

Rail-to-rail input/output 8 MHz operational amplifiers

Features

- Rail-to-rail input and output
- Wide bandwidth
- Low power consumption: 1.1 mA max.
- Unity gain stability
- High output current: 35 mA
- Operating from 2.5 V to 5.5 V
- Low input bias current, 1 pA typ
- ESD internal protection ≥ 5 kV
- Latch-up immunity

Applications

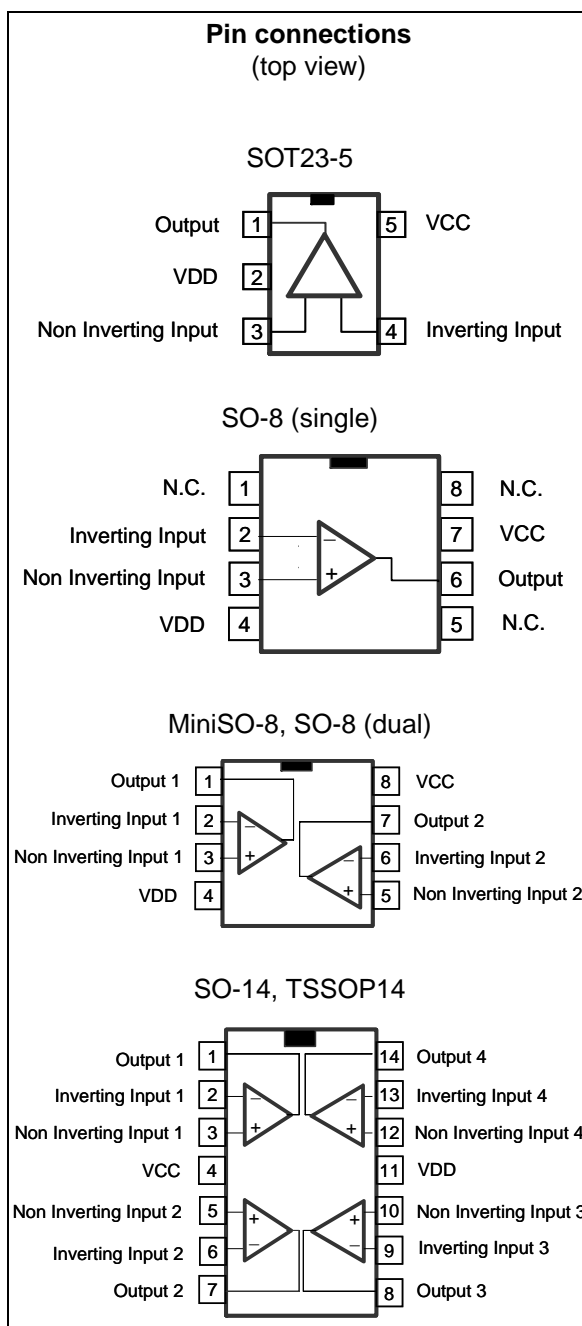
- Battery-powered applications
- Portable devices
- Signal conditioning
- Active filtering
- Medical instrumentation
- Automotive applications

Description

The TSV911/2/4 family of single, dual and quad operational amplifiers offers low voltage operation and rail-to-rail input and output.

This family features an excellent speed/power consumption ratio, offering an 8 MHz gain-bandwidth product while consuming only 1.1 mA max at 5 V supply voltage. These op-amps are unity gain stable for capacitive loads up to 200 pF. They also feature an ultra-low input bias current.

These characteristics make the TSV911/2/4 family ideal for sensor interfaces, battery-supplied and portable applications, as well as active filtering.



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⁾	$\pm V_{CC}$	V	
V_{in}	Input voltage ⁽³⁾	$V_{DD}-0.2$ to $V_{CC}+0.2$	V	
T_{stg}	Storage temperature	-65 to +150	°C	
R_{thja}	Thermal resistance junction to ambient ^{(4) (5)}			
	SOT23-5	250	°C/W	
	SO-8	125		
	MiniSO-8	190		
	SO-14	103		
TSSOP14	100			
R_{thjc}	Thermal resistance junction to case ^{(4) (5)}			
	SOT23-5	81	°C/W	
	SO-8	40		
	MiniSO-8	39		
	SO-14	31		
TSSOP14	32			
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⁾	SOT23-5, SO-8, MiniSO-8	1500	V
		TSSOP14	750	
SO-14		500		
	Latch-up immunity	200	mA	

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.
3. $V_{CC}-V_{in}$ must not exceed 6V.
4. Short-circuits can cause excessive heating and destructive dissipation.
5. R_{th} are typical values.
6. Human body model: A 100pF capacitor is charged to the specified voltage, then discharged through a 1.5k 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 200pF 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	2.5 to 5.5	V
V_{icm}	Common mode input voltage range	$V_{DD} - 0.1$ to $V_{CC} + 0.1$	V
T_{oper}	Operating free air temperature range	-40 to +125	°C

2 Electrical characteristics

Table 3. Electrical characteristics at $V_{CC} = +2.5V$ with $V_{DD} = 0V$, $V_{icm} = V_{CC}/2$, R_L connected to $V_{CC}/2$, full temperature range (unless otherwise specified)⁽¹⁾

