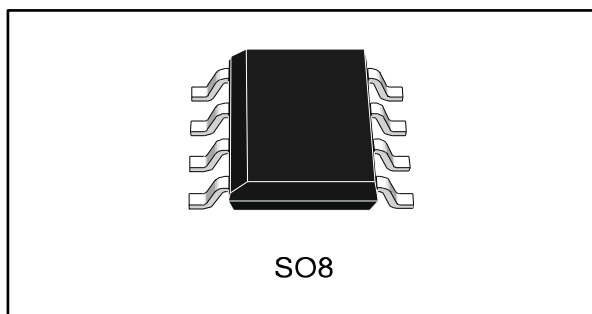

High temperature, rail-to-rail input/output, 8 MHz operational amplifier

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.

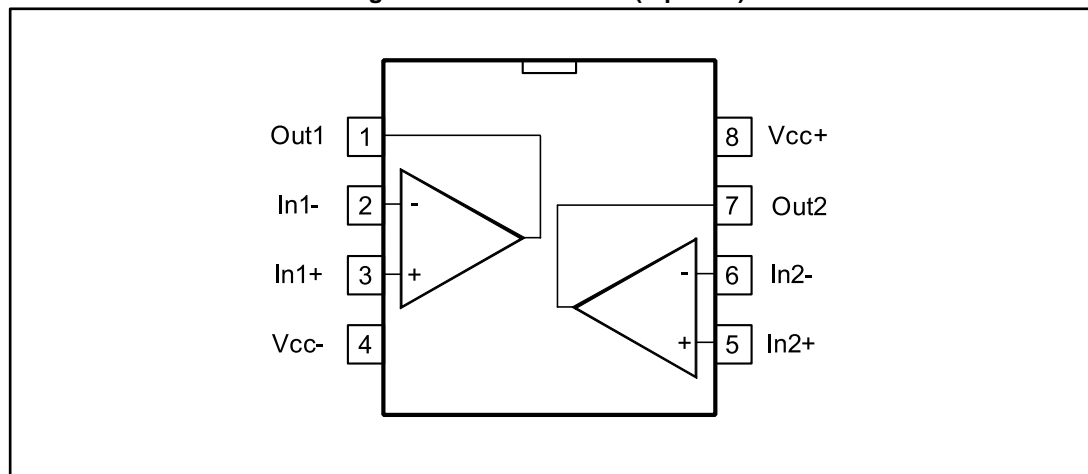
The TSV912H is a high temperature version of the TSV912, and can operate from -40 °C to 150 °C with unique characteristics. Its main target applications are automotive, but the device is also ideal for sensor interfaces, battery-supplied and portable applications, as well as active filtering.

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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
V _{CC}	Supply voltage, (V _{CC} ⁺) - (V _{CC} ⁻) ⁽¹⁾	6	V
V _{id}	Differential input voltage ⁽²⁾	±V _{CC}	
V _{in}	Input voltage ⁽³⁾	(V _{CC} ⁻) - 0.2 to (V _{CC} ⁺) + 0.2	
I _{in}	Input current ⁽⁴⁾	10	mA
T _{stg}	Storage temperature	-65 to 150	°C
T _j	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	
ESD	HBM: human body model ⁽⁷⁾	5	kV
	MM: machine model ⁽⁸⁾	400	V
	CDM: charged device model ⁽⁹⁾	1500	
	Latch-up immunity	200	mA

Notes:

