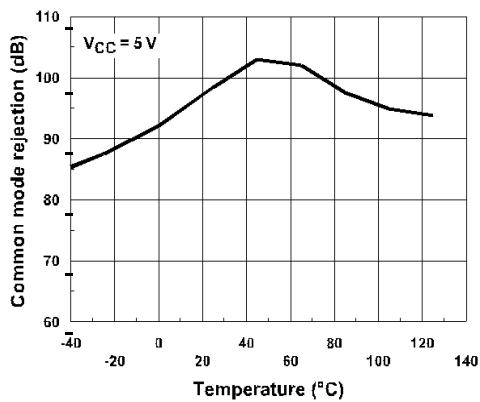
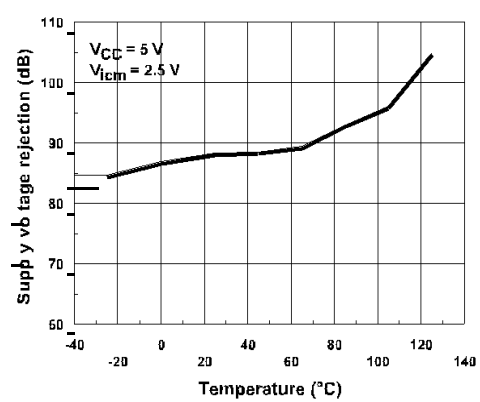

 Figure 2: Input bias current vs. temperature  
 ( $V_{CC} = 3\text{ V}$ ,  $V_{icm} = 1.5\text{ V}$ )

 Figure 3: Input bias current vs. temperature  
 ( $V_{CC} = 5\text{ V}$ ,  $V_{icm} = 2.5\text{ V}$ )

 Figure 4: Common mode rejection vs. temperature  
 ( $V_{CC} = 3\text{ V}$ )

 Figure 5: Common mode rejection vs. temperature  
 ( $V_{CC} = 5\text{ V}$ )

 Figure 6: Supply voltage rejection vs. temperature  
 ( $V_{CC} = 5\text{ V}$ ,  $V_{icm} = 2.5\text{ V}$ )


Figure 7: Open loop gain vs. temperature  
( $V_{CC} = 3\text{ V}$ ,  $R_L = 10/2\text{ k}\Omega$ )

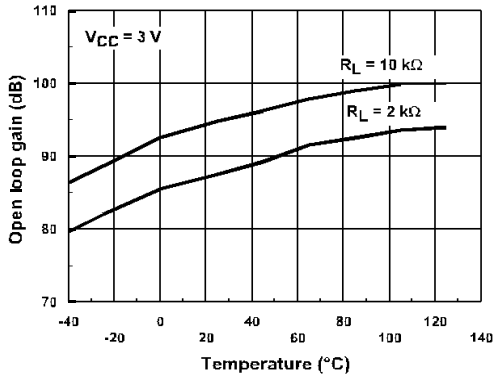


Figure 8: Open loop gain vs. temperature  
( $V_{CC} = 5\text{ V}$ ,  $R_L = 10/2\text{ k}\Omega$ )

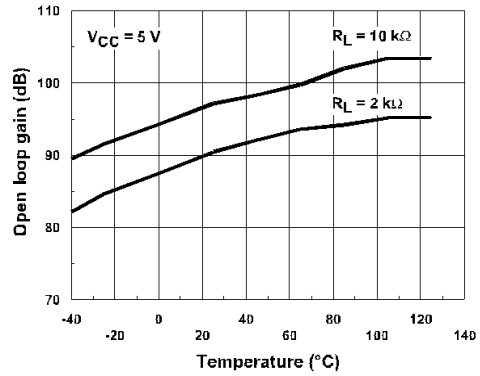


Figure 9: Supply voltage rejection vs. temperature  
( $V_{CC} = 3\text{ V}$ ,  $V_{icm} = 1.5\text{ V}$ )

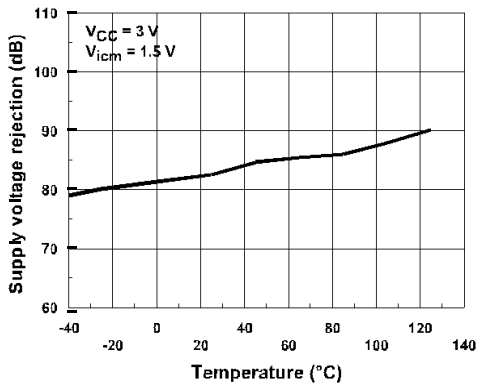


Figure 10: Output current vs. output voltage  
( $V_{CC} = 3\text{ V}$ ,  $V_{id} = 0.1\text{ V}$ ,  $V_{icm} = 1.5\text{ V}$ )