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Offset voltage TSV91x	$T = 25^\circ C$ $T_{min} < T_{op} < T_{max}$	-	0.1	4.5	mV
	TSV91xA	$T = 25^\circ C$ $T_{min} < T_{op} < T_{max}$	-	-	7.5	
DV_{io}/DT	Input offset voltage drift		-	2	-	$\mu V/^\circ C$
I_{io}	Input offset current	$T = 25^\circ C$ $T_{min} < T_{op} < T_{max}$	-	1	$10^{(2)}$	pA
I_{ib}	Input bias current	$T = 25^\circ C$ $T_{min} < T_{op} < T_{max}$	-	-	100	pA
CMR	Common mode rejection ratio $20 \log (\Delta V_{ic}/\Delta V_{io})$	$0V$ to $2.5V$, $V_{out} = 1.25V$	58	75	-	dB
A_{vd}	Large signal voltage gain	$R_L = 10k\Omega$, $V_{out} = 0.5V$ to $2V$, $T = 25^\circ C$ $T_{min} < T_{op} < T_{max}$	80	89	-	dB
$V_{CC}-V_{OH}$	High level output voltage	$R_L = 10k\Omega$ $R_L = 600\Omega$		15	40	mV
V_{OL}	Low level output voltage	$R_L = 10k\Omega$ $R_L = 600\Omega$	-	15	40	mV
I_{out}	I_{sink}	$V_o = 2.5V$, $T = 25^\circ C$ $T_{min} < T_{amb} < T_{max}$	18	32	-	mA
	I_{source}	$V_o = 0V$, $T = 25^\circ C$ $T_{min} < T_{amb} < T_{max}$	16	-	-	
I_{CC}	Supply current (per operator)	No load, $V_{out} = V_{CC}/2$	-	0.78	1.1	mA
AC performance						
GBP	Gain bandwidth product	$R_L = 2k\Omega$, $C_L = 100pF$, $f = 100kHz$, $T = 25^\circ C$	-	8	-	MHz
F_u	Unity gain frequency	$R_L = 2k\Omega$, $C_L = 100pF$, $T = 25^\circ C$		7.2		MHz
ϕ_m	Phase margin	$R_L = 2k\Omega$, $C_L = 100pF$, $T = 25^\circ C$	-	45	-	Degrees
G_m	Gain margin	$R_L = 2k\Omega$, $C_L = 100pF$, $T = 25^\circ C$	-	8	-	dB
SR	Slew rate	$R_L = 2k\Omega$, $C_L = 100pF$, $A_v = 1$, $T = 25^\circ C$	-	4.5	-	$V/\mu s$
e_n	Equivalent input noise voltage	$f = 10kHz$, $T = 25^\circ C$	-	21	-	$\frac{nV}{\sqrt{Hz}}$
THD+ e_n	Total harmonic distortion	$G = 1$, $f = 1kHz$, $R_L = 2k\Omega$, $Bw = 22kHz$, $T = 25^\circ C$, $V_{icm} = (V_{CC} + 1)/2$, $V_{out} = 1.1V_{pp}$	-	0.001	-	%

1. All parameter limits at temperatures other than $25^\circ C$ are guaranteed by correlation.
2. Guaranteed by design.

Table 4. Electrical characteristics at $V_{CC} = +3.3V$ with $V_{DD} = 0V$, $V_{icm} = V_{CC}/2$, R_L connected to $V_{CC}/2$, full temperature range (unless otherwise specified)⁽¹⁾

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Offset voltage TSV91x	$T = 25^\circ C$ $T_{min} < T_{op} < T_{max}$	-	0.1	4.5	mV
	TSV91xA	$T = 25^\circ C$ $T_{min} < T_{op} < T_{max}$	-	-	7.5	
DV_{io}	Input offset voltage drift		-	2	-	$\mu V/^\circ C$
I_{io}	Input offset current	$T = 25^\circ C$ $T_{min} < T_{op} < T_{max}$	-	1	$10^{(2)}$ 100	pA
I_{ib}	Input bias current	$T = 25^\circ C$ $T_{min} < T_{op} < T_{max}$	-	1	$10^{(2)}$ 100	pA
CMR	Common mode rejection ratio $20 \log (\Delta V_{ic}/\Delta V_{io})$	0V to 3.3V, $V_{out} = 1.65V$	60	78	-	dB
A_{vd}	Large signal voltage gain	$R_L = 10k\Omega$, $V_{out} = 0.5V$ to $2.8V$, $T = 25^\circ C$ $T_{min} < T_{op} < T_{max}$	80 75	90	-	dB
$V_{CC} - V_{OH}$	High level output voltage	$R_L = 10k\Omega$ $R_L = 600\Omega$		15 45	40 150	mV
V_{OL}	Low level output voltage	$R_L = 10k\Omega$ $R_L = 600\Omega$	-	15 45	40 150	mV
I_{out}	I_{sink}	$V_o = 3.3V$, $T = 25^\circ C$ $T_{min} < T_{amb} < T_{max}$	18 16	32 -	- -	mA
	I_{source}	$V_o = 0V$, $T = 25^\circ C$ $T_{min} < T_{amb} < T_{max}$	18 16	35 -	- -	
I_{CC}	Supply current (per operator)	No load, $V_{out} = V_{CC}/2$	-	0.8	1.1	mA
AC performance						
GBP	Gain bandwidth product	$R_L = 2k\Omega$, $C_L = 100pF$, $f = 100kHz$, $T = 25^\circ C$	-	8	-	MHz
F_u	Unity gain frequency	$R_L = 2k\Omega$, $C_L = 100pF$, $T = 25^\circ C$	-	7.2	-	MHz
ϕ_m	Phase margin	$R_L = 2k\Omega$, $C_L = 100pF$, $T = 25^\circ C$	-	45	-	Degrees
G_m	Gain margin	$R_L = 2k\Omega$, $C_L = 100pF$, $T = 25^\circ C$	-	8	-	dB
SR	Slew rate	$R_L = 2k\Omega$, $C_L = 100pF$, $A_v = 1$, $T = 25^\circ C$	-	4.5	-	V/ μs
e_n	Equivalent input noise voltage	$f = 10kHz$, $T = 25^\circ C$	-	21	-	$\frac{nV}{\sqrt{Hz}}$
THD+ e_n	Total harmonic distortion	$G = 1$, $f = 1kHz$, $R_L = 2k\Omega$, $BW = 22kHz$, $V_{icm} = (V_{CC} + 1)/2$, $V_{out} = 1.9V_{pp}$, $T = 25^\circ C$	-	0.0007	-	%

1. All parameter limits at temperatures other than $25^\circ C$ are guaranteed by correlation.

2. Guaranteed by design.

Table 5. Electrical characteristics at $V_{CC} = +5V$ with $V_{DD} = 0V$, $V_{icm} = V_{CC}/2$, R_L connected to $V_{CC}/2$, full temperature range (unless otherwise specified)⁽¹⁾

