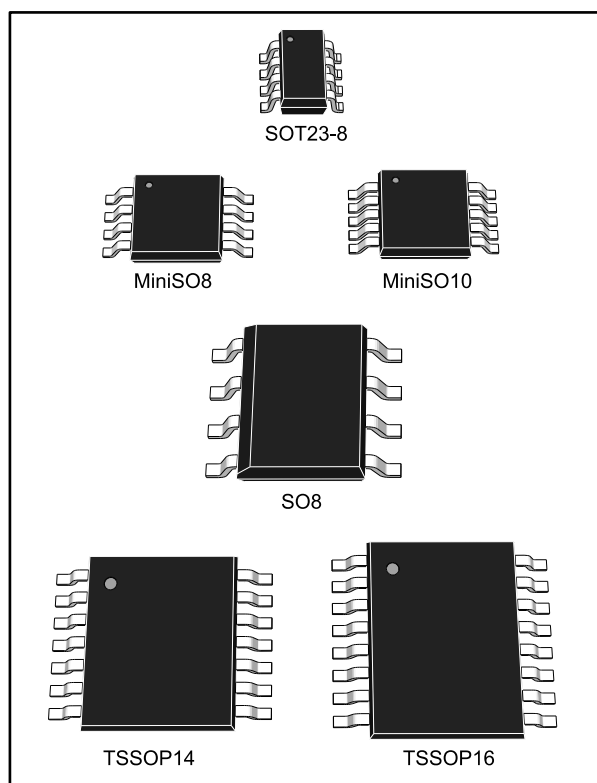


Micropower (60 μ A), wide bandwidth (2.4 MHz) CMOS op amps

Datasheet - production data



Applications

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

Description

The TSV639x series of dual and quad operational amplifiers (op amps) offers low voltage operation and rail-to-rail input and output.

For applications configured with gain, the TSV639x series offers an excellent speed/power consumption ratio, 2.4 MHz gain bandwidth product while consuming only 60 μ A at 5 V. The devices also feature an ultra-low input bias current and have a shutdown mode (TSV6393, TSV6395).

These features make the TSV639x family ideal for sensor interfaces, battery supplied and portable applications, as well as active filtering.

Features

- Rail-to-rail input and output
- Low-power consumption: 60 μ A typ at 5 V
- Low supply voltage: 1.5 V - 5.5 V
- Gain bandwidth product: 2.4 MHz typ, stable for gain equal or above -3 or 4
- Low-power shutdown mode: 5 nA typ
- Low offset voltage: 800 μ V max (A version)
- Low input bias current: 1 pA typ
- EMI hardened operational amplifiers
- High tolerance to ESD: 4 kV HBM
- Extended temperature range: -40 $^{\circ}$ C to 125 $^{\circ}$ C

Table 1: Device summary

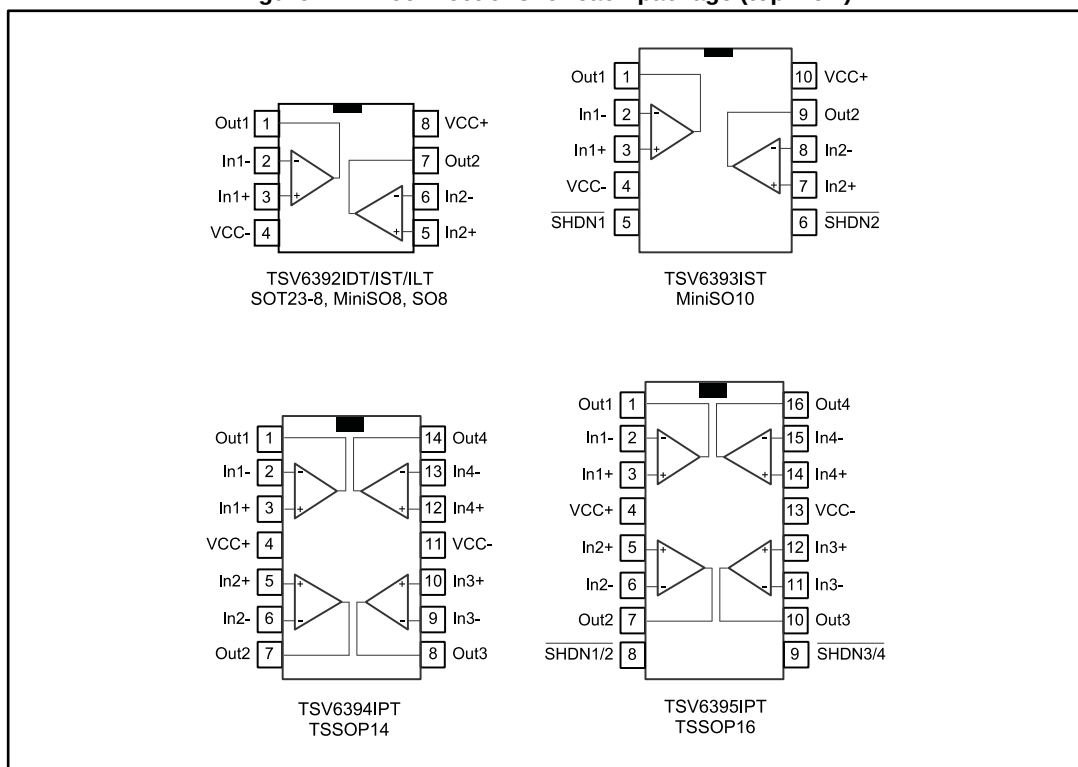
Reference	Dual version		Quad version	
	Without standby	With standby	Without standby	With standby
TSV639x	TSV6392	TSV6393	TSV6394	TSV6395
TSV639xA	TSV6392A	TSV6393A	TSV6394A	TSV6395A