- ⁽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 2: Operating conditions

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

3 Electrical characteristics

Table 3: Electrical characteristics at $V_{CC+} = 2.5\text{ V}$ with $V_{CC-} = 0\text{ V}$, $V_{icm} = V_{CC}/2$, R_L connected to $V_{CC}/2$, $T = 25\text{ °C}$ (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Input offset voltage	$T = 25\text{ °C}$		0.1	4.5	mV
		$T_{min} < T < T_{max}$			7.5	
DV_{io}/DT	Input offset voltage drift	$-40\text{ °C} < T < 125\text{ °C}$		2		$\mu\text{V}/\text{°C}$
		$125\text{ °C} < T < 150\text{ °C}$		20		
I_{io}	Input offset current	$V_{out} = V_{CC}/2$, $T = 25\text{ °C}$		1	$10^{(1)}$	pA
		$V_{out} = V_{CC}/2$, $T_{min} < T < T_{max}$			5	nA
I_{ib}	Input bias current	$V_{out} = V_{CC}/2$, $T = 25\text{ °C}$		1	$10^{(1)}$	pA
		$V_{out} = V_{CC}/2$, $T_{min} < T < T_{max}$			5	nA
CMR	Common mode rejection ratio $20 \log (\Delta V_{ic}/\Delta V_{io})$	$0\text{ V to } 2.5\text{ V}$, $V_{out} = 1.25\text{ V}$, $T = 25\text{ °C}$	58	75		dB
		$0\text{ V to } 2.5\text{ V}$, $V_{out} = 1.25\text{ V}$, $T_{min} < T < T_{max}$	53			
A_{vd}	Large signal voltage gain	$R_L = 10\text{ k}\Omega$, $V_{out} = 0.5\text{ V to } 2\text{ V}$, $T = 25\text{ °C}$	80	89		
		$R_L = 10\text{ k}\Omega$, $V_{out} = 0.5\text{ V to } 2\text{ V}$, $T_{min} < T < T_{max}$	70			
$V_{CC} - V_{OH}$	High-level output voltage	$R_L = 10\text{ k}\Omega$, $T = 25\text{ °C}$		15	40	mV
		$R_L = 10\text{ k}\Omega$, $T_{min} < T < T_{max}$			60	
		$R_L = 600\ \Omega$, $T = 25\text{ °C}$		45	150	
		$R_L = 600\ \Omega$, $T_{min} < T < T_{max}$			250	
V_{OL}	Low-level output voltage	$R_L = 10\text{ k}\Omega$, $T = 25\text{ °C}$		15	40	
		$R_L = 10\text{ k}\Omega$, $T_{min} < T < T_{max}$			60	
		$R_L = 600\ \Omega$, $T = 25\text{ °C}$		45	150	
		$R_L = 600\ \Omega$, $T_{min} < T < T_{max}$			250	
I_{out}	I_{sink}	$V_{out} = 2.5\text{ V}$, $T = 25\text{ °C}$	18	32		mA
		$V_{out} = 2.5\text{ V}$, $T_{min} < T < T_{max}$	14			
	I_{source}	$V_{out} = 0\text{ V}$, $T = 25\text{ °C}$	18	35		
		$V_{out} = 0\text{ V}$, $T_{min} < T < T_{max}$	14			
I_{CC}	Supply current (per operator)	No load, $V_{out} = V_{CC}/2$, $T = 25\text{ °C}$		0.78	1.1	
		No load, $V_{out} = V_{CC}/2$, $T_{min} < T < T_{max}$			1.1	
AC performance						
GBP	Gain bandwidth product	$R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$, $f = 100\text{ kHz}$, $T = 25\text{ °C}$		8		MHz
		$R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$, $f = 100\text{ kHz}$, $T_{min} < T < T_{max}$		4		
F_u	Unity gain frequency	$R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$		7.2		

Electrical characteristics

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Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
ϕ_m	Phase margin	$R_L = 2\text{ k}\Omega, C_L = 100\text{ pF}$		45		Degrees
G_m	Gain margin			8		dB
SR	Slew rate	$R_L = 2\text{ k}\Omega, C_L = 100\text{ pF}, A_v = 1, T = 25\text{ }^\circ\text{C}$		4.5		V/ μs
		$R_L = 2\text{ k}\Omega, C_L = 100\text{ pF}, A_v = 1, T_{\text{min}} < T < T_{\text{max}}$		3.5		
e_n	Equivalent input noise voltage	$f = 10\text{ kHz}$		21		nV/ $\sqrt{\text{Hz}}$
THD+ e_n	Total harmonic distortion	$G = 1, f = 1\text{ kHz}, R_L = 2\text{ k}\Omega, Bw = 22\text{ kHz}, V_{\text{icm}} = (V_{\text{CC}} + 1)/2, V_{\text{out}} = 1.1\text{ V}_{\text{pp}}$		0.001		%

Notes:

⁽¹⁾Guaranteed by design.