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Offset voltage TSV91x	$T = 25^{\circ}C$ $T_{min} < T_{op} < T_{max}$	-	0.1	4.5	mV
	TSV91xA	$T = 25^{\circ}C$ $T_{min} < T_{op} < T_{max}$	-	-	7.5	
DV_{io}	Input offset voltage drift		-	2	-	$\mu V/^{\circ}C$
I_{io}	Input offset current	$T = 25^{\circ}C$ $T_{min} < T_{op} < T_{max}$	-	1	$10^{(2)}$	pA
I_{ib}	Input bias current	$T = 25^{\circ}C$ $T_{min} < T_{op} < T_{max}$	-	-	100	
CMR	Common mode rejection ratio $20 \log (\Delta V_{ic}/\Delta V_{io})$	$0V$ to $5V$, $V_{out} = 2.5V$	62	82	-	dB
SVR	Supply voltage rejection ratio $20 \log (\Delta V_{CC}/\Delta V_{io})$	$V_{CC} = 2.5$ to $5V$	70	86	-	dB
A_{vd}	Large signal voltage gain	$R_L = 10k\Omega$, $V_{out} = 0.5V$ to $4.5V$, $T = 25^{\circ}C$ $T_{min} < T_{op} < T_{max}$	80	91	-	dB
$V_{CC}-V_{OH}$	High level output voltage	$R_L = 10k\Omega$ $R_L = 600\Omega$	-	15	40	
V_{OL}	Low level output voltage	$R_L = 10k\Omega$ $R_L = 600\Omega$	-	15	40	mV
I_{out}	I_{sink}	$V_o = 5V$, $T = 25^{\circ}C$ $T_{min} < T_{amb} < T_{max}$	18	32	-	
	I_{source}	$V_o = 0V$, $T = 25^{\circ}C$ $T_{min} < T_{amb} < T_{max}$	16	-	-	
I_{CC}	Supply current (per operator)	No load, $V_{out} = 2.5V$	-	0.82	1.1	mA
AC performance						
GBP	Gain bandwidth product	$R_L = 2k\Omega$, $C_L = 100pF$, $f = 100kHz$, $T = 25^{\circ}C$	-	8	-	MHz
F_u	Unity gain frequency	$R_L = 2k\Omega$, $C_L = 100pF$, $T = 25^{\circ}C$	-	7.5	-	MHz
ϕ_m	Phase margin	$R_L = 2k\Omega$, $C_L = 100pF$, $T = 25^{\circ}C$	-	45	-	Degrees
G_m	Gain margin	$R_L = 2k\Omega$, $C_L = 100pF$, $T = 25^{\circ}C$	-	8	-	dB
SR	Slew rate	$R_L = 2k\Omega$, $C_L = 100pF$, $A_v = 1$, $T = 25^{\circ}C$	-	4.5	-	$V/\mu s$
e_n	Equivalent input noise voltage	$f = 1kHz$, $T = 25^{\circ}C$	-	27	-	$\frac{nV}{\sqrt{Hz}}$
		$f = 10kHz$, $T = 25^{\circ}C$	-	21	-	
THD+ e_n	Total harmonic distortion	$G = 1$, $f = 1kHz$, $R_L = 2k\Omega$, $Bw = 22kHz$, $T = 25^{\circ}C$, $V_{icm} = (V_{CC} + 1)/2$, $V_{out} = 3.6V_{pp}$	-	0.0004	-	%

