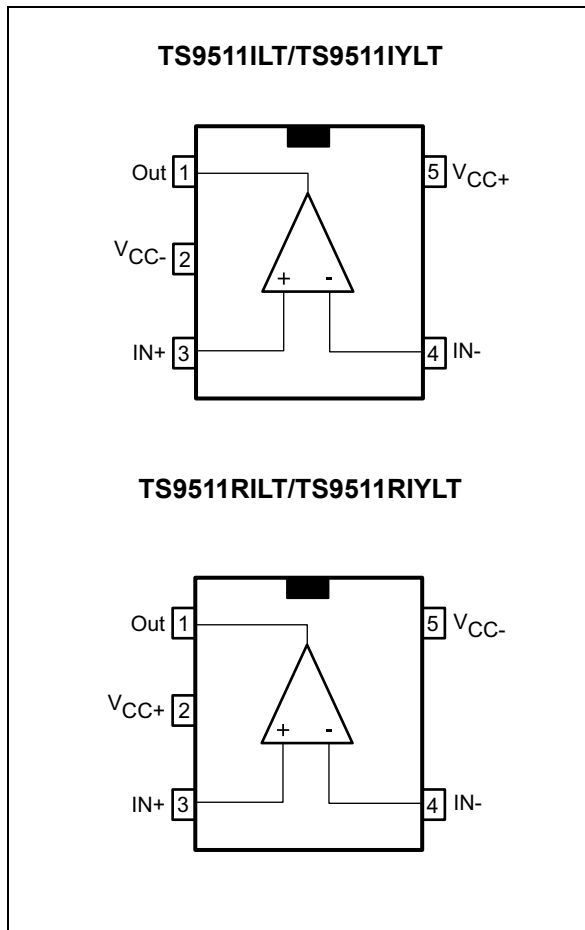


## Precision rail-to-rail input/output 3 MHz single operational amplifier

Datasheet - production data



### Applications

- Signal conditioning
- Automotive applications
- Laptop/notebook computers
- Transformer/line drivers
- Personal entertainment (CD players)
- Portable communication (cell phones, pagers)
- Digital-to-analog converter buffers
- Portable headphone speaker drivers

### Description

The TS9511 device is a single, precision rail-to-rail operational amplifier whose supply voltage range extends from 2.7 V to 12 V.

Its high-precision performance associated with an SOT23-5 package make it suitable for a wide range of demanding applications, such as industrial, automotive, consumer, and computer applications.

### Features

- Good precision: 800  $\mu\text{V}$  max.
- Rail-to-rail input and output
- Wide supply voltage range: 2.7 V to 12 V
- High-speed (3 MHz, 1 V/ $\mu\text{s}$ )
- Low consumption (900  $\mu\text{A}$  at 3 V)
- Supply voltage rejection ratio: 85 dB
- Micropackage: SOT23-5

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# 1 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{CC}$	Supply voltage <sup>(1)</sup>	14	V
$V_{id}$	Differential input voltage <sup>(2)</sup>	$\pm 1$	
$V_{in}$	Input voltage <sup>(3)</sup>	$V_{DD}-0.3$ to $V_{CC}+0.3$	
$T_{stg}$	Storage temperature range	-65 to +150	°C
$T_j$	Maximum junction temperature	150	
$R_{thja}$	Thermal resistance junction-to-ambient <sup>(4)</sup> SOT23-5	250	°C/W
$R_{thjc}$	Thermal resistance junction-to-case <sup>(4)</sup> SOT23-5	81	
ESD	HBM: human body model <sup>(5)</sup>	1	kV
	MM: machine model <sup>(6)</sup>	100	V
	CDM: charged device model <sup>(7)</sup>	1.5	kV
	Latch-up immunity	200	mA
	Lead temperature (soldering, 10 sec.)	260	°C

- All voltage values, except differential voltage, are with respect to network ground terminal.
- The differential voltage is the non-inverting input terminal with respect to the inverting input terminal. If  $V_{id} > \pm 1$  V, the maximum input current must not exceed  $\pm 1$  mA. In this case ( $V_{id} > \pm 1$  V), an input series resistor must be added to limit input current.
- Do not exceed 14 V.
- Short-circuits can cause excessive heating and destructive dissipation.  $R_{th}$  are typical values.
- Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 k $\Omega$  resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
- 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  $\Omega$ ). This is done for all couples of connected pin combinations while the other pins are floating.
- Charged device model: all pins and the package are charged together to the specified voltage and then discharged directly to ground through only one pin. This is done for all pins.