Table 4: Electrical characteristics at $V_{CC+} = 3.3\text{ V}$ with $V_{CC-} = 0\text{ V}$, $V_{icm} = V_{CC}/2$, R_L connected to $V_{CC}/2$, $T = 25\text{ }^{\circ}\text{C}$ (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Input offset voltage	$T = 25\text{ }^{\circ}\text{C}$		0.1	4.5	mV
		$T_{min} < T < T_{max}$			7.5	
DV_{io}	Input offset voltage drift	$-40\text{ }^{\circ}\text{C} < T < 125\text{ }^{\circ}\text{C}$		2		$\mu\text{V}/^{\circ}\text{C}$
		$125\text{ }^{\circ}\text{C} < T < 150\text{ }^{\circ}\text{C}$		20		
I_{io}	Input offset current	$V_{out} = V_{CC}/2$, $T = 25\text{ }^{\circ}\text{C}$		1	10 ⁽¹⁾	pA
		$V_{out} = V_{CC}/2$, $T_{min} < T < T_{max}$			5	nA
I_{ib}	Input bias current	$V_{out} = V_{CC}/2$, $T = 25\text{ }^{\circ}\text{C}$		1	10 ⁽¹⁾	pA
		$V_{out} = V_{CC}/2$, $T_{min} < T < T_{max}$			5	nA
CMR	Common mode rejection ratio $20 \log (\Delta V_{ic}/\Delta V_{io})$	$0\text{ V to } 3.3\text{ V}$, $V_{out} = 1.65\text{ V}$, $T = 25\text{ }^{\circ}\text{C}$	60	78		dB
		$0\text{ V to } 3.3\text{ V}$, $V_{out} = 1.65\text{ V}$, $T_{min} < T < T_{max}$	55			
A_{vd}	Large signal voltage gain	$R_L = 10\text{ k}\Omega$, $V_{out} = 0.5\text{ V to } 2.8\text{ V}$, $T = 25\text{ }^{\circ}\text{C}$	80	90		dB
		$R_L = 10\text{ k}\Omega$, $V_{out} = 0.5\text{ V to } 2.8\text{ V}$, $T_{min} < T < T_{max}$	70			
$V_{CC} - V_{OH}$	High-level output voltage	$R_L = 10\text{ k}\Omega$, $T = 25\text{ }^{\circ}\text{C}$		15	40	mV
		$R_L = 10\text{ k}\Omega$, $T_{min} < T < T_{max}$			60	
		$R_L = 600\text{ }\Omega$, $T = 25\text{ }^{\circ}\text{C}$		45	150	
		$R_L = 600\text{ }\Omega$, $T_{min} < T < T_{max}$			250	
V_{OL}	Low-level output voltage	$R_L = 10\text{ k}\Omega$, $T = 25\text{ }^{\circ}\text{C}$		15	40	mV
		$R_L = 10\text{ k}\Omega$, $T_{min} < T < T_{max}$			60	
		$R_L = 600\text{ }\Omega$, $T = 25\text{ }^{\circ}\text{C}$		45	150	
		$R_L = 600\text{ }\Omega$, $T_{min} < T < T_{max}$			250	
I_{out}	I_{sink}	$V_{out} = 3.3\text{ V}$, $T = 25\text{ }^{\circ}\text{C}$	18	32		mA
		$V_{out} = 3.3\text{ V}$, $T_{min} < T < T_{max}$	14			
	I_{source}	$V_{out} = 0\text{ V}$, $T = 25\text{ }^{\circ}\text{C}$	18	35		
		$V_{out} = 0\text{ V}$, $T_{min} < T < T_{max}$	14			
I_{CC}	Supply current (per operator)	No load, $V_{out} = V_{CC}/2$, $T = 25\text{ }^{\circ}\text{C}$		0.8	1.1	mA
		No load, $V_{out} = V_{CC}/2$, $T_{min} < T < T_{max}$			1.1	
AC performance						
GBP	Gain bandwidth product	$R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$, $f = 100\text{ kHz}$, $T = 25\text{ }^{\circ}\text{C}$		8		MHz
		$R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$, $f = 100\text{ kHz}$, $T_{min} < T < T_{max}$		4.2		
F_u	Unity gain frequency			7.2		
ϕ_m	Phase margin	$R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$		45		Degrees
G_m	Gain margin			8		dB

Electrical characteristics

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Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
SR	Slew rate	$R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$, $A_v = 1$, $T = 25\text{ }^\circ\text{C}$		4.5		V/ μs
		$R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$, $A_v = 1$, $T_{\text{min}} < T < T_{\text{max}}$		3.5		
e_n	Equivalent input noise voltage	$f = 10\text{ kHz}$		21		nV/ $\sqrt{\text{Hz}}$
THD+ e_n	Total harmonic distortion	$G = 1$, $f = 1\text{ kHz}$, $R_L = 2\text{ k}\Omega$, $Bw = 22\text{ kHz}$, $V_{\text{icm}} = (V_{\text{CC}} + 1)/2$, $V_{\text{out}} = 1.9\text{ V}_{\text{pp}}$		0.0007		%

Notes:⁽¹⁾Guaranteed by design.