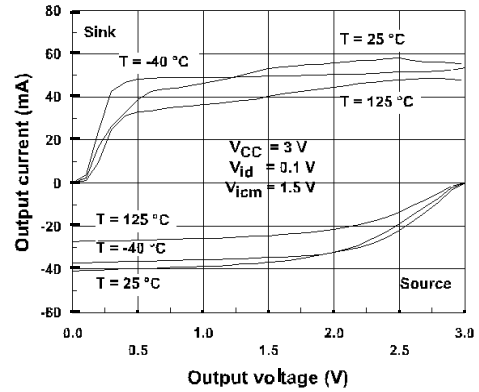


Figure 11: Output current vs. output voltage  
( $V_{CC} = 5\text{ V}$ ,  $V_{id} = 0.1\text{ V}$ ,  $V_{icm} = 2.5\text{ V}$ )

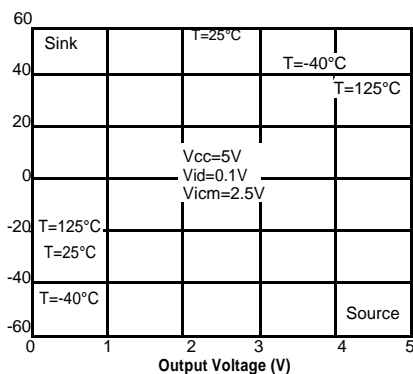
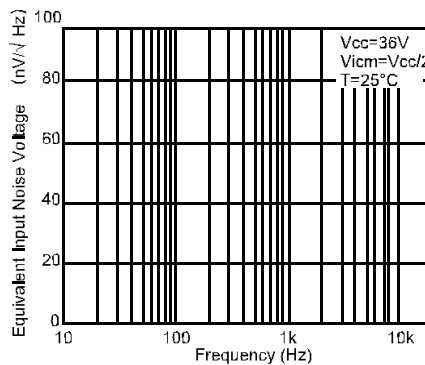