Contents

1	Package pin connections.....	3
2	Absolute maximum ratings and operating conditions	4
3	Electrical characteristics	5
4	Electrical characteristic curves	10
5	Application information	13
	5.1 Operating voltages	13
	5.2 Rail-to-rail input	13
	5.3 Rail-to-rail output.....	13
	5.4 Shutdown function (TSV6393 - TSV6395)	14
	5.5 Optimization of DC and AC parameters	15
	5.6 Driving resistive and capacitive loads	15
	5.7 PCB layouts	15
	5.8 Macromodel	15
6	Package information	16
	6.1 SOT23-8 package information	17
	6.2 MiniSO8 package information	18
	6.3 MiniSO10 package information	19
	6.4 SO8 package information.....	20
	6.5 TSSOP14 package information.....	21
	6.6 TSSOP16 package information.....	22
7	Ordering information.....	23
8	Revision history	24

1 Package pin connections

Figure 1: Pin connections for each package (top view)



2 Absolute maximum ratings and operating conditions

Table 2: 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_{in}	Input voltage ⁽³⁾		$(V_{CC}) - 0.2$ to $(V_{CC}^{+}) + 0.2$	
I_{in}	Input current ⁽⁴⁾		10	mA
$\overline{SHDN}$	Shutdown voltage ⁽³⁾		$(V_{CC}) - 0.2$ to $(V_{CC}^{+}) + 0.2$	V
T_{stg}	Storage temperature		-65 to 150	°C
T_j	Maximum junction temperature		150	
R_{thja}	Thermal resistance junction to ambient ⁽⁵⁾⁽⁶⁾	SOT23-8	105	°C/W
		MiniSO8	190	
		MiniSO10	113	
		SO8	125	
		TSSOP14	100	
		TSSOP16	95	
ESD	HBM: human body model ⁽⁷⁾		4	kV
	MM: machine model ⁽⁸⁾		300	V
	CDM: charged device model ⁽⁹⁾		1.5	kV
	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, V_{in} must not exceed 6 V.

⁽⁴⁾ The 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: 100 pF discharged through a 1.5 k Ω resistor between two pins of the device, done for all couples of pin combinations with other pins 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), done for all couples of pin combinations with other pins floating.

⁽⁹⁾ Charged device model: all pins plus package are charged together to the specified voltage and then discharged directly to the ground.

Table 3: Operating conditions

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage	1.5 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 125	°C