1. All parameter limits at temperatures other than $25^{\circ}C$ are guaranteed by correlation.
2. Guaranteed by design.

Figure 1. Input offset voltage distribution at T = 25°C

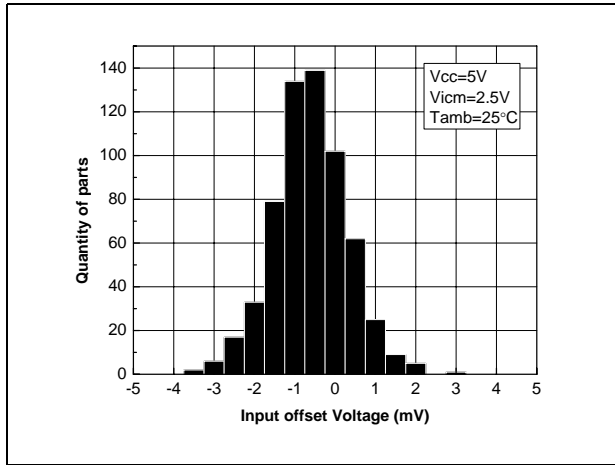


Figure 2. Input offset voltage distribution at T = 125°C

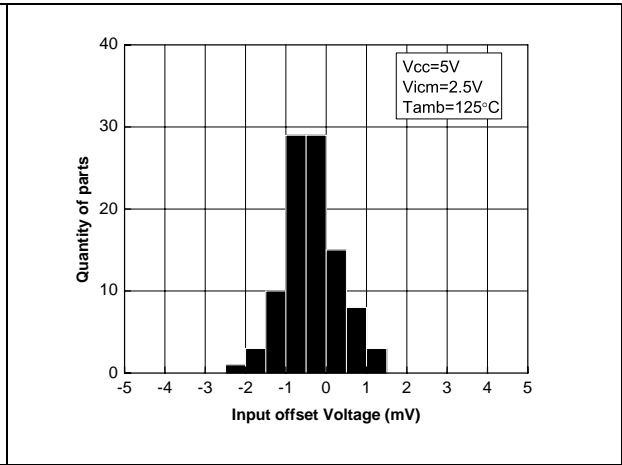


Figure 3. Supply current vs. input common mode voltage at V_{CC} = 2.5V

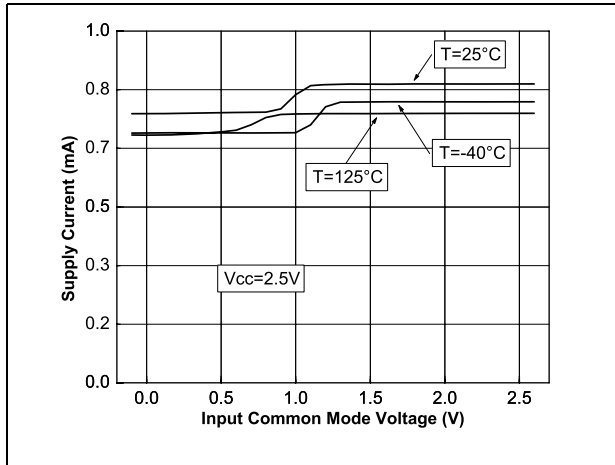


Figure 4. Supply current vs. input common mode voltage at V_{CC} = 5V

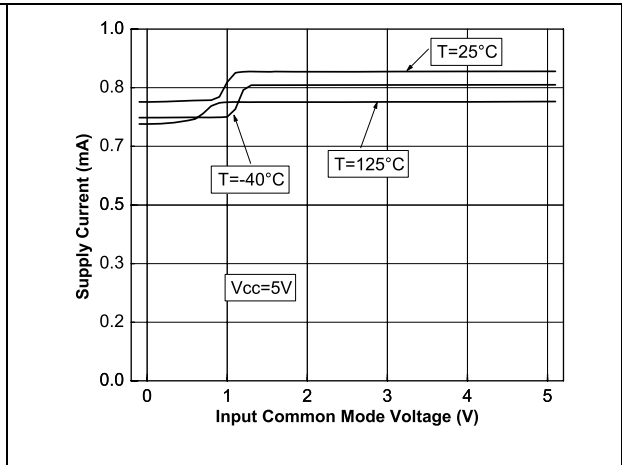


Figure 5. Output current vs. output voltage at V_{CC} = 2.5V

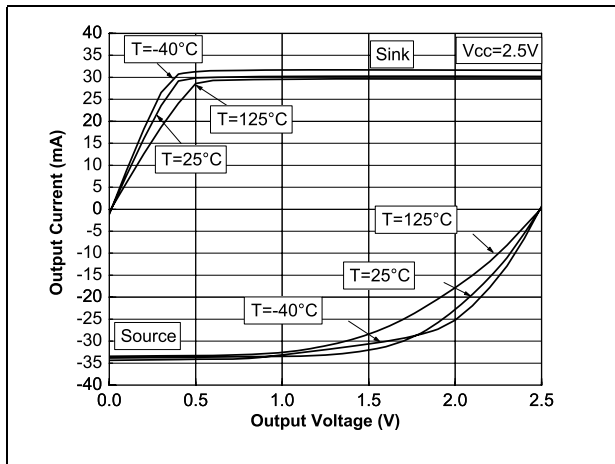


Figure 6. Output current vs. output voltage at V_{CC} = 5V

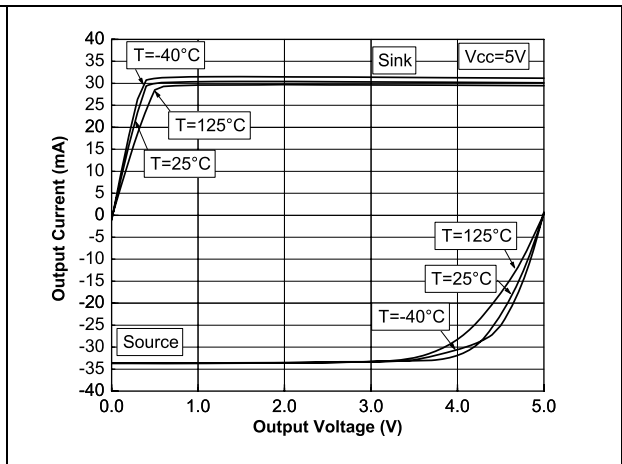


Figure 7. Voltage gain and phase vs frequency at $V_{CC}= 2.5V$ and $V_{icm}= 0.5V$

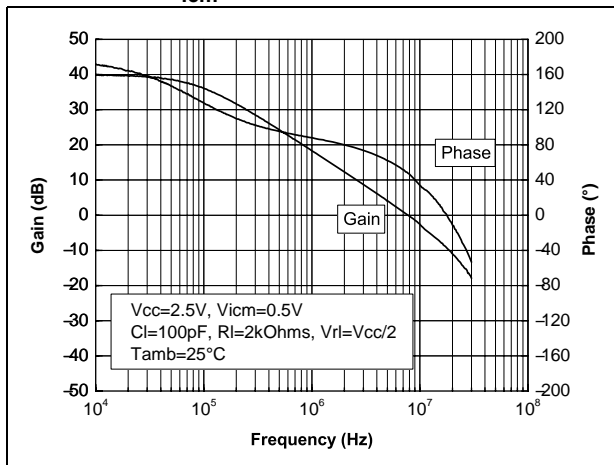


Figure 8. Voltage gain and phase vs frequency at $V_{CC}= 5.5V$ and $V_{icm}= 0.5V$

