



钜地半导体
Tudi Semiconductor

Product Specification

TUDI-TS507

High precision rail-to-rail operational amplifier

网址 www.sztdbdt.com Q

用芯智造 · 卓越品质

**semiconductor device
manufacturer**

- Design
- research and development
- production
- and sales



Features

- Ultra low offset voltage: 25 μ V typ, 100 μ V max
- Rail-to-rail input/output voltage swing
- Operates from 2.7 V to 5.5 V
- High speed: 1.9 MHz
- 45° phase margin with 100 pF
- Low consumption: 0.8 mA at 2.7 V
- Very large signal voltage gain: 131 dB
- High-power supply rejection ratio: 105 dB
- Very high ESD protection 5kV (HBM)
- Latchup immunity
- Available in SOT23-5 micropackage
- Automotive qualification

Applications

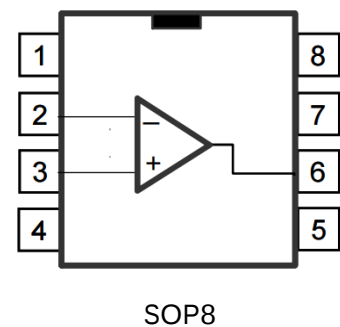
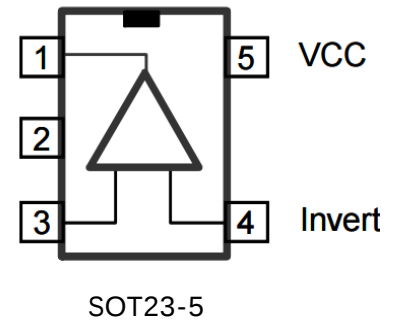
- Battery-powered applications
- Portable devices
- Signal conditioning
- Medical instrumentation

Description

The TS507 is a high performance rail-to-rail input/output amplifier with very low offset voltage. This amplifier uses a new trimming technique that yields ultra low offset voltages without any need for external zeroing.

The circuit offers very stable electrical characteristics over the entire supply voltage range, and is particularly intended for automotive and industrial applications.

The TS507 is housed in the space-saving 5-pin SOT23 package, making it well suited for battery-powered systems. This micropackage simplifies the PC board design because of its ability to be placed in small spaces (external dimensions are 2.8 mm x 2.9 mm).





1 Absolute maximum ratings and operating conditions

Table 1. Absolute maximum ratings (AMR)

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage ⁽¹⁾	6	V
V_{id}	Differential input voltage ⁽²⁾	± 2.5	
V_{in}	Input voltage ⁽³⁾	$V_{DD}-0.3$ to $V_{CC}+0.3$	
T_{stg}	Storage temperature	-65 to +150	°C
R_{thja}	Thermal resistance junction to ambient ⁽⁴⁾⁽⁵⁾		°C/W
	SOT23-5 SO-8	250 125	
R_{thjc}	Thermal resistance junction to case		°C/W
	SOT23-5 SO-8	81 40	
T_j	Maximum junction temperature	150	°C
ESD	HBM: human body model ⁽⁶⁾	5	kV
	MM: machine model ⁽⁷⁾	300	V
	CDM: charged device model ⁽⁸⁾	2	kV
	Latchup immunity	class A	

1. Value with respect to V_{DD} pin.
2. Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
3. $V_{CC}-V_{in}$ and V_{in} must not exceed 6 V.
4. Short-circuits can cause excessive heating and destructive dissipation.
5. $R_{thja/c}$ are typical values.
6. Human body model: A 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 k Ω resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
7. 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.
8. 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.