Figure 12: Noise versus frequency



## SOT23-5 package information

Figure 13: SOT23-5 package outline

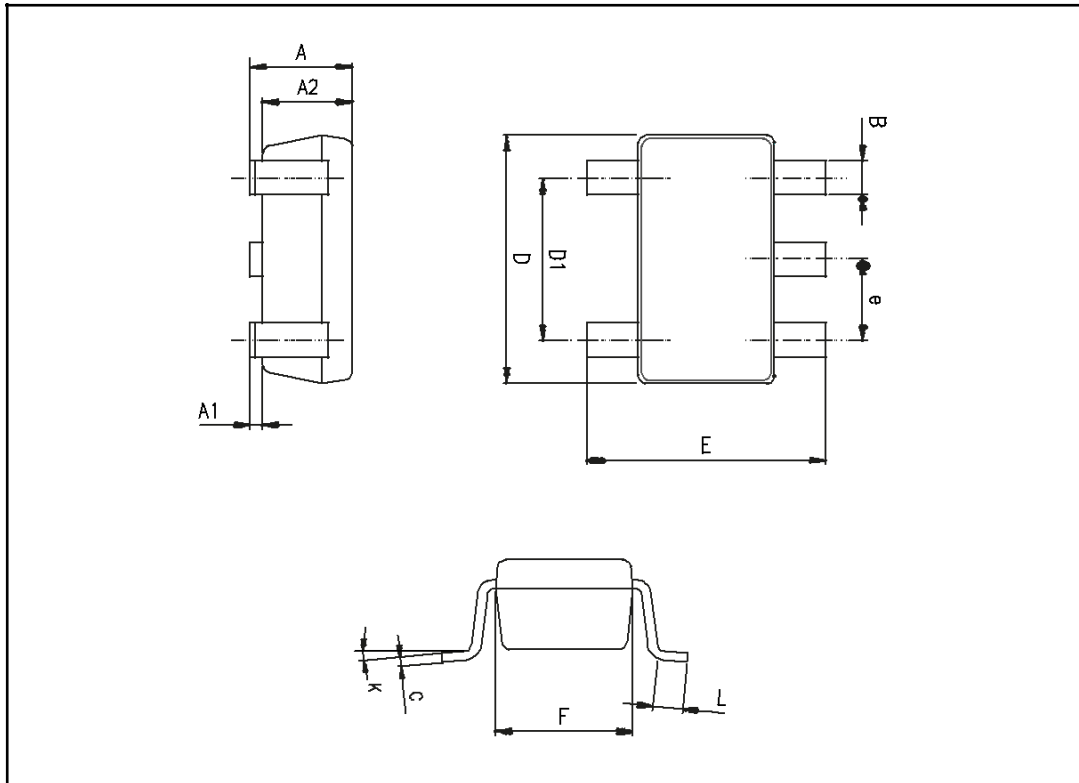


Table 5: SOT23-5 mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.90	1.20	1.45	0.035	0.047	0.057
A1			0.15			0.006
A2	0.90	1.05	1.30	0.035	0.041	0.051
B	0.35	0.40	0.50	0.014	0.016	0.020
C	0.09	0.15	0.20	0.004	0.006	0.008
D	2.80	2.90	3.00	0.110	0.114	0.118
D1		1.90			0.075	
e		0.95			0.037	
E	2.60	2.80	3.00	0.102	0.110	0.118
F	1.50	1.60	1.75	0.059	0.063	0.069
L	0.10	0.35	0.60	0.004	0.014	0.024
K	0 degrees		10 degrees	0 degrees		10 degrees



## SO8 package information

Figure 14: SO8 package outline

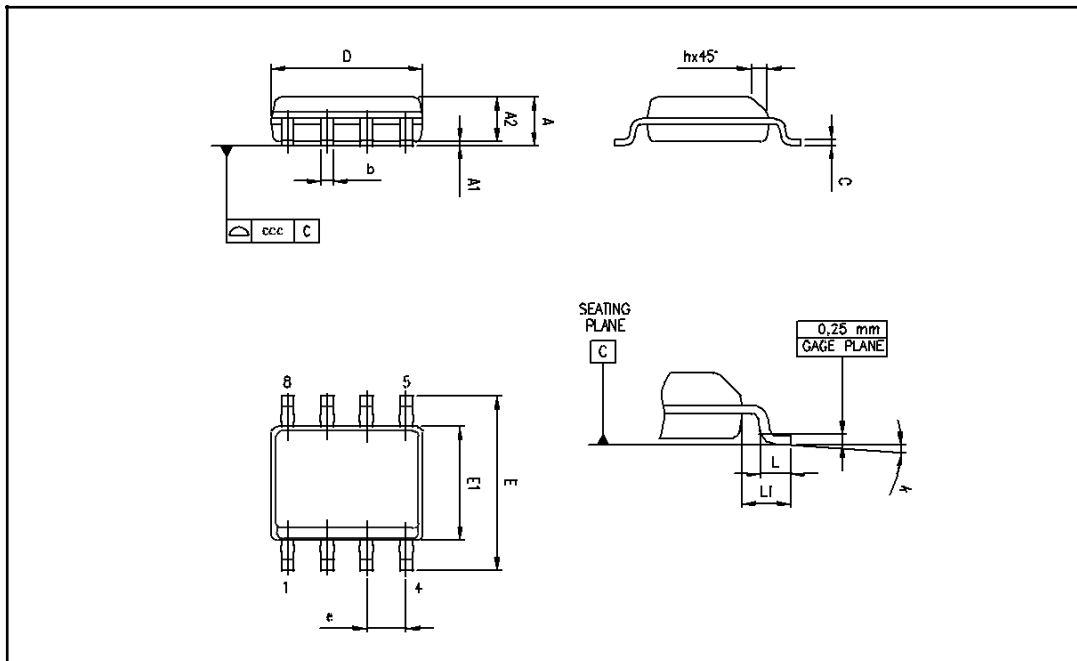


Table 6: SO8 mechanical data

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
E	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
L1		1.04			0.040	
k	1°		8°	1°		8°
ccc			0.10			0.004

