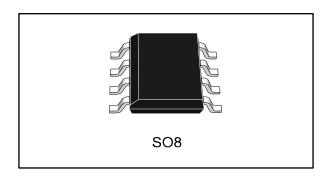
TSV912H



High temperature, rail-to-rail input/output, 8 MHz operational amplifier

Datasheet - production data



Features

- Rail-to-rail input and output
- Wide bandwidth
- Low power consumption: 820 μA typ
- Unity gain stability
- High output current: 35 mA
- Operating range from 2.5 to 5.5 V
- Low input bias current, 1 pA typ
- ESD internal protection ≥ 5 kV
- Latch-up immunity

Applications

• Automotive products

Description

The TSV912H operational amplifier offers low voltage operation and rail-to-rail input and output.

The device features an excellent speed/power consumption ratio, offering an 8 MHz gain-bandwidth product while consuming only 1.1 mA maximum at 5 V. It is unity gain stable and features an ultra-low input bias current.

The TSV912H is a high temperature version of the TSV912, and can operate from -40 °C to 150 °C with unique characteristics. Its main target applications are automotive, but the device is also ideal for sensor interfaces, battery-supplied and portable applications, as well as active filtering.

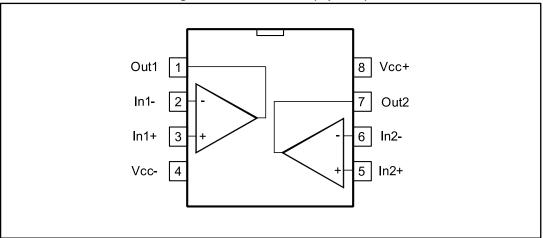
Contents TSV912H

Contents

1	Packag	e pin connections	3
2	Absolut	te maximum ratings and operating conditions	4
3	Electric	al characteristics	5
4	Electric	al characteristic curves	11
5	Applica	tion information	14
	5.1	Driving resistive and capacitive loads	14
	5.2	PCB layouts	14
6	Packag	e information	15
	6.1	SO8 package information	16
7	Orderin	g information	17
Q	Povisio	n history	1Ω

1 Package pin connections

Figure 1: Pin connection (top view)



2 Absolute maximum ratings and operating conditions

Table 1: Absolute maximum ratings

Symbol	Parameter	Value	Unit
Vcc	Supply voltage, (V _{CC} ⁺) - (V _{CC} ⁻) ⁽¹⁾	6	
V_{id}	Differential input voltage (2)	±V _{CC}	V
V_{in}	Input voltage (3)	(V_{CC}^{-}) - 0.2 to (V_{CC}^{+}) + 0.2	
l _{in}	Input current ⁽⁴⁾	10	mA
T _{stg}	Storage temperature	-65 to 150	•°C
Tj	Maximum junction temperature	160	
R _{thja}	Thermal resistance junction to ambient (5)(6)	125	°C/W
R _{thjc}	Thermal resistance junction to case (5)(6)	40	C/VV
	HBM: human body model (7)	5	kV
ESD	MM: machine model (8)	400	V
	CDM: charged device model (9)	1500	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \
	Latch-up immunity	200	mA

Table 2: Operating conditions

Symbol	Parameter	Value	Unit
Vcc	Supply voltage (V _{CC} ⁺) - (V _{CC} ⁻)	2.5 to 5.5	W
V _{icm}	Common mode input voltage range	(V_{CC}^{-}) - 0.1 to (V_{CC}^{+}) + 0.1	V
T _{oper}	Operating free-air temperature range	-40 to 150	°C



⁽¹⁾All voltage values, except the differential voltage, are with respect to the 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 6 V.

⁽⁴⁾Input current must be limited by a resistor in series with the inputs.

 $^{^{(5)}}$ R_{th} are typical values.

⁽⁶⁾Short-circuits can cause excessive heating and destructive dissipation.

 $^{^{(7)}}$ 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.

 $^{^{(8)}}$ 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.