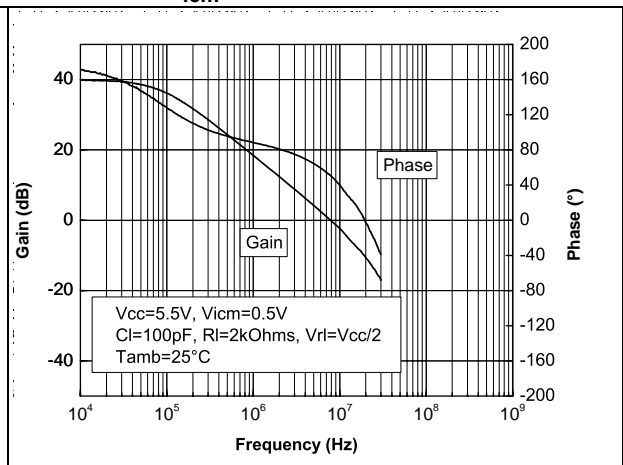


Figure 9. Phase margin vs. capacitive load

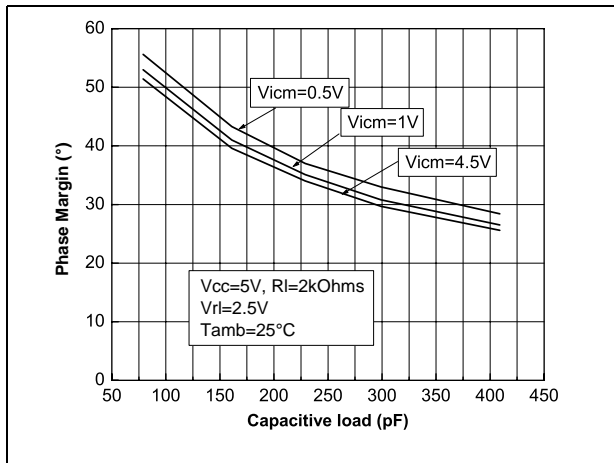


Figure 10. Phase margin vs. output current

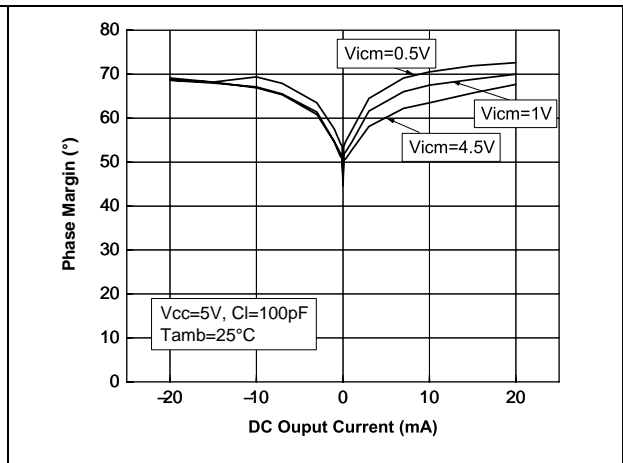


Figure 11. Positive slew rate

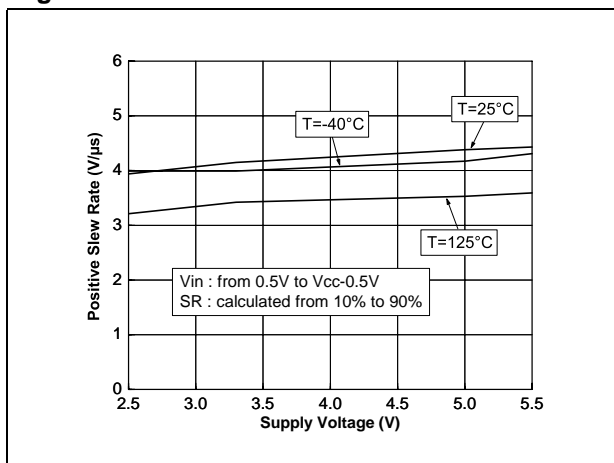


Figure 12. Negative slew rate

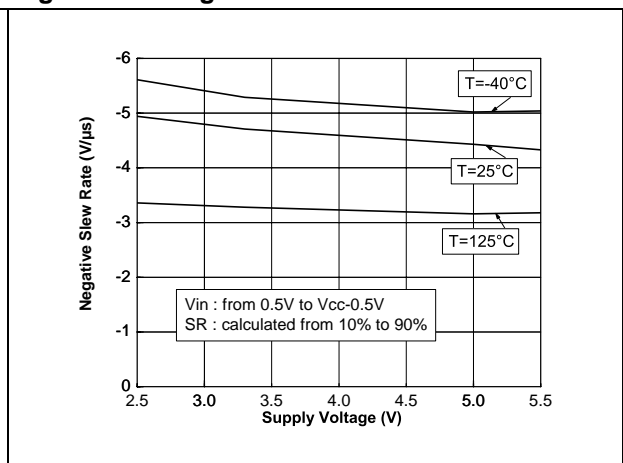


Figure 13. Distorsion + noise vs. frequency

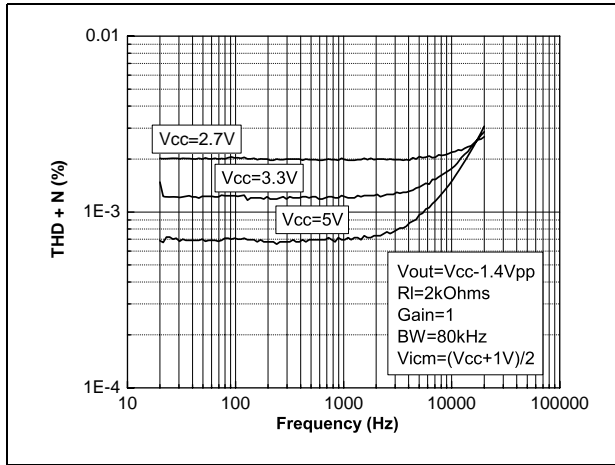


Figure 14. Distorsion + noise vs. output voltage

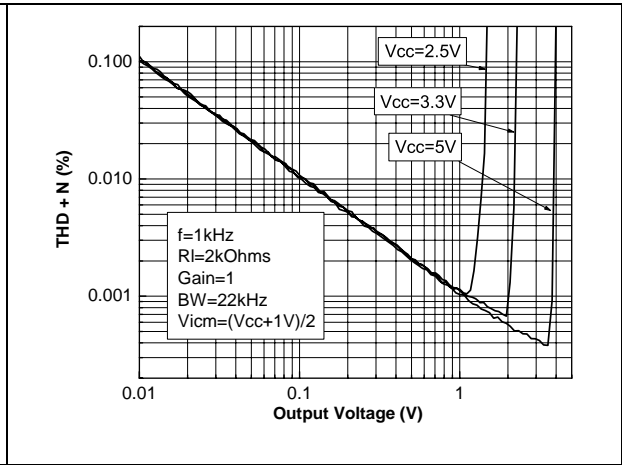


Figure 15. Noise vs. frequency

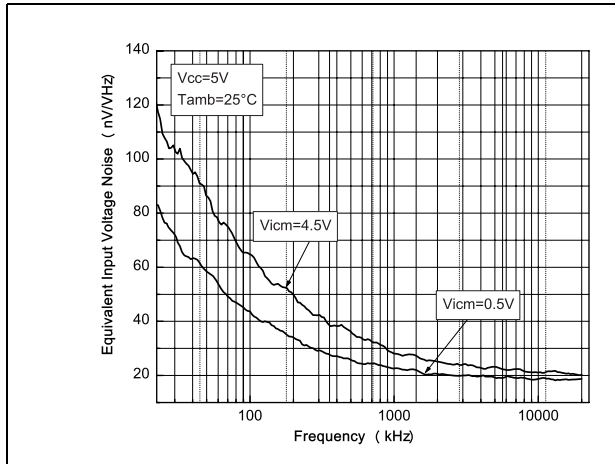
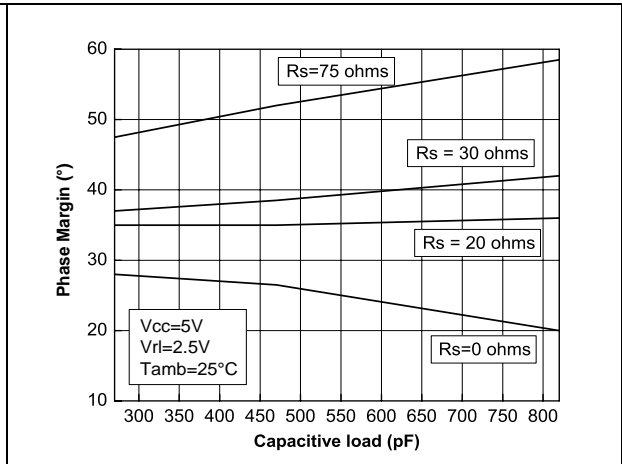


Figure 16. Phase margin vs. capacitive load and serial resistor



3 Package information

In order to meet environmental requirements, STMicroelectronics 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 STMicroelectronics trademark. ECOPACK specifications are available at: www.st.com.

Note: All packages are Moisture Sensitivity Level 1 as per Jedec J-STD-020-C, except SO-14 which is Jedec level 3.