## TSSOP8 package information

Figure 15: TSSOP8 package outline

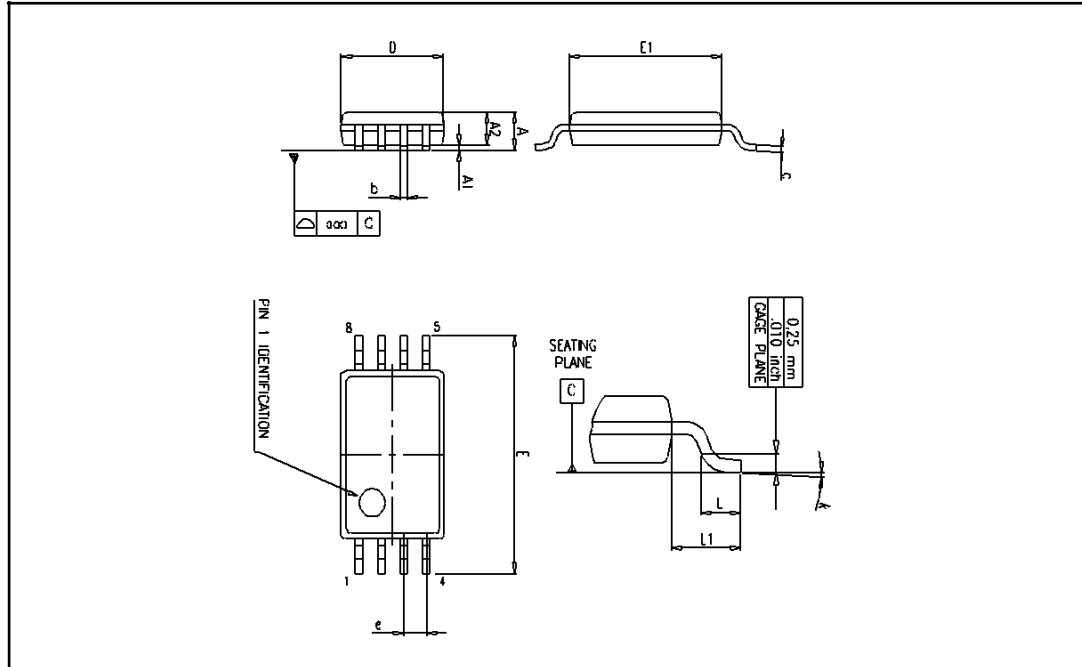
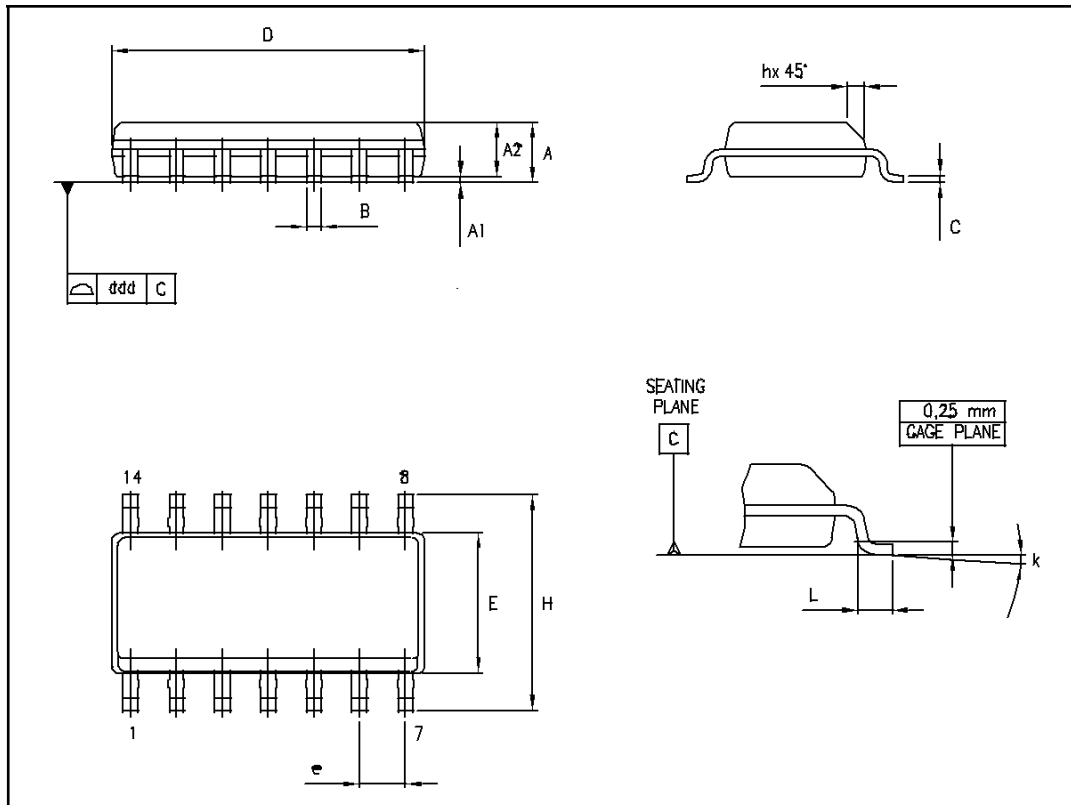