⁽⁹⁾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 3: Electrical characteristics at VCC+ = 2.5 V with VCC- = 0 V, Vicm = VCC/2, RL connected to VCC/2, $T = 25 \,^{\circ}\text{C}$ (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Unit
DC perfor	rmance		1	ı		
.,		T = 25 °C		0.1	4.5	.,
V_{io}	Input offset voltage	$T_{min} < T < T_{max}$			7.5	mV
->- (-40 °C < T < 125 °C		2		
DV _{io} /DT	Input offset voltage drift	125 °C < T < 150 °C		20		μV/°C
		V _{out} = V _{CC} /2, T = 25 °C		1	10 ⁽¹⁾	рА
l _{io}	Input offset current	$V_{out} = V_{CC}/2$, $T_{min} < T < T_{max}$			5	nA
	1 (1)	V _{out} = V _{CC} /2, T = 25 °C		1	10 ⁽¹⁾	рА
l _{ib}	Input bias current	$V_{out} = V_{CC}/2$, $T_{min} < T < T_{max}$			5	nA
OMP	Common mode rejection	0 V to 2.5 V, V _{out} = 1.25 V, T = 25 °C	58	75		
CMR	ratio 20 log (ΔV _{ic} /ΔV _{io})	0 V to 2.5 V, $V_{out} = 1.25 V$, $T_{min} < T < T_{max}$	53			ID.
Δ.	Large signal voltage gain	R_L = 10 k Ω , V_{out} = 0.5 V to 2 V, T = 25 °C	80	89		dB
A_{vd}		R_L = 10 k Ω , V_{out} = 0.5 V to 2 V, T_{min} < T < T_{max}	70			
	High-level output voltage	R _L = 10 kΩ, T = 25 °C		15	40	
V _{CC} -		$R_L = 10 \text{ k}\Omega, T_{min} < T < T_{max}$			60	
V_{OH}		R _L = 600 Ω, T = 25 °C		45	150	
		$R_L = 600 \Omega$, $T_{min} < T < T_{max}$			250	
		R _L = 10 kΩ, T = 25 °C		15	40	mV
\/	Low lovel output voltogo	$R_L = 10 \text{ k}\Omega$, $T_{min} < T < T_{max}$			60	
V_{OL}	Low-level output voltage	R _L = 600 Ω, T = 25 °C		45	150	
		$R_L = 600 \Omega$, $T_{min} < T < T_{max}$			250	
		V _{out} = 2.5 V, T = 25 °C	18	32		
	I _{sink}	$V_{out} = 2.5 \text{ V}, T_{min} < T < T_{max}$	14			
l _{out}		V _{out} = 0 V, T = 25 °C	18	35		A
	I _{source}	$V_{out} = 0 \text{ V}, T_{min} < T < T_{max}$	14			mA
	Supply current	No load, V _{out} = V _{CC} /2, T = 25 °C		0.78	1.1	
(per operator)		No load, V _{out} = V _{CC} /2, T _{min} < T < T _{max}			1.1	
AC perfor	rmance					
OPP	Cain handwidth and dust	R_L = 2 k Ω , C_L = 100 pF, f = 100 kHz, T = 25 °C		8		
GBP	Gain bandwidth product	$R_L = 2 \text{ k}\Omega, C_L = 100 \text{ pF, f} = 100 \text{ kHz,}$ $T_{min} < T < T_{max}$		4		MHz
Fu	Unity gain frequency	$R_L = 2 k\Omega, C_L = 100 pF$		7.2		

TSV912H

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Unit
φm	Phase margin	B = 2 k0 C 400 pF		45		Degrees
G _m	Gain margin	$R_L = 2 k\Omega, C_L = 100 pF$		8		dB
CD.	Clayrote	$R_L = 2 k\Omega$, $C_L = 100 pF$, $A_v = 1$, $T = 25 °C$		4.5		\//ua
SR	Slew rate	$R_L = 2 k\Omega, C_L = 100 pF, A_v = 1,$ $T_{min} < T < T_{max}$		3.5		V/μs
e _n	Equivalent input noise voltage	f = 10 kHz		21		nV/√Hz
THD+e _n	Total harmonic distortion	$G = 1$, $f = 1$ kHz, $R_L = 2$ k Ω , $Bw = 22$ kHz, $V_{icm} = (V_{CC} + 1)/2$, $V_{out} = 1.1$ V_{pp}		0.001		%

⁽¹⁾Guaranteed by design.