**Table 2. Operating conditions**

Symbol	Parameter	Value	Unit
$V_{CC}$	Supply voltage	2.7 to 12	V
$V_{icm}$	Common mode input voltage range	$V_{DD}-0.2$ to $V_{CC}+0.2$	
$T_{oper}$	Operating free air temperature range	-40 to +125	°C

## 2 Electrical characteristics

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

Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{io}$	Input offset voltage $T_{min} \leq T_{amb} \leq T_{max}$			800 1500	$\mu\text{V}$
$\Delta V_{io}/\Delta T$	Input offset voltage drift		2		$\mu\text{V}/\text{°C}$
$I_{io}$	Input offset current $T_{min} \leq T_{amb} \leq T_{max}$		1	30 80	nA
$I_{ib}$	Input bias current $T_{min} \leq T_{amb} \leq T_{max}$		30	70 150	
CMR	Common mode rejection ratio $T_{min} \leq T_{amb} \leq T_{max}$	60 55	90		dB
SVR	Supply voltage rejection ratio, $V_{CC} = 2.7$ to $3.3\text{ V}$ $T_{min} \leq T_{amb} \leq T_{max}$	65 60	90		
$A_{vd}$	Large signal voltage gain, $V_o = 2 V_{pk-pk}$ , $R_L = 600\ \Omega$ $T_{min} \leq T_{amb} \leq T_{max}$	70 65	80		
$V_{OH}$	High level output voltage, $R_L = 600\ \Omega$ $T_{min} \leq T_{amb} \leq T_{max}$	2.8 2.8	2.9		V
$V_{OL}$	Low level output voltage, $R_L = 600\ \Omega$ $T_{min} \leq T_{amb} \leq T_{max}$		80	250 250	mV
$I_{sc}$	Output short-circuit current	10	20		mA
$I_{CC}$	Supply current (per amplifier), no load, $V_{icm} = V_{CC}/2$ $T_{min} \leq T_{amb} \leq T_{max}$		0.8	1 1.2	
GBP	Gain bandwidth product $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$		3		MHz
SR	Slew rate $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$		1		V/ $\mu\text{s}$
$\phi_m$	Phase margin at unit gain $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$		58		Degrees
Gm	Gain margin $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$		12		dB
$e_n$	Equivalent input noise voltage $f = 1\text{ kHz}$		25		$\frac{\text{nV}}{\sqrt{\text{Hz}}}$
THD	Total harmonic distortion $V_{out} = 4 V_{pk-pk}$ , $F = 10\text{ kHz}$ , $A_V = 2$ , $R_L = 10\text{ k}\Omega$		0.01		%

**Table 4. Electrical characteristics at  $V_{CC} = +5\text{ V}$ ,  $V_{DD} = 0\text{ V}$ ,  $V_{icm} = V_{CC}/2$ ,  $R_L$  connected to  $V_{CC}/2$ ,  $T_{amb} = 25\text{ °C}$  (unless otherwise specified)**

Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{io}$	Input offset voltage $T_{min} \leq T_{amb} \leq T_{max}$			800 1500	$\mu\text{V}$
$\Delta V_{io}/\Delta T$	Input offset voltage drift		2		$\mu\text{V}/\text{°C}$
$I_{io}$	Input offset current $V_{icm} = V_{CC}/2$ $T_{min} \leq T_{amb} \leq T_{max}$		1	30 80	nA
$I_{ib}$	Input bias current $T_{min} \leq T_{amb} \leq T_{max}$		30	70 150	
CMR	Common mode rejection ratio $T_{min} \leq T_{amb} \leq T_{max}$	60 55	90		dB
SVR	Supply voltage rejection ratio, $V_{CC} = 4$ to $5\text{ V}$ $T_{min} \leq T_{amb} \leq T_{max}$	65 60	90		
$A_{vd}$	Large signal voltage gain, $V_o = 2 V_{pk-pk}$ , $R_L = 600\ \Omega$ $T_{min} \leq T_{amb} \leq T_{max}$	75 70	86		
$V_{OH}$	High level output voltage, $R_L = 600\ \Omega$ $T_{min} \leq T_{amb} \leq T_{max}$	4.7 4.7	4.8		V
$V_{OL}$	Low level output voltage, $R_L = 600\ \Omega$ $T_{min} \leq T_{amb} \leq T_{max}$		80	300 300	mV
$I_{sc}$	Output short-circuit current	10	20		mA
$I_{CC}$	Supply current (per amplifier), no load, $V_{icm} = V_{CC}/2$ $T_{min} \leq T_{amb} \leq T_{max}$		0.95	1.2 1.3	
GBP	Gain bandwidth product $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$		3		MHz
SR	Slew rate $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$		1		V/ $\mu\text{s}$
$\phi_m$	Phase margin at unit gain $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$		61		Degrees
Gm	Gain margin $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$		13		dB
$e_n$	Equivalent input noise voltage $f = 1\text{ kHz}$		25		$\frac{\text{nV}}{\sqrt{\text{Hz}}}$
THD	Total harmonic distortion $V_{out} = 4 V_{pk-pk}$ , $F = 10\text{ kHz}$ , $A_V = 2$ , $R_L = 10\text{ k}\Omega$		0.01		%