Table 2. Operating conditions

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage ⁽¹⁾	2.7 to 5.5	V
V_{icm}	Common mode input voltage range	V_{DD} to V_{CC}	
V_{id}	Differential input voltage ⁽²⁾	± 2.5	
T_{oper}	Operating free air temperature range		°C
	TS507C TS507I	0 to +85 -40 to +125	

1. Value with respect to V_{DD} pin.
2. Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.



2 Electrical characteristics

Table 3. Electrical characteristics at $V_{CC} = +5\text{ V}$, $V_{DD} = 0\text{ V}$, $V_{icm} = V_{CC}/2$, $T_{amb} = 25\text{ }^{\circ}\text{C}$, R_L connected to $V_{CC}/2$ (unless otherwise specified)⁽¹⁾

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Input offset voltage ⁽²⁾	$V_{icm} = 0$ to 3.8 V , $T=25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range		25	100 250 400	μV
		$V_{icm} = 0\text{ V}$ to 5 V , $T=25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range			450 550 750	
$\Delta V_{io}/\Delta t$	V_{io} drift vs. temperature	$T_{min} < T_{op} < T_{max}$		1		$\mu\text{V}/^{\circ}\text{C}$
I_{ib}	Input bias current	$T = 25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range		8	70 75 110	nA
I_{io}	Input offset current	$T = 25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range		2	25 35 50	
CMRR	Common mode rejection ratio $20 \log (\Delta V_{icm}/\Delta V_{io})$	V_{icm} from 0 V to 3.8 V , $T=25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range	94 94 91	115		dB
		V_{icm} from 0 V to 5 V		96		
PSRR	Power supply rejection ratio $20 \log (\Delta V_{CC}/\Delta V_{io})$	V_{CC} from 2.7 V to 5.5 V , $V_{icm}=V_{CC}/2$, $T=25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range	91 90 89	105		
A_{vd}	Large signal voltage gain	$R_L = 10\text{ k}\Omega$, $V_{out} = 0.5\text{ V}$ to 4.5 V Full temperature range	99 98	131		
$V_{CC}-V_{OH}$	High level output voltage drop	$R_L = 600\Omega$, $T=25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range		67	95 110 120	mV
		$R_L = 10\text{ k}\Omega$, $T=25\text{ }^{\circ}\text{C}$ Full temperature range		4	15 15	
V_{OL}	Low level output voltage	$R_L = 600\Omega$, $T=25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range		64	90 110 125	
		$R_L = 10\text{ k}\Omega$, $T=25\text{ }^{\circ}\text{C}$ Full temperature range		4	15 15	



Table 3. Electrical characteristics at $V_{CC} = +5\text{ V}$, $V_{DD} = 0\text{ V}$, $V_{icm} = V_{CC}/2$, $T_{amb} = 25\text{ }^{\circ}\text{C}$, R_L connected to $V_{CC}/2$ (unless otherwise specified)⁽¹⁾ (continued)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
I _{out}	I _{sink}	V _{out} = V _{CC} , V _{id} =-1 V, T=25 °C TS507C full temperature range TS507I full temperature range	74 60 53	104		mA
	I _{source}	V _{out} = V _{DD} , V _{id} =1 V, T=25 °C TS507C full temperature range TS507I full temperature range	90 77 70	128		
I _{CC}	Supply current (per operator) ⁽²⁾	No load, V _{out} =V _{CC} /2, V _{icm} =0 to 5 V, T=25 °C Full temperature range		0.85	1.15 1.25	
Dynamic performance						
GBP	Gain bandwidth product	R _L = 2 kΩ, C _L = 100 pF, f = 100 kHz		1.9		MHz
ϕ _m	Phase margin	R _L = 2 kΩ, C _L =100 pF		45		Degrees
G _m	Gain margin			10		dB
SR	Slew rate	R _L = 2 kΩ, C _L =100 pF, V _{out} = 1.25 V to 3.75 V, 10% to 90%		0.6		V/μs
e _N	Equivalent input noise voltage	f = 1 kHz		12		nV/√Hz
i _N	Equivalent input noise current	f = 10 kHz		1.2		pA/√Hz
THD+e _N	THD + noise	f=1 kHz, G=1, R _L =2 kΩ, V _{icm} =2 V, V _{out} =3.5 V _{pp}		0.0003		%

1. All parameter limits at temperatures different from $25\text{ }^{\circ}\text{C}$ are guaranteed by correlation.
2. Measurements made at 4 V_{icm} values: $V_{icm} = 0\text{ V}$, $V_{icm} = 3.8\text{ V}$, $V_{icm} = 4.2\text{ V}$, $V_{icm} = 5\text{ V}$.