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

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
V_{io}	Input offset voltage	$T = 25\text{ }^{\circ}\text{C}$		0.1	4.5	mV
		$T_{min} < T < T_{max}$			7.5	
DV_{io}	Input offset voltage drift	$-40\text{ }^{\circ}\text{C} < T < 125\text{ }^{\circ}\text{C}$		2		$\mu\text{V}/^{\circ}\text{C}$
		$125\text{ }^{\circ}\text{C} < T < 150\text{ }^{\circ}\text{C}$		20		
I_{io}	Input offset current	$V_{out} = V_{CC}/2$, $T = 25\text{ }^{\circ}\text{C}$		1	10 ⁽¹⁾	pA
		$V_{out} = V_{CC}/2$, $T_{min} < T < T_{max}$			5	nA
I_{ib}	Input bias current	$V_{out} = V_{CC}/2$, $T = 25\text{ }^{\circ}\text{C}$		1	10 ⁽¹⁾	pA
		$V_{out} = V_{CC}/2$, $T_{min} < T < T_{max}$			5	nA
CMR	Common mode rejection ratio $20\log(\Delta V_{ic}/\Delta V_{io})$	$0\text{ V to }5\text{ V}$, $V_{out} = 2.5\text{ V}$, $T = 25\text{ }^{\circ}\text{C}$	62	82		dB
		$0\text{ V to }5\text{ V}$, $V_{out} = 2.5\text{ V}$, $T_{min} < T < T_{max}$	58			
SVR	Supply voltage rejection ratio $20\log(\Delta V_{CC}/\Delta V_{io})$	$V_{CC} = 2.5\text{ to }5\text{ V}$, $T = 25\text{ }^{\circ}\text{C}$	70	86		dB
		$V_{CC} = 2.5\text{ to }5\text{ V}$, $T_{min} < T < T_{max}$	65			
A_{vd}	Large signal voltage gain	$R_L = 10\text{ k}\Omega$, $V_{out} = 0.5\text{ V to }4.5\text{ V}$, $T = 25\text{ }^{\circ}\text{C}$	80	91		
		$R_L = 10\text{ k}\Omega$, $V_{out} = 0.5\text{ V to }4.5\text{ V}$, $T_{min} < T < T_{max}$	70			
$V_{CC} - V_{OH}$	High-level output voltage	$R_L = 10\text{ k}\Omega$, $T = 25\text{ }^{\circ}\text{C}$		15	40	mV
		$R_L = 10\text{ k}\Omega$, $T_{min} < T < T_{max}$			60	
		$R_L = 600\text{ }\Omega$, $T = 25\text{ }^{\circ}\text{C}$		45	150	
		$R_L = 600\text{ }\Omega$, $T_{min} < T < T_{max}$			250	
V_{OL}	Low-level output voltage	$R_L = 10\text{ k}\Omega$, $T = 25\text{ }^{\circ}\text{C}$		15	40	mV
		$R_L = 10\text{ k}\Omega$, $T_{min} < T < T_{max}$			60	
		$R_L = 600\text{ }\Omega$, $T = 25\text{ }^{\circ}\text{C}$		45	150	
		$R_L = 600\text{ }\Omega$, $T_{min} < T < T_{max}$			250	
I_{out}	I_{sink}	$V_{out} = 5\text{ V}$, $T = 25\text{ }^{\circ}\text{C}$	18	32		mA
		$V_{out} = 5\text{ V}$, $T_{min} < T < T_{max}$	14			
	I_{source}	$V_{out} = 0\text{ V}$, $T = 25\text{ }^{\circ}\text{C}$	18	35		
		$V_{out} = 0\text{ V}$, $T_{min} < T < T_{max}$	14			
I_{CC}	Supply current (per operator)	No load, $V_{out} = 2.5\text{ V}$, $T = 25\text{ }^{\circ}\text{C}$		0.82	1.1	
		No load, $V_{out} = 2.5\text{ V}$, $T_{min} < T < T_{max}$			1.1	
AC performance						
GBP	Gain bandwidth product	$R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$, $f = 100\text{ kHz}$, $T = 25\text{ }^{\circ}\text{C}$		8		MHz
		$R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$, $f = 100\text{ kHz}$, $T_{min} < T < T_{max}$		4.5		
F_u	Unity gain frequency	$R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$		7.5		

Electrical characteristics

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Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
ϕ_m	Phase margin	$R_L = 2\text{ k}\Omega, C_L = 100\text{ pF}$		45		Degrees
G_m	Gain margin			8		dB
SR	Slew rate	$R_L = 2\text{ k}\Omega, C_L = 100\text{ pF}, A_v = 1, T = 25\text{ }^\circ\text{C}$		4.5		V/ μs
		$R_L = 2\text{ k}\Omega, C_L = 100\text{ pF}, A_v = 1, T_{\text{min}} < T < T_{\text{max}}$		3.5		
e_n	Equivalent input noise voltage	$f = 1\text{ kHz}$		27		nV/ $\sqrt{\text{Hz}}$
		$f = 10\text{ kHz}$		21		
THD+ e_n	Total harmonic distortion	$G = 1, f = 1\text{ kHz}, R_L = 2\text{ k}\Omega, \text{Bw} = 22\text{ kHz}, V_{\text{icm}} = (V_{\text{CC}} + 1)/2, V_{\text{out}} = 3.6\text{ V}_{\text{pp}}$		0.0004		%

Notes:

⁽¹⁾Guaranteed by design.