Figure 1. Supply current vs. supply voltage

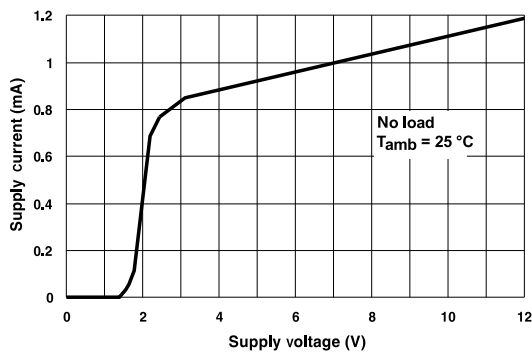


Figure 2. Supply current vs. temperature

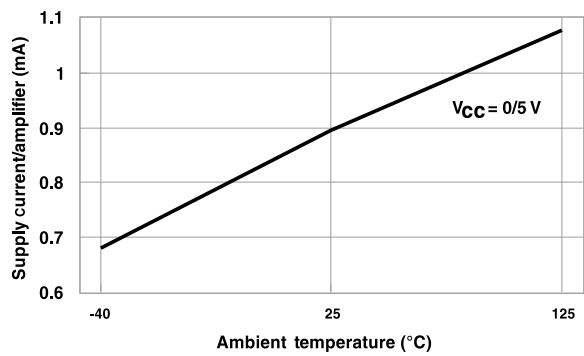


Figure 3. Output short-circuit current vs. output voltage

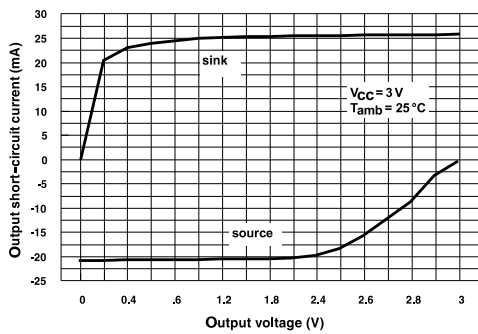


Figure 4. Output short-circuit current vs. temperature

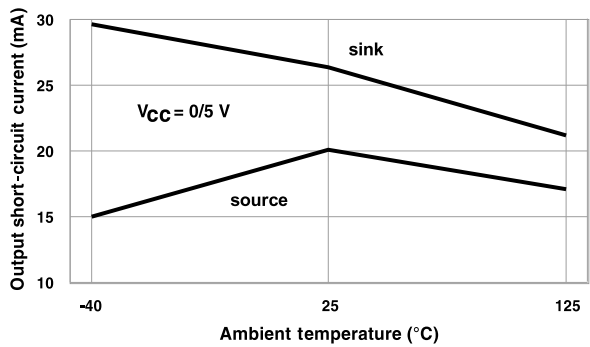