Table 4. Electrical characteristics at $V_{CC} = +3.3\text{ V}$, $V_{DD} = 0\text{ V}$, $V_{icm} = V_{CC}/2$, $T_{amb} = 25\text{ }^{\circ}\text{C}$, R_L connected to $V_{CC}/2$ (unless otherwise specified)⁽¹⁾

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Input offset voltage ⁽²⁾	$V_{icm} = 0\text{ to }2.1\text{ V}$, $T=25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range		25	100 250 400	μV
		$V_{icm} = 0\text{ V to }3.3\text{ V}$, $T=25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range			450 550 750	
ΔV_{io}	V_{io} drift vs. temperature	$T_{min} < T_{op} < T_{max}$		1		$\mu\text{V}/^{\circ}\text{C}$
I_{ib}	Input bias current	$T = 25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range		6	70 75 145	nA
I_{io}	Input offset current	$T = 25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range		2	25 40 45	
CMRR	Common mode rejection ratio $20 \log (\Delta V_{icm}/\Delta V_{io})$	V_{icm} from 0 V to 2.1 V		115		dB
A_{vd}	Large signal voltage gain	$R_L = 10\text{ k}\Omega$, $V_{out} = 0.5\text{ V to }2.8\text{ V}$		127		
$V_{CC}-V_{OH}$	High level output voltage drop	$R_L = 600\text{ }\Omega$, $T=25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range		59	85 100 110	mV
		$R_L = 10\text{ k}\Omega$, $T=25\text{ }^{\circ}\text{C}$ Full temperature range		4	15 15	
V_{OL}	Low level output voltage	$R_L = 600\text{ }\Omega$, $T=25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range		57	80 100 115	
		$R_L = 10\text{ k}\Omega$, $T=25\text{ }^{\circ}\text{C}$ Full temperature range		4	15 15	
I_{out}	I_{sink}	$V_{out} = V_{CC}$, $V_{id} = -1\text{ V}$, $T=25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range	33 26 22	48		mA
	I_{source}	$V_{out} = V_{DD}$, $V_{id} = 1\text{ V}$, $T=25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range	37 32 29	56		
I_{CC}	Supply current (per operator) ⁽²⁾	No load, $V_{out}=V_{CC}/2$, $V_{icm}=0\text{ to }3.3\text{ V}$, $T=25\text{ }^{\circ}\text{C}$ Full temperature range		0.81	1.1 1.2	



Table 4. Electrical characteristics at $V_{CC} = +3.3\text{ V}$, $V_{DD} = 0\text{ V}$, $V_{icm} = V_{CC}/2$, $T_{amb} = 25\text{ }^{\circ}\text{C}$, R_L connected to $V_{CC}/2$ (unless otherwise specified)⁽¹⁾ (continued)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Dynamic performance						
GBP	Gain bandwidth product	$R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$, $f = 100\text{ kHz}$		1.9		MHz
ϕ_m	Phase margin	$R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$		45		Degrees
G_m	Gain margin			10		dB
SR	Slew rate	$R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$, $V_{out} = 0.5\text{ V to } 2.8\text{ V}$, 10 % to 90 %		0.6		V/ μ s
e_N	Equivalent input noise voltage	$f = 1\text{ kHz}$		12		nV/ $\sqrt{\text{Hz}}$
THD+ e_N	THD + noise	$f = 1\text{ KHz}$, $G = 1$, $R_L = 2\text{ k}\Omega$, $V_{icm} = 1.15\text{ V}$, $V_{out} = 1.8\text{ V}_{pp}$		0.0004		%

1. All parameter limits at temperatures different from $25\text{ }^{\circ}\text{C}$ are guaranteed by correlation.
2. Measurements done at 4 V_{icm} values: $V_{icm} = 0\text{ V}$, $V_{icm} = 2.1\text{ V}$, $V_{icm} = 2.5\text{ V}$, $V_{icm} = 3.3\text{ V}$.