4 Electrical characteristic curves

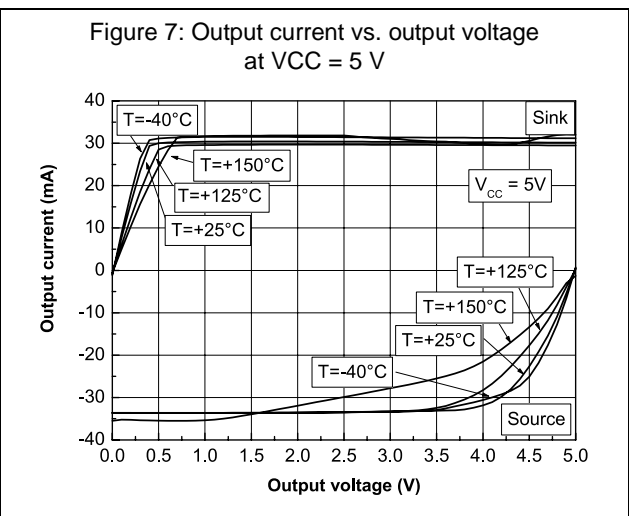
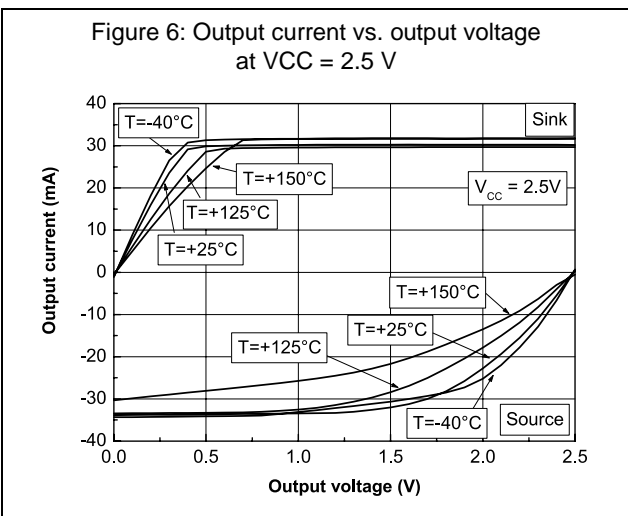
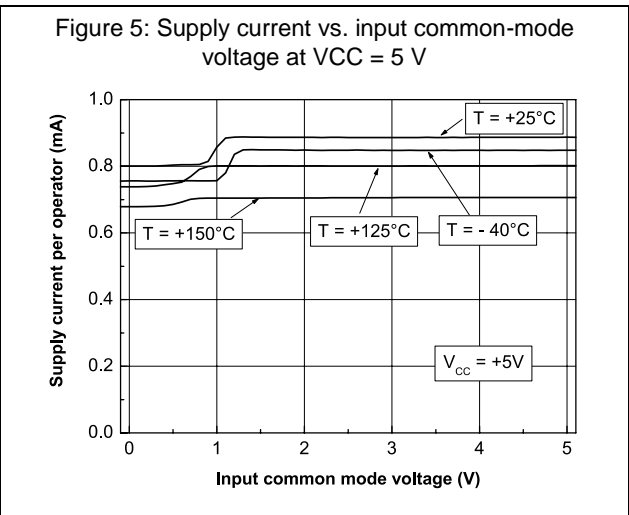
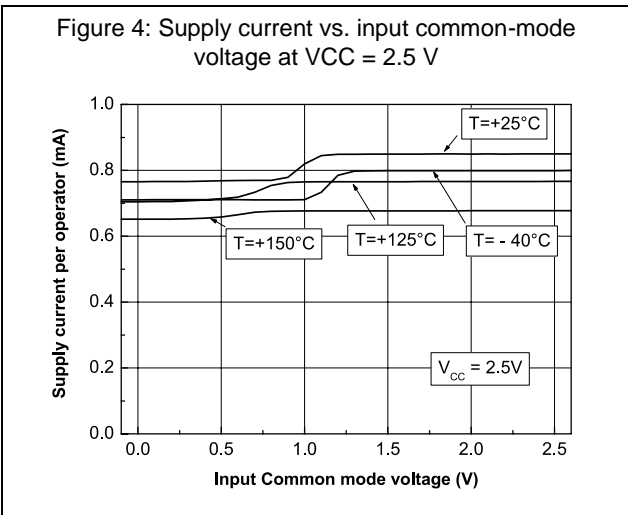
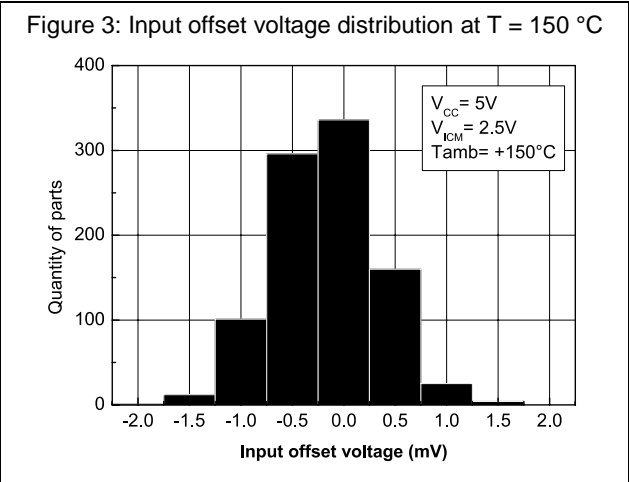
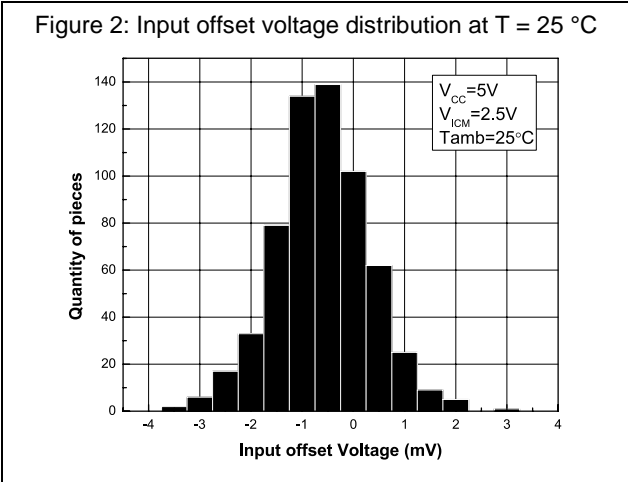


Figure 8: Voltage gain and phase vs frequency at $V_{CC} = 2.5\text{ V}$ and $V_{ICM} = 0.5\text{ V}$