3.1 SOT23-5 package information

Figure 17. SOT23-5 package mechanical drawing

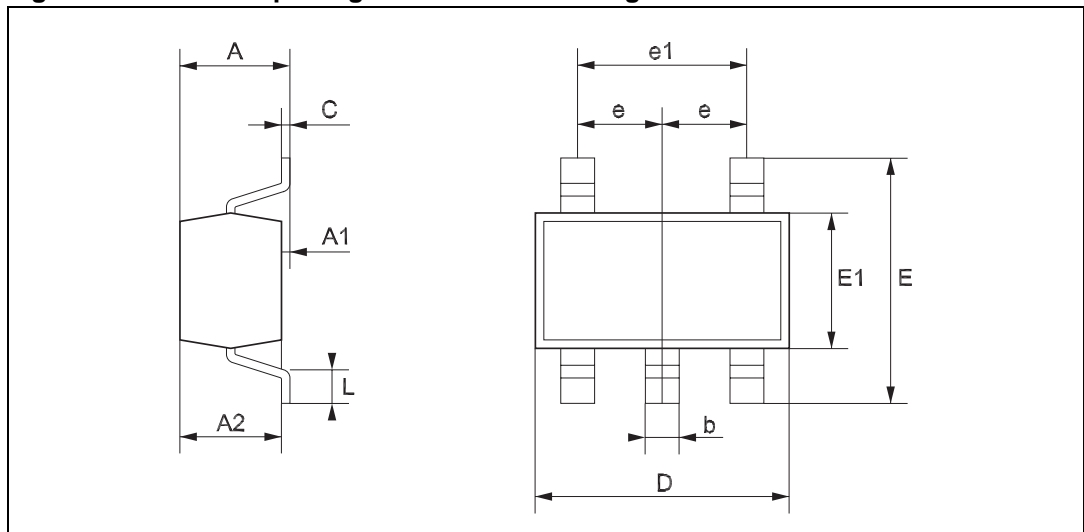


Table 6. SOT23-5 package mechanical data

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

3.2 MiniSO-8 package information

Figure 18. MiniSO-8 package mechanical drawing

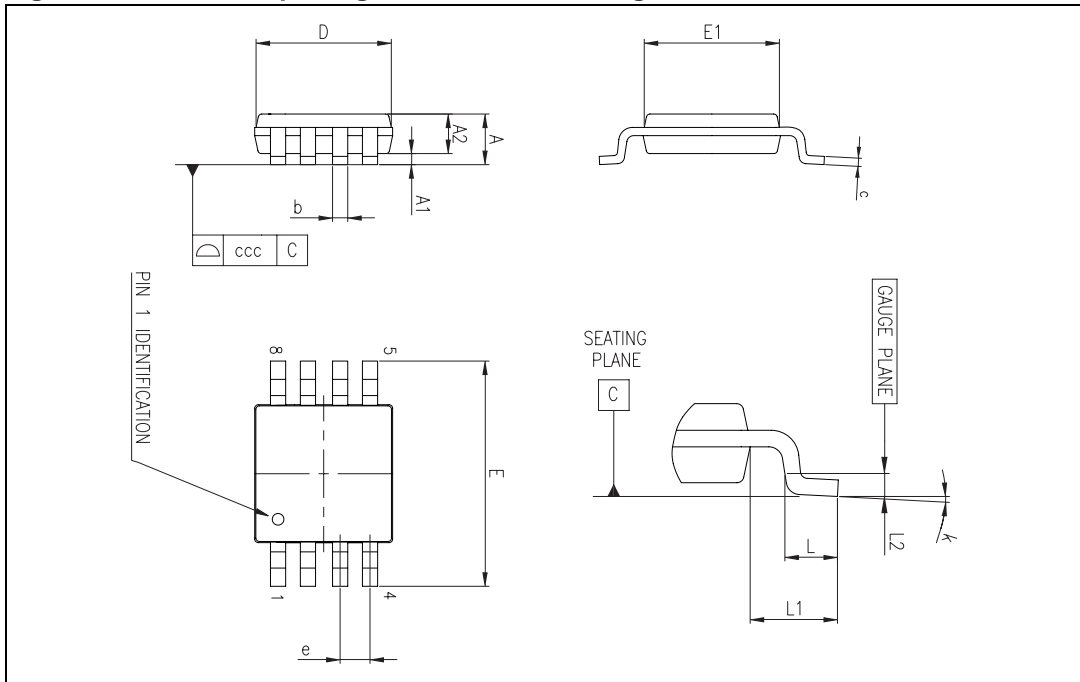


Table 7. MiniSO-8 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.1			0.043
A1	0		0.15	0		0.006
A2	0.75	0.85	0.95	0.030	0.033	0.037
b	0.22		0.40	0.009		0.016
c	0.08		0.23	0.003		0.009
D	2.80	3.00	3.20	0.11	0.118	0.126
E	4.65	4.90	5.15	0.183	0.193	0.203
E1	2.80	3.00	3.10	0.11	0.118	0.122
e		0.65			0.026	