Table 5. Electrical characteristics at $V_{CC} = +2.7\text{ V}$, $V_{DD} = 0\text{ V}$, $V_{icm} = V_{CC}/2$, $T_{amb} = 25\text{ }^{\circ}\text{C}$, R_L connected to $V_{CC}/2$ (unless otherwise specified)⁽¹⁾ (continued)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Dynamic performance						
GBP	Gain bandwidth product	$R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$, $f = 100\text{ kHz}$		1.9		MHz
ϕ_m	Phase margin	$R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$		45		Degrees
G_m	Gain margin			11		dB
SR	Slew rate	$R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$, $V_{out} = 0.5\text{ V to } 2.2\text{ V}$, 10 % to 90 %		0.6		V/ μ s
e_N	Equivalent input noise voltage	$f = 1\text{ kHz}$		12		nV/ $\sqrt{\text{Hz}}$
THD+ e_N	THD + noise	$f = 1\text{ KHz}$, $G = 1$, $R_L = 2\text{ k}\Omega$, $V_{icm} = 0.85\text{ V}$, $V_{out} = 1.2\text{ V}_{pp}$		0.0005		%

1. All parameter limits at temperatures different from $25\text{ }^{\circ}\text{C}$ are guaranteed by correlation.
2. Measurements done at 4 V_{icm} values: $V_{icm} = 0\text{ V}$, $V_{icm} = 1.5\text{ V}$, $V_{icm} = 1.9\text{ V}$, $V_{icm} = 2.7\text{ V}$.



Table 5. Electrical characteristics at $V_{CC} = +2.7\text{ V}$, $V_{DD} = 0\text{ V}$, $V_{icm} = V_{CC}/2$, $T_{amb} = 25\text{ }^{\circ}\text{C}$, R_L connected to $V_{CC}/2$ (unless otherwise specified)⁽¹⁾

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Input offset voltage ⁽²⁾	$V_{icm} = 0$ to 1.9 V , $T=25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range		25	100 250 400	μV
		$V_{icm} = 0\text{ V}$ to 2.7 V , $T=25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range			450 550 750	
ΔV_{io}	V_{io} drift vs. temperature	$T_{min} < T_{op} < T_{max}$		1		$\mu\text{V}/^{\circ}\text{C}$
I_{ib}	Input bias current	$T = 25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range		8	70 75 160	nA
I_{io}	Input offset current	$T = 25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range		2	25 45 45	
CMRR	Common mode rejection ratio $20 \log (\Delta V_{icm}/\Delta V_{io})$	V_{icm} from 0 V to 1.5 V		115		dB
A_{vd}	Large signal voltage gain	$R_L = 10\text{ k}\Omega$, $V_{out} = 0.5\text{ V}$ to 2.2 V		126		
$V_{CC}-V_{OH}$	High level output voltage drop	$R_L = 600\text{ }\Omega$, $T=25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range		57	85 100 105	mV
		$R_L = 10\text{ k}\Omega$, $T=25\text{ }^{\circ}\text{C}$ Full temperature range		4	15 15	
V_{OL}	Low level output voltage	$R_L = 600\text{ }\Omega$, $T=25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range		57	80 100 115	
		$R_L = 10\text{ k}\Omega$, $T=25\text{ }^{\circ}\text{C}$ Full temperature range		4	15 15	
I_{out}	I_{sink}	$V_{out} = V_{CC}$, $V_{id} = -1\text{ V}$, $T=25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range	20 15 13	30		mA
	I_{source}	$V_{out} = V_{DD}$, $V_{id} = 1\text{ V}$, $T=25\text{ }^{\circ}\text{C}$ TS507C full temperature range TS507I full temperature range	22 19 17	35		
I_{CC}	Supply current (per operator) ⁽²⁾	No load, $V_{out}=V_{CC}/2$, $V_{icm}=0$ to 2.7 V , $T=25\text{ }^{\circ}\text{C}$ Full temperature range		0.79	1.1 1.2	