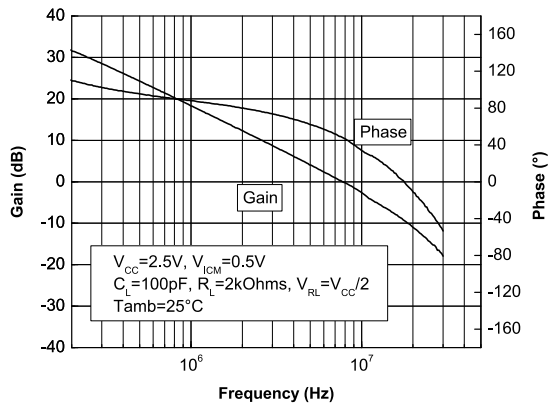


Figure 9: Voltage gain and phase vs frequency at $V_{CC} = 5.5\text{ V}$ and $V_{ICM} = 0.5\text{ V}$

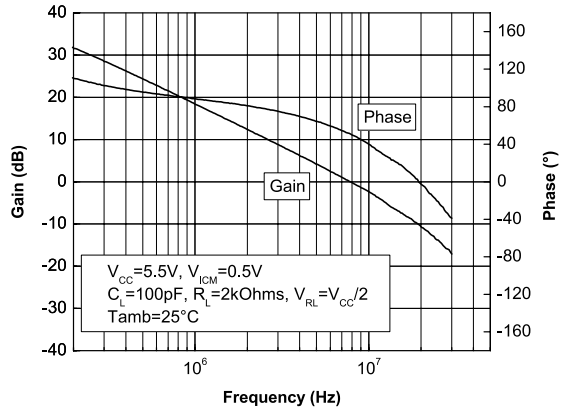


Figure 10: Phase margin vs. capacitive load

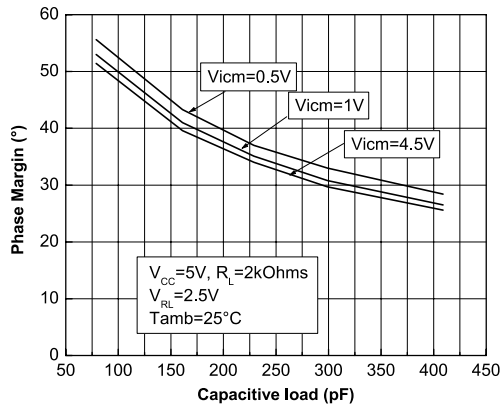


Figure 11: Phase margin vs. output current