Figure 5. Voltage gain and phase vs. frequency, RL = 600 Ω, CL = 100 pF

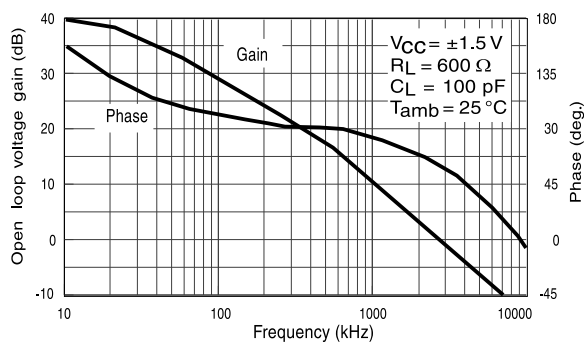
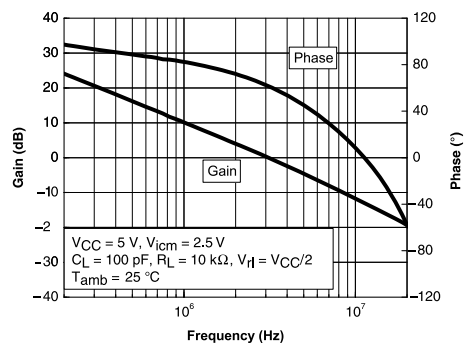
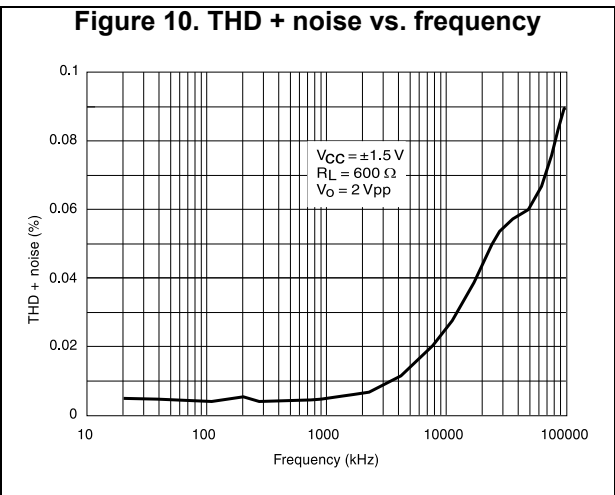
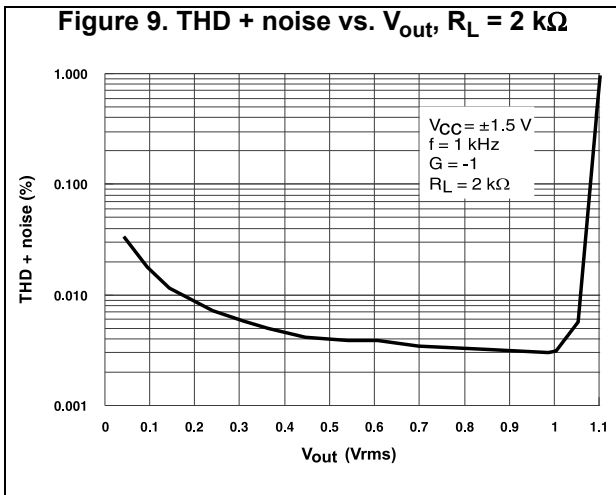
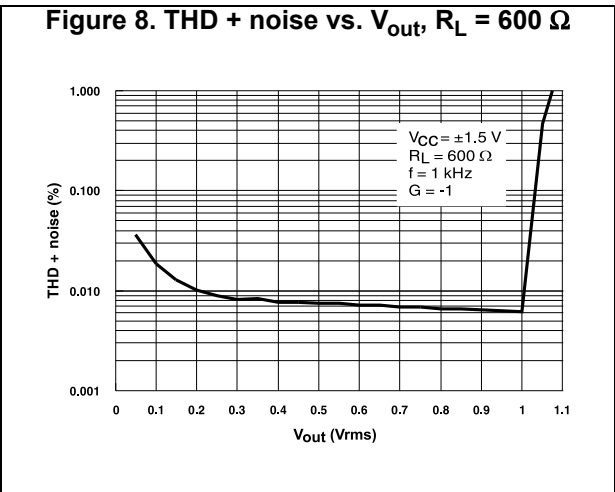
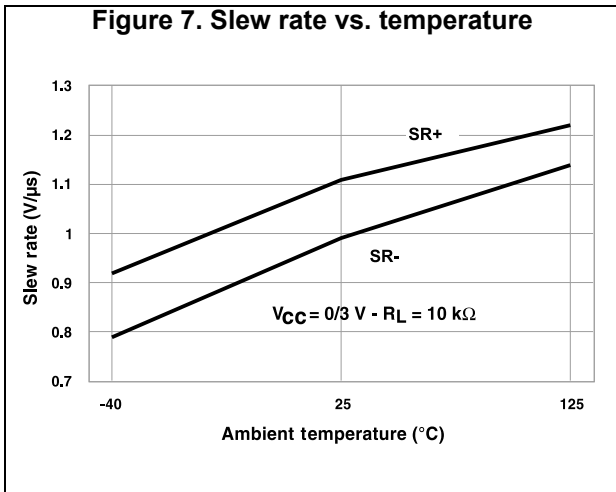
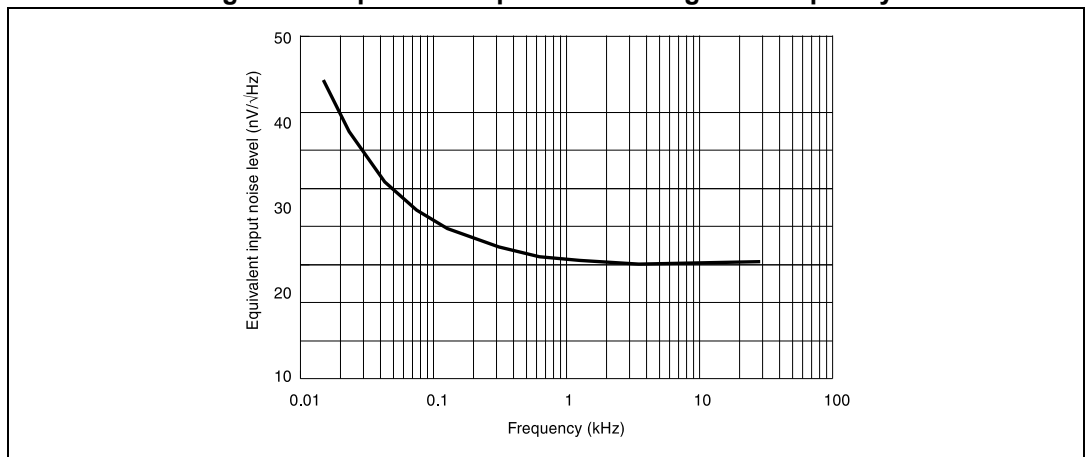