3

Application note

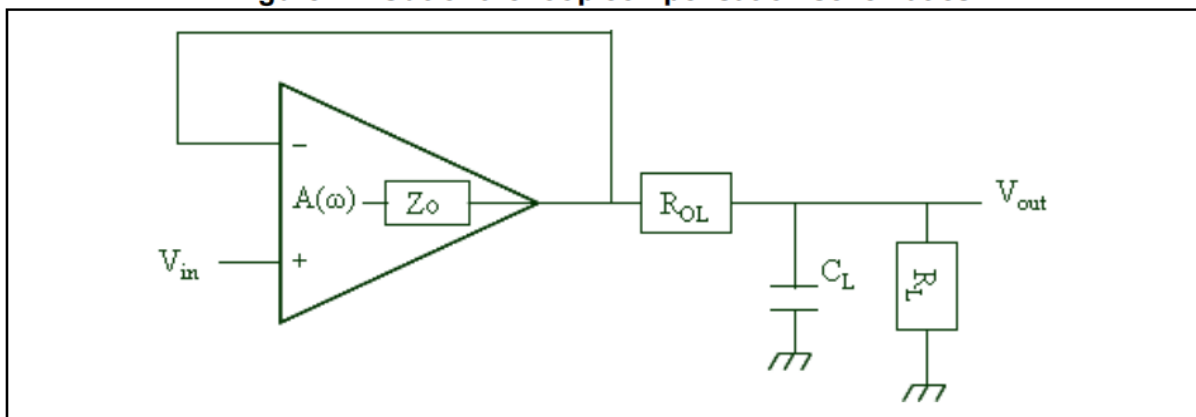
The application note AN2653, based on the TS507, describes three compensation techniques for solving stability issues when driving large capacitive loads. Two of these techniques are briefly explained below. For more details, refer to the AN2653 on: www.st.com.

3.1

Out-of-the-loop compensation technique

The first technique, named **out-of-the-loop** compensation, uses an isolation resistor, R_{OL} , added in series between the output of the amplifier and its load (see [Figure 27](#)). The resistor isolates the op-amp feedback network from the capacitive load. This compensation method is effective, but the drawback is a limitation on the accuracy of V_{out} depending on the resistive load value.

Figure 27. Out-of-the-loop compensation schematics



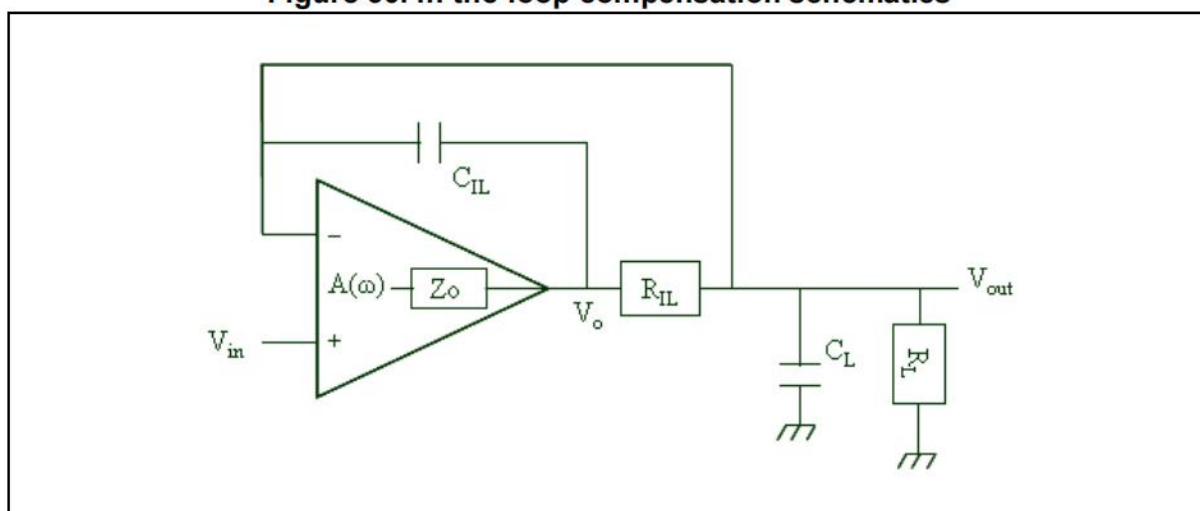
To help implement the compensation, the abacus given in [Figure 28](#) and [Figure 29](#) provides the R_{OL} value to be chosen for a given C_L and phase/gain margins. These abacus are plotted for voltage follower configuration with a load resistor of 10 k Ω at 25 °C.