L	0.40	0.60	0.80	0.016	0.024	0.031
L1		0.95			0.037	
L2		0.25			0.010	
k	0°		8°	0°		8°
ccc			0.10			0.004

3.3 SO-8 package information

Figure 19. SO-8 package mechanical drawing

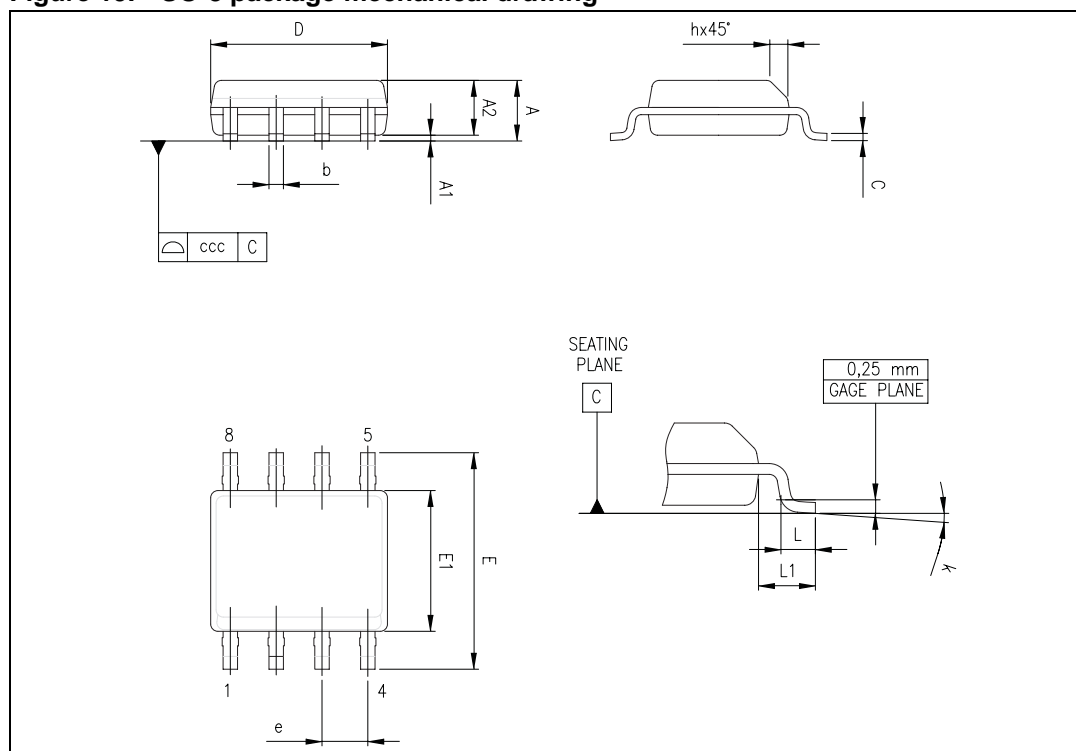


Table 8. SO-8 package mechanical data

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

3.4 TSSOP14 package information

Figure 20. TSSOP14 package mechanical drawing

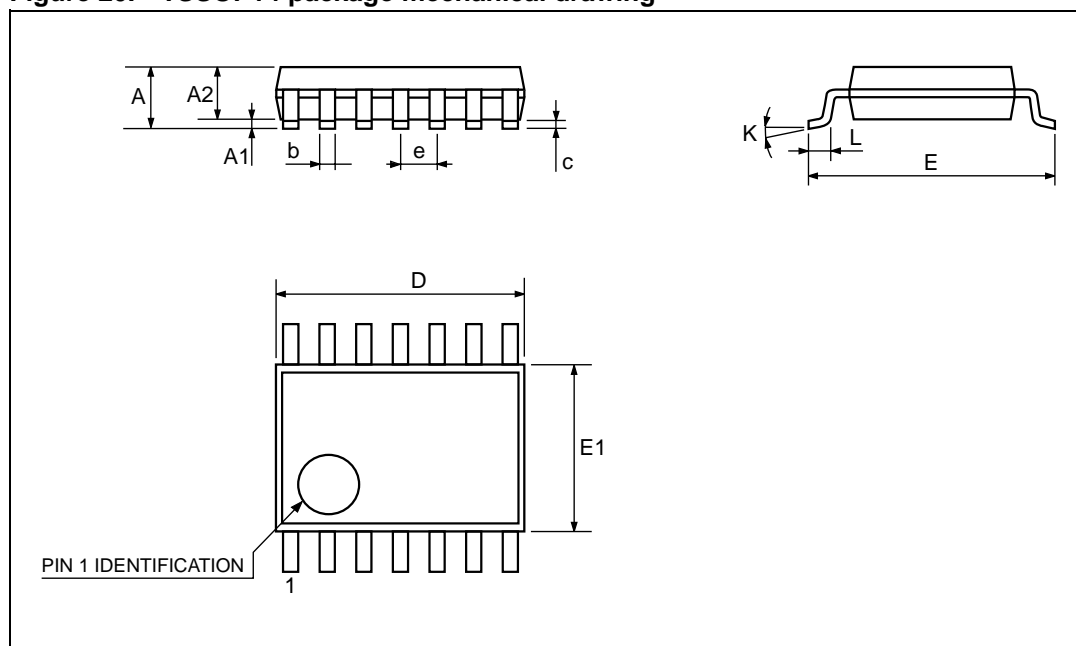


Table 9. TSSOP14 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.2			0.047
A1	0.05		0.15	0.002	0.004	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°
L1	0.45	0.60	0.75	0.018	0.024	0.030