Figure 6. Voltage gain and phase vs. frequency, RL = 10 kΩ, CL = 100 pF





**Figure 11. Equivalent input noise voltage vs. frequency**



### 3 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK is an ST trademark.



### 3.1 SOT23-5 package information

Figure 12. SOT23-5 package outline

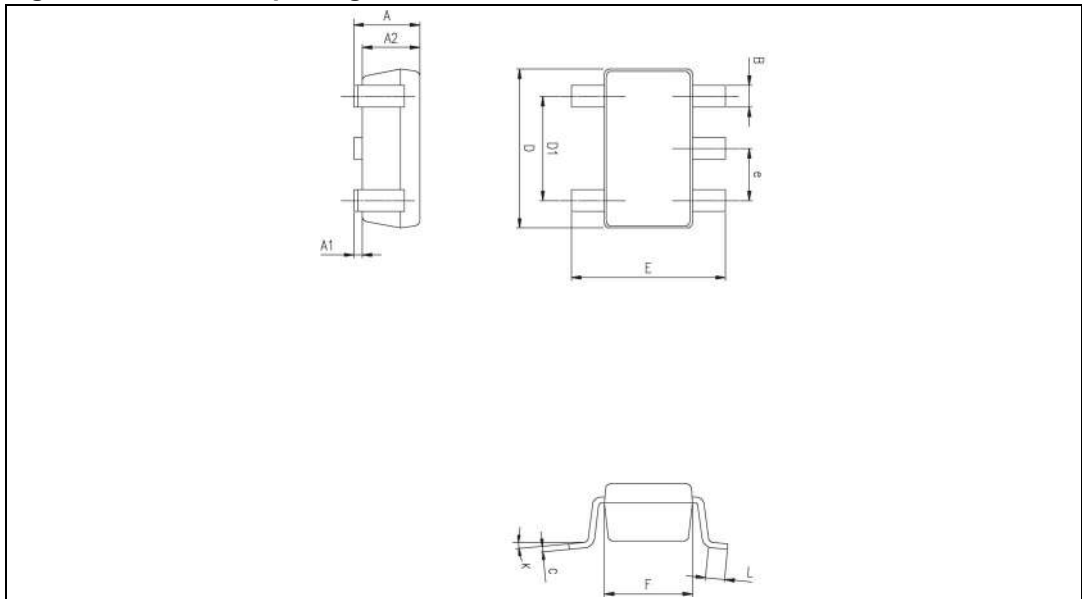


Table 5. SOT23-5 package mechanical data

Symbol	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	0.013	0.015	0.019
C	0.09	0.15	0.20	0.003	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	0.013	0.023
K	0 degrees		10 degrees	0 degrees		10 degrees

## 4 Ordering information

**Table 6. Order codes**

Order code	Temperature range	Package	Packing	Marking
TS9511ILT	-40 °C to +125 °C	SOT23-5L	Tape and reel	K1A1
TS9511RILT				K1A3
TS9511IYLT <sup>(1)</sup>		SOT23-5L (automotive grade)		K1A2
TS9511RIYLT <sup>(1)</sup>				K1A4

1. Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 and Q 002 or equivalent.

## 5 Revision history

**Table 7. Document revision history**

Date	Revision	Changes
25-Jun-2009	1	Initial release.
17-Dec-2009	2	Modified CMR, SVR, $A_{vd}$ , $V_{OH}$ , $V_{OL}$ , $I_{SC}$ and $I_{CC}$ values in <a href="#">Table 3</a> and <a href="#">Table 4</a> .
19-Sep-2012	3	Updated title of <a href="#">Figure 8</a> and <a href="#">Figure 9</a> (added conditions). Updated TS9511IYLT order code (qualified status) in <a href="#">Table 6</a> . Minor corrections throughout document.
23-Nov-2012	4	Updated <a href="#">Table 5</a> Updated markings of <a href="#">Table 6</a>
17-Jul-2013	5	Added two new order codes: TS9511RILT and TS9511RIYLT with associated new pinout configuration. <a href="#">Table 6</a> : added footnote <a href="#">1</a> .
25-Jul-2013	6	Updated pinout numbers in cover page.

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