Table 4: Electrical characteristics at VCC+ = 3.3 V with VCC- = 0 V, Vicm = VCC/2, RL connected to VCC/2, T = 25 °C (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Unit
DC perfo				71		
ропо		T = 25 °C		0.1	4.5	
V_{io}	Input offset voltage	$T_{\text{min}} < T < T_{\text{max}}$	1	0.1	7.5	mV
		-40 °C < T < 125 °C		2	7.0	
DV_{io}	Input offset voltage drift	125 °C < T < 150 °C		20		μV/°C
		V _{out} = V _{CC} /2, T = 25 °C		1	10 (1)	pА
I_{io}	Input offset current	$V_{\text{out}} = V_{\text{CC}}/2$, $T = 20^{\circ}$ $V_{\text{out}} = V_{\text{CC}}/2$, $T_{\text{min}} < T < T_{\text{max}}$		•	5	nA
		$V_{\text{out}} = V_{\text{CC}}/2, T = 25 \text{ °C}$		1	10 (1)	pA
I_{ib}	Input bias current	$V_{\text{out}} = V_{\text{CC}}/2$, $T_{\text{min}} < T < T_{\text{max}}$		•	5	nA
	Common mode rejection	0 V to 3.3 V, V _{out} = 1.65 V, T = 25 °C	60	78		
CMR	ratio 20 log (ΔV _{ic} /ΔV _{io})	0 V to 3.3 V, $V_{out} = 1.65 \text{ V}$, $T_{min} < T < T_{max}$	55			10
۸	Large signal voltage gain	$R_L = 10 \text{ k}\Omega, V_{out} = 0.5 \text{ V to } 2.8 \text{ V},$ T = 25 °C	80	90		dB
A _{vd}		$\begin{split} R_L &= 10 \text{ k}\Omega, V_{out} = 0.5 \text{ V to } 2.8 \text{ V}, \\ T_{min} &< T < T_{max} \end{split}$	70			
	High-level output voltage	R _L = 10 kΩ, T = 25 °C		15	40	mV
V _{CC} -		$R_L = 10 \text{ k}\Omega, T_{min} < T < T_{max}$			60	
V_{OH}		R _L = 600 Ω, T = 25 °C		45	150	
		$R_L = 600 \Omega$, $T_{min} < T < T_{max}$			250	
		R _L = 10 kΩ, T = 25 °C		15	40	IIIV
\ <i>/</i>		$R_L = 10 \text{ k}\Omega, T_{min} < T < T_{max}$			60	-
V_{OL}	Low-level output voltage	R _L = 600 Ω, T = 25 °C		45	150	
		$R_L = 600 \ \Omega, \ T_{min} < T < T_{max}$			250	
	1	V _{out} = 3.3 V, T = 25 °C	18	32		
	Isink	$V_{out} = 3.3 \text{ V}, T_{min} < T < T_{max}$	14			
l _{out}		V _{out} = 0 V, T = 25 °C	18	35		A
	Isource	V _{out} = 0 V, T _{min} < T < T _{max}	14			mA
	Supply current	No load, V _{out} = V _{CC} /2, T = 25 °C		0.8	1.1	
I _{CC}	(per operator)	No load, $V_{out} = V_{CC}/2$, $T_{min} < T < T_{max}$			1.1	
AC perfo	rmance					
CPP	Cain handwidth aradust	$R_L = 2 k\Omega$, $C_L = 100 pF$, $f = 100 kHz$, $T = 25 °C$		8		MHz
GBP	Gain bandwidth product	$\begin{aligned} R_L &= 2 \text{ k}\Omega, C_L = 100 \text{ pF, } f = 100 \text{ kHz,} \\ T_{min} &< T < T_{max} \end{aligned}$		4.2		
F_u	Unity gain frequency			7.2		
φm	Phase margin	$R_L = 2 \text{ k}\Omega, C_L = 100 \text{ pF}$		45		Degree
G_{m}	Gain margin			8		dB



TSV912H

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Unit
CD.	Claurata	$R_L = 2 k\Omega$, $C_L = 100 pF$, $A_v = 1$, $T = 25 °C$		4.5		\//··-
SR	Slew rate	$R_L = 2 k\Omega, C_L = 100 pF, A_v = 1,$ $T_{min} < T < T_{max}$		3.5		V/µs
en	Equivalent input noise voltage	f = 10 kHz		21		nV/√Hz
THD+e _n	Total harmonic distortion	$G = 1$, $f = 1$ kHz, $R_L = 2$ k Ω , Bw = 22 kHz, $V_{icm} = (V_{CC} + 1)/2$, $V_{out} = 1.9$ V_{pp}		0.0007		%

⁽¹⁾Guaranteed by design.