3.5 SO-14 package information

Figure 21. SO-14 package mechanical drawing

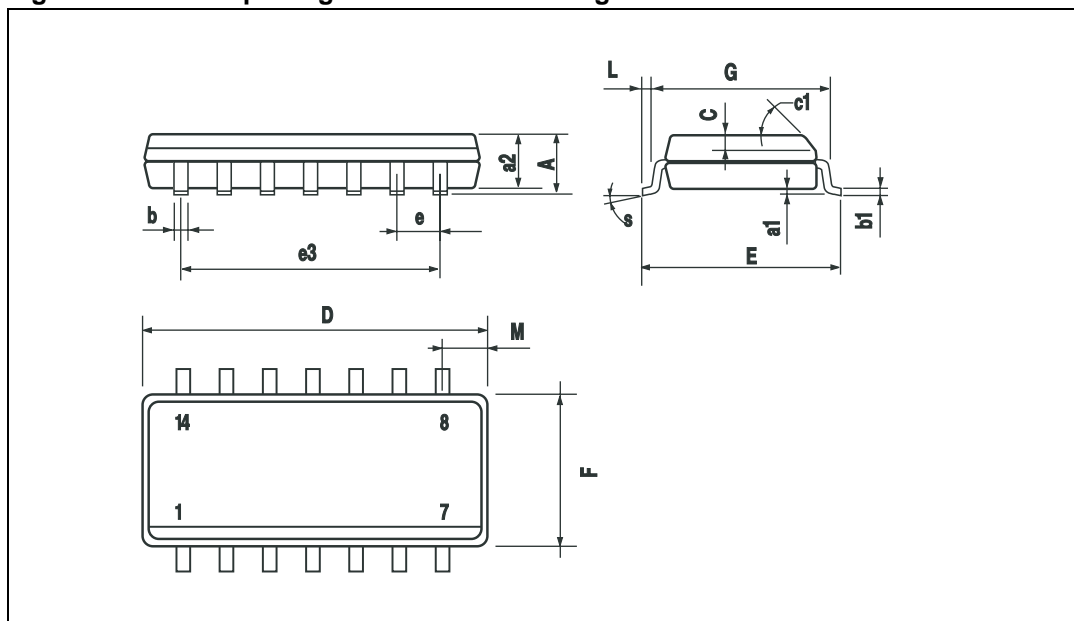


Table 10. SO-14 package mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	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.)					

4 Ordering information

Table 11. Order codes⁽¹⁾

Order code	Temperature range	Package	Packing	Marking
TSV911ID TSV911IDT	-40°C to +125°C	SO-8	Tube or Tape & reel	V911I
TSV911AID TSV911AIDT				V911AI
TSV911ILT		SOT23-5	Tape & reel	K127
TSV911AILT				K128
TSV912IST				K125
TSV912AIST		MiniSO-8		K126
TSV912ID TSV912IDT		SO-8	Tube or Tape & reel	V912I
TSV912AID TSV912AIDT				V912AI
TSV914IPT		TSSOP14	Tape & reel	V914I
TSV914AIPT				V914AI
TSV914ID TSV914IDT		SO-14 ⁽¹⁾		V914I
TSV914AID TSV914AIDT				V914AI
TSV911IYD ⁽²⁾ TSV911IYDT ⁽²⁾		SO-8 Automotive grade level	Tube or Tape & reel	V911IY
TSV911AIYD ⁽²⁾ TSV911AIYDT ⁽²⁾				V911IAY
TSV912IYD ⁽²⁾ TSV912IYDT ⁽²⁾				V912IY
TSV912AIYD ⁽²⁾ TSV912AIYDT ⁽²⁾				V912IAY
TSV914IYD ⁽²⁾ TSV914IYDT ⁽²⁾				V914IY
TSV914AIYD ⁽²⁾ TSV914AIYDT ⁽²⁾				V914IAY
TSV914ID TSV914IDT		SO-14 ⁽¹⁾		V914I
TSV914AID TSV914AIDT				V914AI
TSV911IYD ⁽²⁾ TSV911IYDT ⁽²⁾	SO-8 Automotive grade level	Tube or Tape & reel	V911IY	
TSV911AIYD ⁽²⁾ TSV911AIYDT ⁽²⁾			V911IAY	
TSV912IYD ⁽²⁾ TSV912IYDT ⁽²⁾			V912IY	
TSV912AIYD ⁽²⁾ TSV912AIYDT ⁽²⁾			V912IAY	
TSV914IYD ⁽²⁾ TSV914IYDT ⁽²⁾			V914IY	
TSV914AIYD ⁽²⁾ TSV914AIYDT ⁽²⁾			V914IAY	

1. All packages are Moisture Sensitivity Level 1 as per Jecdec J-STD-020-C, except SO-14 which is Jecdec level 3.

2. Qualification and characterization according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent are on-going.

5 Revision history

Table 12. Document revision history

Date	Revision	Changes
28-Aug-2006	1	First release.
07-Jun-2007	2	Modified ESD CDM parameter for SO-14 package in Table 1: Absolute maximum ratings (AMR) . Noise parameters updated in Section 2: Electrical characteristics . Added limits in temperature in Section 2: Electrical characteristics . Added automotive grade level description in Table 11: Order codes . Added footnote about SO-14 package in Table 11: Order codes . Added Figure 16: Phase margin vs. capacitive load and serial resistor .
11-Feb-2008	3	Updated footnotes for ESD parameters in Table 1: Absolute maximum ratings (AMR) . Corrected MiniSO-8 package information in Table 7: MiniSO-8 package mechanical data . Added missing markings for order codes TSV911AILT and TSV912AILT in Table 11: Order codes .

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