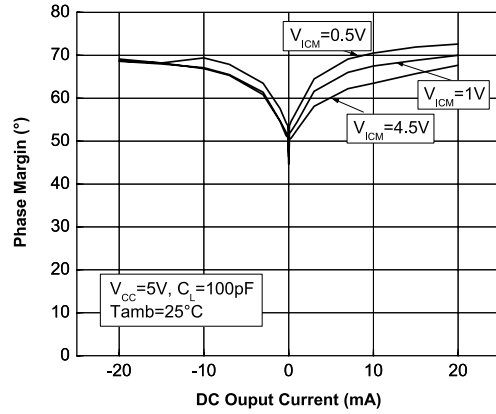


Figure 12: Positive slew rate

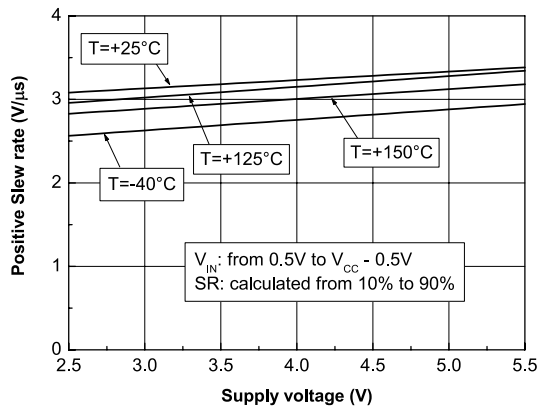
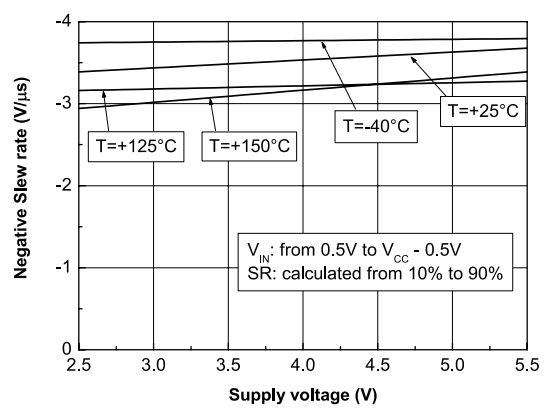
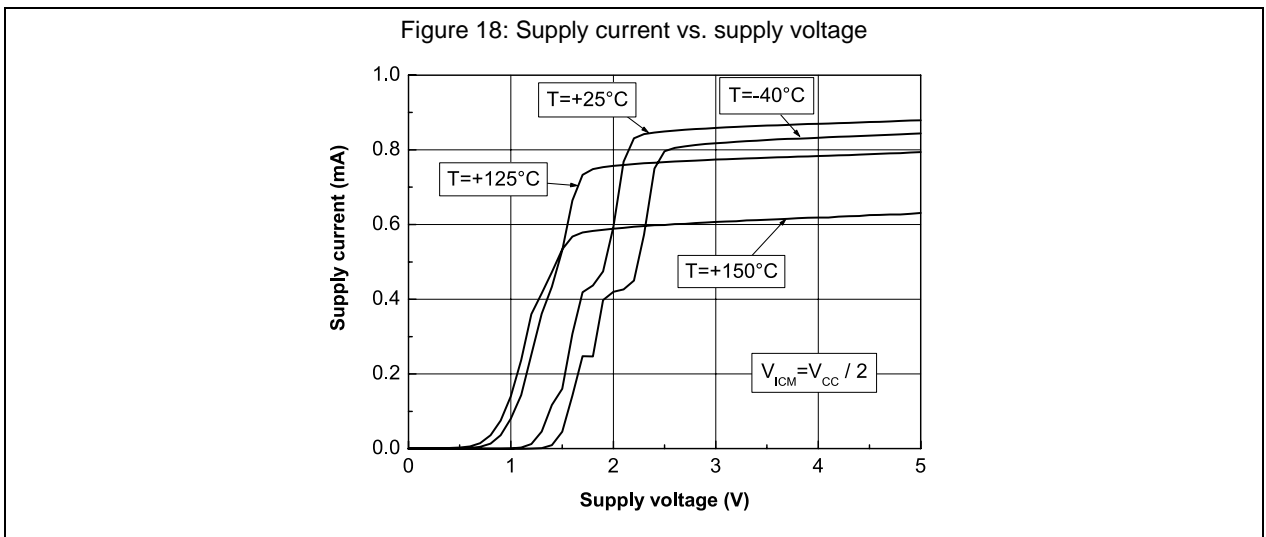
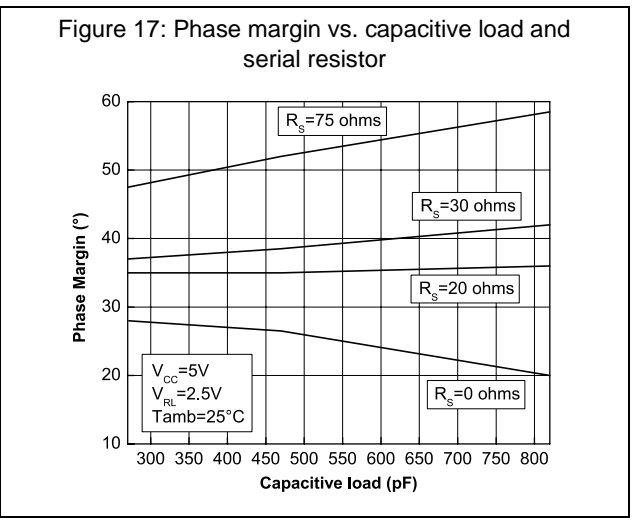
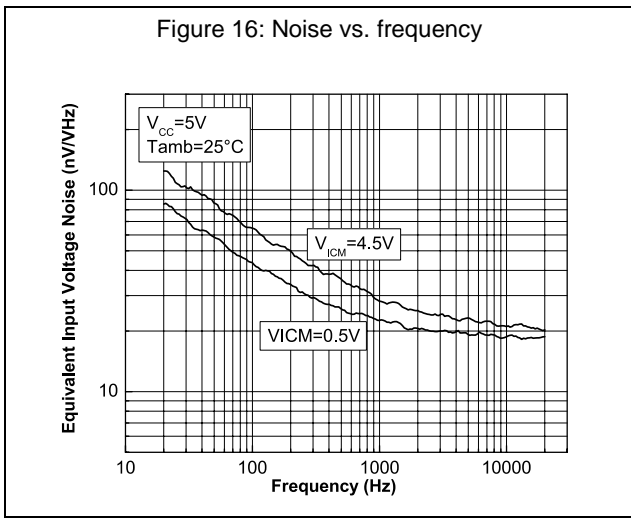
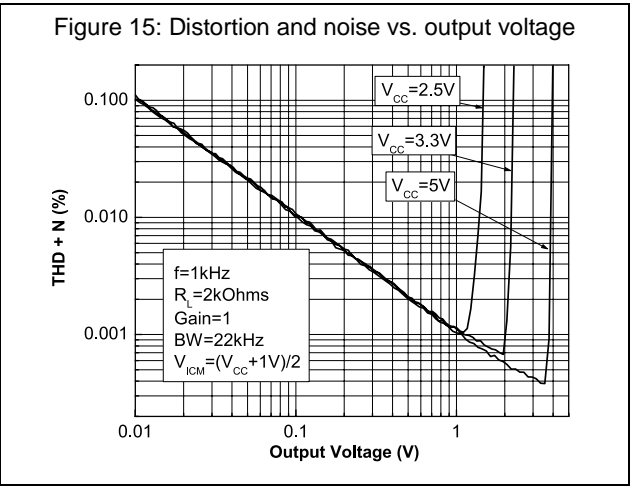
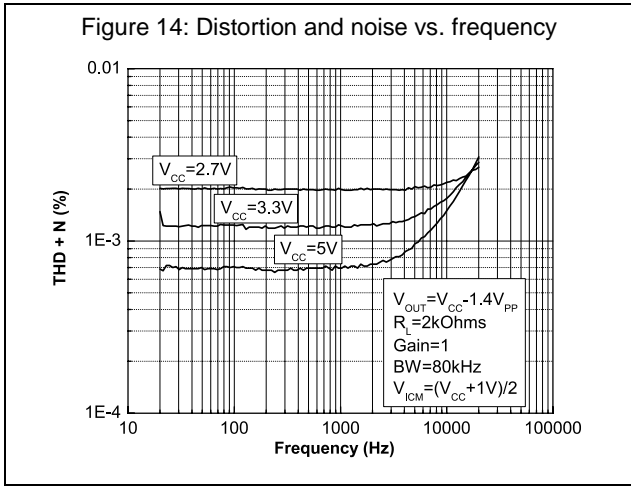