Table 5: Electrical characteristics at VCC+ = 5 V with VCC- = 0 V, Vicm = VCC/2, RL connected to VCC/2, full temperature range (unless otherwise specified)

RL connected to VCC/2, full temperature range (unless otherwise specified)							
Symbol	Parameter	Conditions	Min.	Тур.	Max.	Unit	
DC perfo	rmance						
V _{io} Input offset voltage		T = 25 °C		0.1	4.5	mV	
V _{io}	input onset voltage	$T_{min} < T < T_{max}$			7.5	IIIV	
DV	logert offerst veltoge deift	-40 °C < T < 125 °C		2		\//°C	
DV_io	Input offset voltage drift	125 °C < T < 150 °C		20		μV/°C	
	logist offert expressed	V _{out} = V _{CC} /2, T = 25 °C		1	10 ⁽¹⁾	рА	
l _{io}	Input offset current	$V_{out} = V_{CC}/2$, $T_{min} < T < T_{max}$			5	nA	
	land biograms	V _{out} = V _{CC} /2, T = 25 °C		1	10 ⁽¹⁾	рА	
l _{ib}	Input bias current	V _{out} = V _{CC} /2, T _{min} < T < T _{max}			5	nA	
CMD	Common mode rejection	0 V to 5 V, V _{out} = 2.5 V, T = 25 °C	62	82			
CMR	ratio 20 log (ΔV _{ic} /ΔV _{io})	0 V to 5 V, V_{out} = 2.5 V, T_{min} < T < T_{max}	58				
CV/D	Supply voltage rejection	V _{CC} = 2.5 to 5 V, T = 25 °C	70	86		٩D	
SVR	ratio 20 log ($\Delta V_{CC}/\Delta V_{io}$)	$V_{CC} = 2.5 \text{ to } 5 \text{ V}, T_{min} < T < T_{max}$	65			dB	
	Large signal voltage gain	$R_L = 10 \text{ k}\Omega, V_{out} = 0.5 \text{ V to } 4.5 \text{ V},$ T = 25 °C	80	91			
A_{vd}		$R_L = 10 \text{ k}\Omega, V_{out} = 0.5 \text{ V to } 4.5 \text{ V},$ $T_{min} < T < T_{max}$	70				
	High-level output voltage	R _L = 10 kΩ, T = 25 °C		15	40		
V _{CC} -		$R_L = 10 \text{ k}\Omega, T_{min} < T < T_{max}$			60		
V_{OH}		R _L = 600 Ω, T = 25 °C		45	150		
		$R_L = 600 \Omega$, $T_{min} < T < T_{max}$			250	\/	
		R _L = 10 kΩ, T = 25 °C		15	40	mV	
\ /	Law lawal autout valtage	$R_L = 10 \text{ k}\Omega, T_{min} < T < T_{max}$			60		
V_{OL}	Low-level output voltage	R _L = 600 Ω, T = 25 °C		45	150		
		$R_L = 600 \Omega$, $T_{min} < T < T_{max}$			250		
		V _{out} = 5 V, T = 25 °C	18	32			
	Isink	$V_{out} = 5 \text{ V}, T_{min} < T < T_{max}$	14				
l _{out}		V _{out} = 0 V, T = 25 °C	18	35		Λ	
	Isource	$V_{out} = 0 \text{ V}, T_{min} < T < T_{max}$	14			mA	
	Supply current	No load, V _{out} = 2.5 V, T = 25 °C		0.82	1.1		
I _{CC}	(per operator)	No load, $V_{out} = 2.5 \text{ V}$, $T_{min} < T < T_{max}$			1.1		
AC perfo	rmance						
CDD	Coin handwidth aradust	R_L = 2 k Ω , C_L = 100 pF, f = 100 kHz, T = 25 °C		8			
GBP	Gain bandwidth product	$R_L = 2 \text{ k}\Omega, C_L = 100 \text{ pF}, f = 100 \text{ kHz}, \\ T_{min} < T < T_{max}$		4.5		MHz	
F_{u}	Unity gain frequency	$R_L = 2 k\Omega, C_L = 100 pF$		7.5			

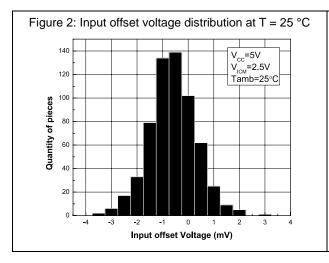


TSV912H

Symbol	Parameter	Conditions	Min.	Тур.	Max.	Unit
φm	Phase margin	B = 3 k0 C 100 pF		45		Degrees
G _m	Gain margin	$R_L = 2 k\Omega, C_L = 100 pF$		8		dB
C.D.	Claurete	$R_L = 2 k\Omega$, $C_L = 100 pF$, $A_v = 1$, $T = 25 °C$		4.5		\//a
SR	Slew rate	$R_L = 2 k\Omega, C_L = 100 pF, A_v = 1,$ $T_{min} < T < T_{max}$		3.5		V/µs
	Equivalent input noise	f = 1 kHz		27		nV/√Hz
e _n	voltage	f = 10 kHz		21		IIV/ VIIZ
THD+e _n	Total harmonic distortion	$G = 1, f = 1 \text{ kHz}, R_L = 2 \text{ k}\Omega, \\ Bw = 22 \text{ kHz}, V_{icm} = (V_{CC} + 1)/2, \\ V_{out} = 3.6 \text{ V}_{pp}$		0.0004		%