3.2 In-the-loop-compensation technique

The second technique is called **in-the-loop-compensation** technique, because the additional components (a resistor and a capacitor) used to improve the stability are inserted in the feedback loop (see [Figure 30](#)).

Figure 30. In-the-loop compensation schematics



This compensation method allows (by a good choice of compensation components) the original pole caused by the capacitive load to be compensated. Stability is thus improved.

The main drawback of this circuit is the reduction of the output swing, because the isolation resistor is in the signal path.

[Table 6](#) shows the best compensation components for different ranges of load capacitors (with $R_L = 10\text{ k}\Omega$) in voltage follower configuration.

Table 6. Best compensation components for different load capacitor ranges in voltage follower configuration for TS507 (with $R_L = 10\text{ k}\Omega$)

Load capacitor range	R_{IL} (k Ω)	C_{IL} (pF)	Minimum gain margin (dB) ⁽¹⁾	Minimum phase margin (degree) ⁽¹⁾
10 pF to 100 pF	1	250	17	55
100 pF to 1 nF	1	250	16	42
1 nF to 10 nF	1	630	11	27

1. Parameter guaranteed by design at 25 °C.

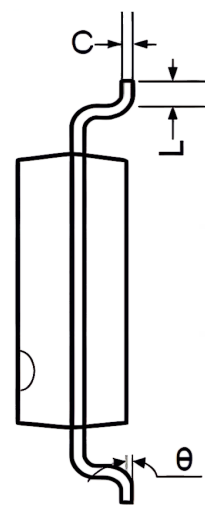
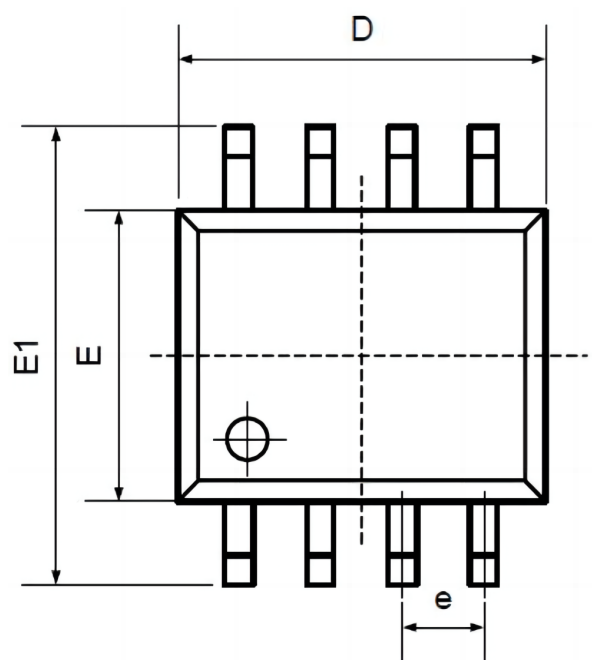