Figure 13: Negative slew rate





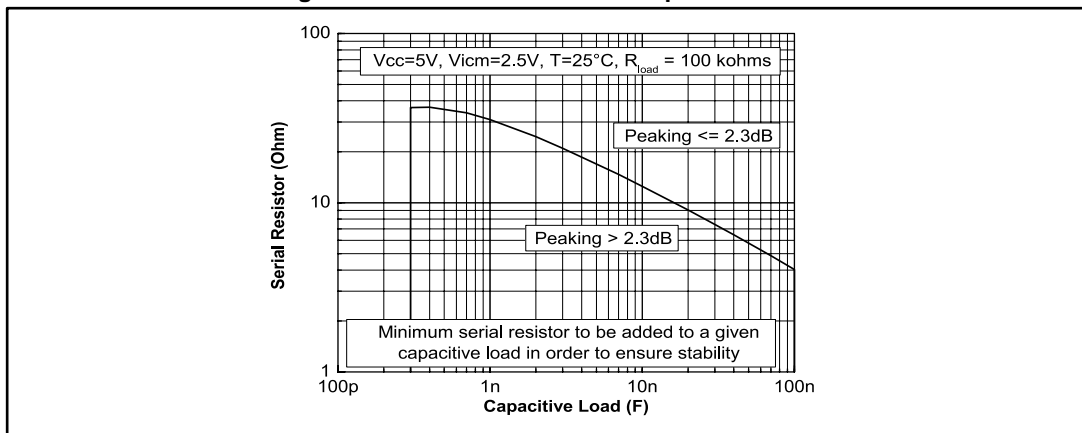
5 Application information

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 kΩ.

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.

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

Figure 20: SO8 package outline

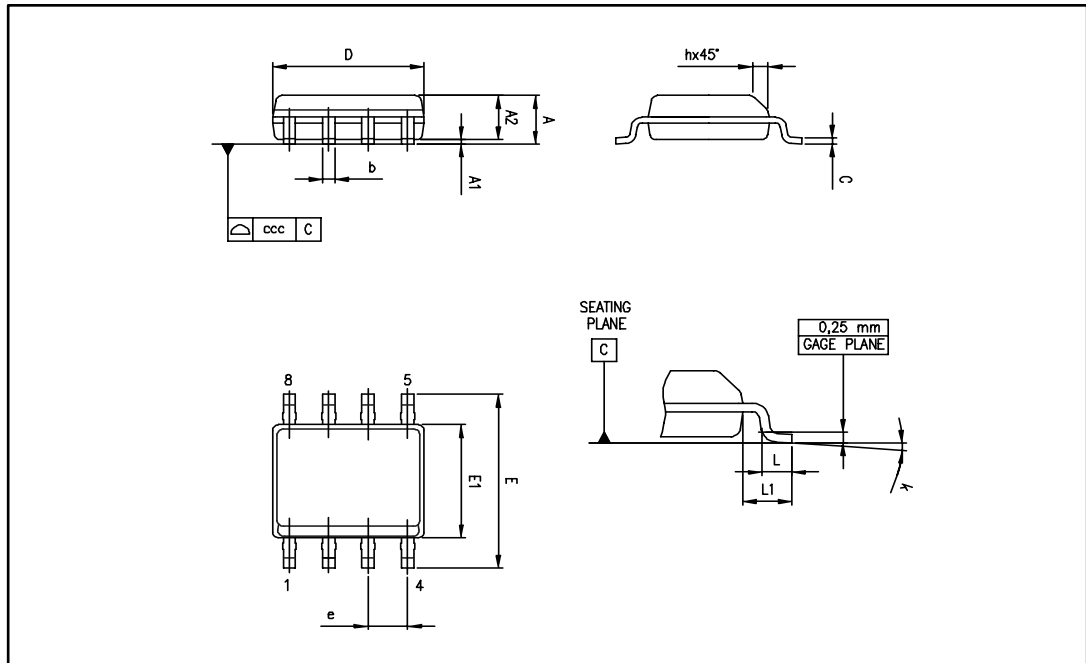


Table 6: SO8 mechanical data

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

7 Ordering information

Table 7: Order codes

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

Notes:

⁽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.

8 Revision history

Table 8: Document revision history

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