⁽¹⁾Guaranteed by design.

4 Electrical characteristic curves



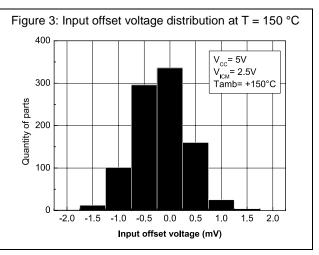


Figure 4: Supply current vs. input common-mode voltage at VCC = 2.5 V 1.0 T=+25°C Supply current per operator (mA) 0.8 0.6 T=+125°C T=+150°C 0.4 V__ = 2.5V 0.2 0.0 0.0 0.5 1.0 1.5 2.0 2.5 Input Common mode voltage (V)

Figure 5: Supply current vs. input common-mode voltage at VCC = 5 V

1.0

1.0

T = +25°C

T = +40°C

O.0

O.0

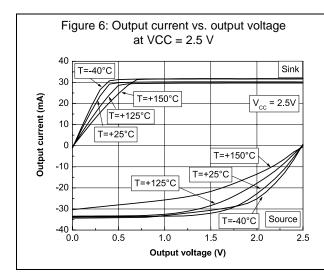
O.0

T = +150°C

T = +125°C

T = -40°C

Input common mode voltage (V)



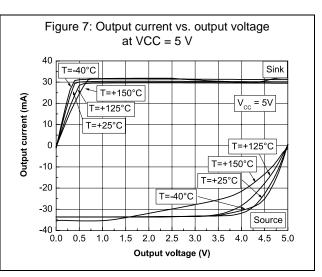
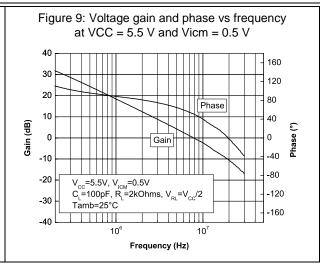
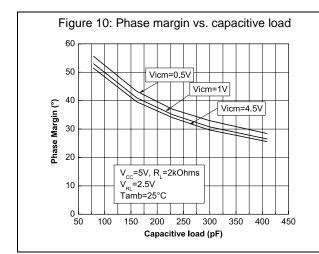
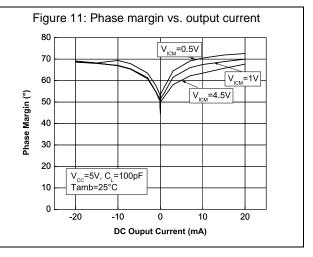
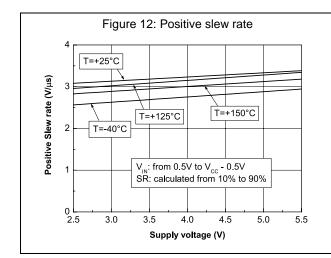


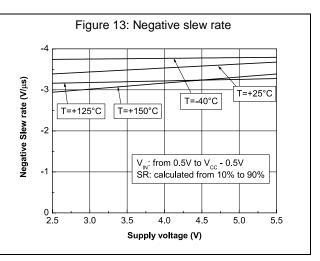
Figure 8: Voltage gain and phase vs frequency at VCC = 2.5 V and Vicm = 0.5 V 40 160 30 120 20 80 10 40 (dB) 0 0 Gain -40 -10 $V_{\rm cc}$ =2.5V, $V_{\rm ICM}$ =0.5V C_L=100pF, R_L=2kOhms, $V_{\rm RL}$ = $V_{\rm cc}$ /2 -80 -20 -120 Tamb=25°C -30 -160 -40 10⁶ 10⁷ Frequency (Hz)