Table 7: TSSOP8 mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	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	
aaa		0.1			0.004	

**SO14 package information**
**Figure 16: SO14 package outline**

**Table 8: SO14 mechanical data**

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	1.35		1.75	0.05		0.068
A1	0.10		0.25	0.004		0.009
A2	1.10		1.65	0.04		0.06
B	0.33		0.51	0.01		0.02
C	0.19		0.25	0.007		0.009
D	8.55		8.75	0.33		0.34
E	3.80		4.0	0.15		0.15
e		1.27			0.05	
H	5.80		6.20	0.22		0.24
h	0.25		0.50	0.009		0.02
L	0.40		1.27	0.015		0.05
k	8° (max)					
ddd			0.10			0.004

## TSSOP14 package information

Figure 17: TSSOP14 package outline

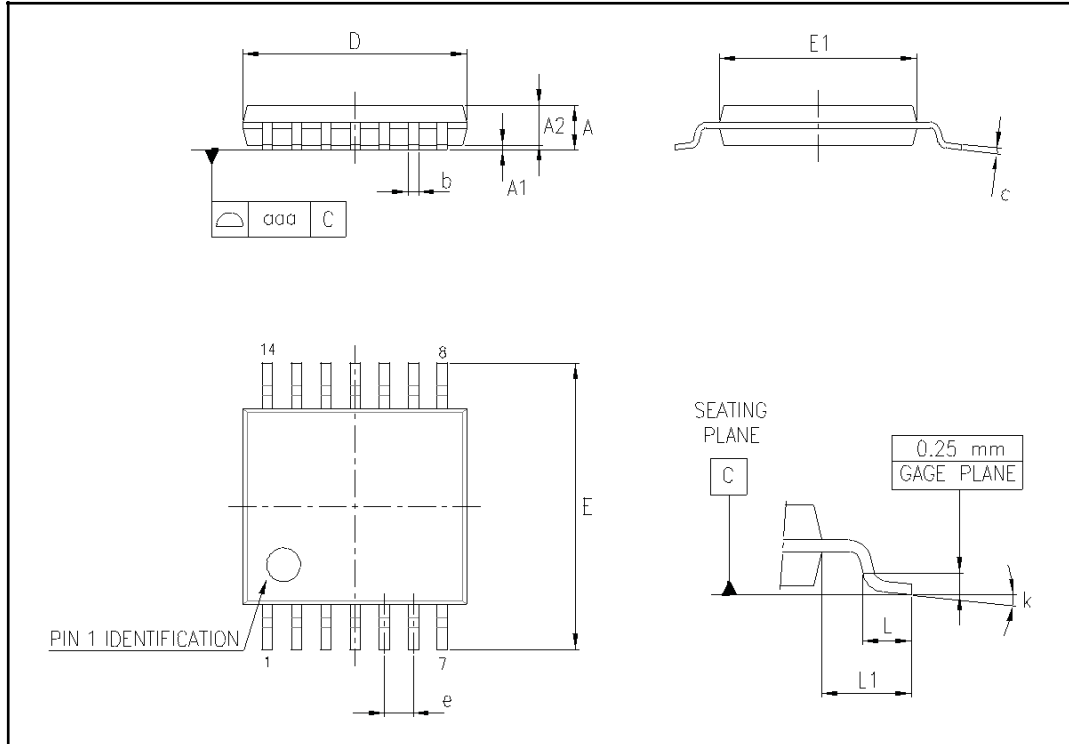


Table 9: TSSOP14 mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.047
A1	0.05		0.15	0.002	0.004	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		0.0089
D	4.90	5.00	5.10	0.193	0.197	0.201
E	6.20	6.40	6.60	0.244	0.252	0.260
E1	4.30	4.40	4.50	0.169	0.173	0.176
e		0.65			0.0256	
L	0.45	0.60	0.75	0.018	0.024	0.030
L1		1.00			0.039	
k	0°		8°	0°		8°
aaa			0.10			0.004

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