Order information

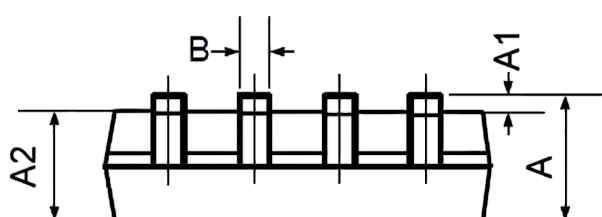
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TS507CDT-TUDI	SOP8	Tape,Reel,2500	TS507CDT
TS507CLT-TUDI	SOT23	Tape,Reel,3000	TS507CLT
TS507IDT-TUDI	SOP8	Tape,Reel,2500	TS507IDT
TS507ILT-TUDI	SOT23	Tape,Reel,3000	TS507ILT



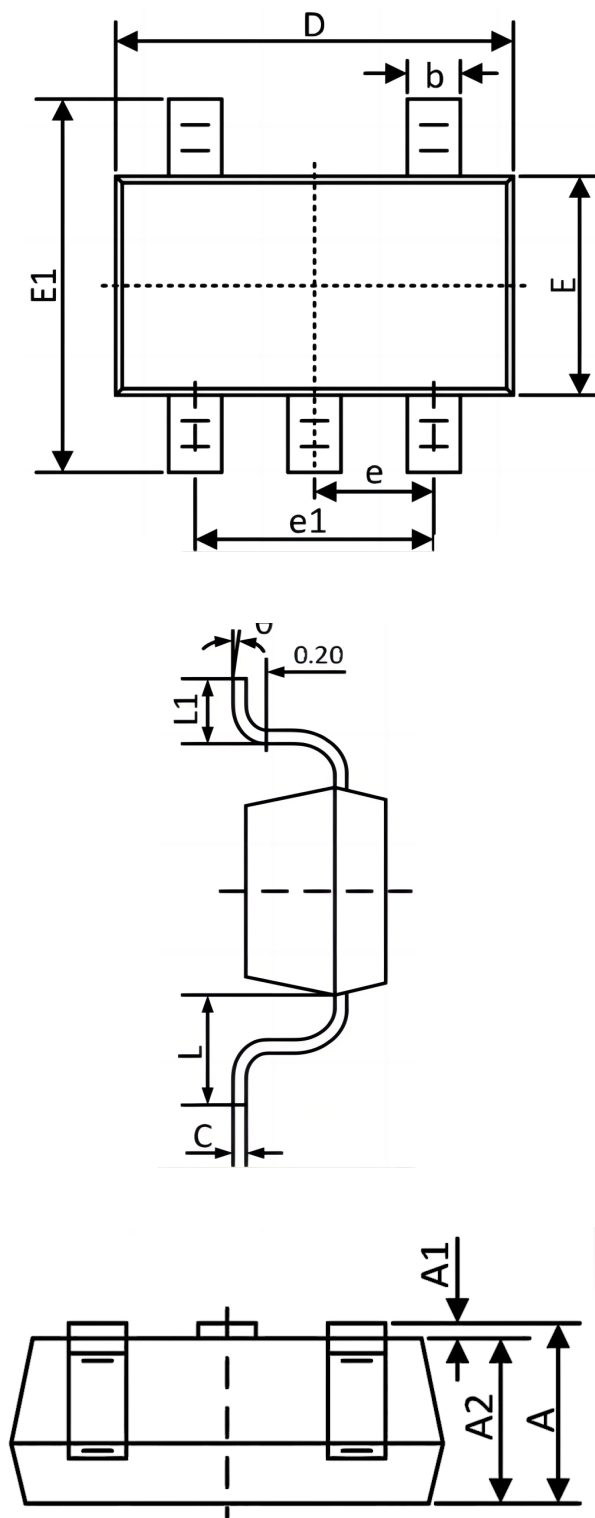
Package SOP8



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
B	0.330	0.510	0.013	0.020
C	0.190	0.250	0.007	0.010
D	4.780	5.000	0.188	0.197
E	3.800	4.000	0.150	0.157
E1	5.800	6.300	0.228	0.248
e	1.270TYP		0.050TYP	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°



Package SOT23-5



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
C	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950TYP		0.037TYP	
e1	1.800	2.000	0.071	0.079
L	0.700REF		0.028REF	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°



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