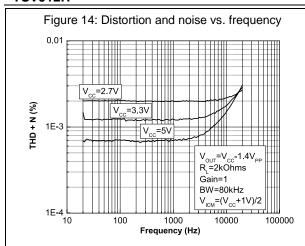












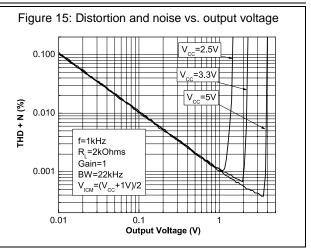


Figure 16: Noise vs. frequency

Figure 16: Noise vs. frequency

V_{Cc}=5V

Tamb=25°C

VICM=0.5V

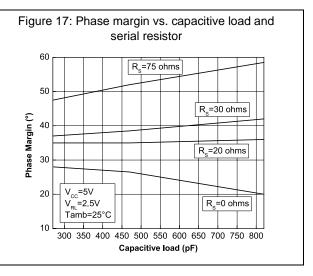
VICM=0.5V

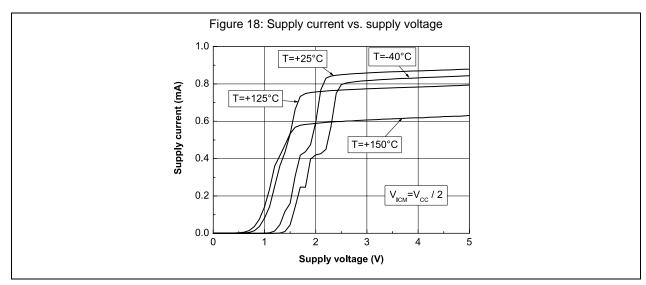
10

10

1000

Frequency (Hz)





5 Application information

5.1 Driving resistive and capacitive loads

These products are low-voltage, low-power operational amplifiers optimized to drive rather large resistive loads above 2 $k\Omega$.

In *follower* configuration, these operational amplifiers can drive capacitive loads up to 100 pF with no oscillations. When driving larger capacitive loads, adding a small in-series resistor at the output can improve the stability of the devices (see *Figure 19: "In-series resistor vs. capacitive load"* for recommended in-series resistor values). Once the in-series resistor value has been selected, the stability of the circuit should be tested on the bench and simulated with the simulation model.

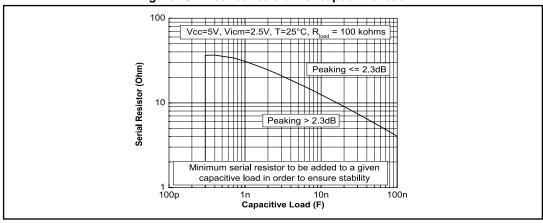


Figure 19: In-series resistor vs. capacitive load

5.2 PCB layouts

For correct operation, it is advised to add 10 nF decoupling capacitors as close as possible to the power supply pins.

TSV912H Package information

6 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**. ECOPACK® is an ST trademark.

6.1 SO8 package information

16/19

Figure 20: SO8 package outline

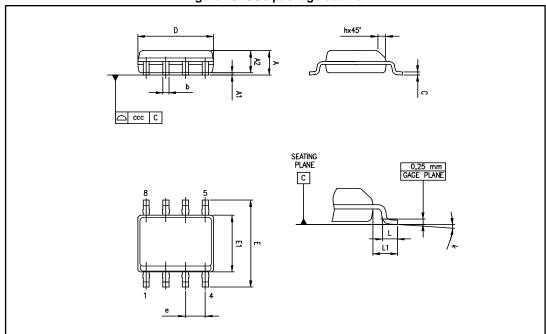


Table 6: SO8 mechanical data

	Dimensions							
Ref.		Millimeters			Inches			
	Min.	Тур.	Max.	Min.	Тур.	Max		
Α			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		
С	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		
е		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		

7 Ordering information

Table 7: Order codes

Order code	Temperature range	Temperature range Package		Marking
TSV912HYDT (1)	-40 °C to 150 °C	SO8 ⁽²⁾ (automotive grade level)	Tape and reel	V912HY

 $^{^{(1)}}$ Qualification and characterization according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent.

 $^{^{(2)}}$ SO8 package is moisture sensitivity level 1 as per Jedec J-STD-020-C.

Revision history TSV912H

8 Revision history

Table 8: Document revision history

Date	Revision	Changes
08-Jul-2010	1	Initial release.
		Removed TSV912AH part number
		Updated layout
22-Feb-2016	2	Table 3, Table 4, and Table 5: removed all references to TSV912AH
		Table 6: updated min (mm) value for k parameter
		Table 7: "Order codes": removed order code TSV912AHYDT

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