3 Electrical characteristics

Table 4: Electrical characteristics at $V_{CC+} = 1.8\text{ V}$ with $V_{CC-} = 0\text{ V}$, $V_{icm} = V_{CC}/2$, $T_{amb} = 25\text{ }^{\circ}\text{C}$, and R_L connected to $V_{CC}/2$ (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit	
DC performance							
V _{io}	Offset voltage	TSV639x			3	mV	
		TSV639xA			0.8		
		TSV6393AIST (MiniSO10)			1		
		T _{min} < T _{op} < T _{max} , TSV639x			4.5		
		T _{min} < T _{op} < T _{max} , TSV639xA			2		
		T _{min} < T _{op} < T _{max} , TSV6393AIST			2.2		
DV _{io}	Input offset voltage drift			2		μV/°C	
I _{io}	Input offset current, V _{out} = V _{CC} /2			1	10 ⁽¹⁾	pA	
		T _{min} < T _{op} < T _{max}		1	100		
I _{ib}	Input bias current, V _{out} = V _{CC} /2			1	10 ⁽¹⁾		100
		T _{min} < T _{op} < T _{max}		1	100		
CMR	Common mode rejection ratio 20 log (ΔV _{ic} /ΔV _{io})	0 V to 1.8 V, V _{out} = 0.9 V	53	74		dB	
		T _{min} < T _{op} < T _{max}	51				
A _{vd}	Large signal voltage gain	R _L = 10 kΩ, V _{out} = 0.5 V to 1.3 V	85	95			
		T _{min} < T _{op} < T _{max}	80				
V _{OH}	High-level output voltage, V _{OH} = V _{CC} - V _{out}	R _L = 10 kΩ		5	35	mV	
		R _L = 10 kΩ, T _{min} < T _{op} < T _{max}			50		
V _{OL}	Low-level output voltage	R _L = 10 kΩ		4	35		50
		R _L = 10 kΩ, T _{min} < T _{op} < T _{max}					
I _{out}	I _{sink}	V _o = 1.8 V	6	12		mA	
		T _{min} < T _{op} < T _{max}	4				
	I _{source}	V _o = 0 V	6	10			
		T _{min} < T _{op} < T _{max}	4				
I _{CC}	Supply current (per operator)	No load, V _{out} = V _{CC} /2	40	50	60	μA	
		T _{min} < T _{op} < T _{max}			62		
AC performance							
GBP	Gain bandwidth product	R _L = 10 kΩ, C _L = 100 pF		2		MHz	
Gain	Minimum gain for stability	Phase margin = 60 °, R _f = 10 kΩ, R _L = 10 kΩ, C _L = 20 pF		4		V/V	
				-3			
SR	Slew rate	R _L = 10 kΩ, C _L = 100 pF, V _{out} = 0.5 V to 1.3 V		0.7		V/μs	
e _n	Equivalent input noise voltage	f = 1 kHz		60		nV/√Hz	
		f = 10 kHz		33			

Notes:

⁽¹⁾Guaranteed by design.



Table 5: Shutdown characteristics VCC = 1.8 V

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
I_{CC}	Supply current in shutdown mode (all operators)	$\overline{SHDN} = V_{CC}^-$		2.5	50	nA
		$T_{min} < T_{op} < 85\text{ }^{\circ}\text{C}$			200	
		$T_{min} < T_{op} < 125\text{ }^{\circ}\text{C}$			1.5	μA
t_{on}	Amplifier turn-on time	$R_L = 2\text{ k}\Omega$, $V_{out} = (V_{CC}^-)$ to $(V_{CC}^-) + 0.2\text{ V}$		200		ns
t_{off}	Amplifier turn-off time	$R_L = 2\text{ k}\Omega$, $V_{out} = (V_{CC}^+) - 0.5\text{ V}$ to $(V_{CC}^+) - 0.7\text{ V}$		20		
V_{IH}	$\overline{SHDN}$ logic high		1.35			V
V_{IL}	$\overline{SHDN}$ logic low				0.6	
I_{IH}	$\overline{SHDN}$ current high	$\overline{SHDN} = V_{CC}^+$		10		pA
I_{IL}	$\overline{SHDN}$ current low	$\overline{SHDN} = V_{CC}^-$		10		
I_{OLeak}	Output leakage in shutdown mode	$\overline{SHDN} = V_{CC}^-$		50		nA
		$T_{min} < T_{op} < 125\text{ }^{\circ}\text{C}$		1		

Table 6: Electrical characteristics at $V_{CC+} = 3.3\text{ V}$, $V_{CC-} = 0\text{ V}$, $V_{icm} = V_{CC}/2$, $T_{amb} = 25\text{ }^{\circ}\text{C}$, R_L connected to $V_{CC}/2$ (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit	
DC performance							
V _{io}	Offset voltage	TSV639x			3	mV	
		TSV639xA			0.8		
		TSV6393AIST (MiniSO10)			1		
		T _{min} < T _{op} < T _{max} , TSV639x			4.5		
		T _{min} < T _{op} < T _{max} , TSV639xA			2		
		T _{min} < T _{op} < T _{max} , TSV6393AIST			2.2		
DV _{io}	Input offset voltage drift			2		μV/°C	
I _{io}	Input offset current			1	10 ⁽¹⁾	pA	
		T _{min} < T _{op} < T _{max}		1	100		
I _{ib}	Input bias current			1	10 ⁽¹⁾		
		T _{min} < T _{op} < T _{max}		1	100		
CMR	Common mode rejection ratio 20 log (ΔV _{ic} /ΔV _{io})	0 V to 3.3 V, V _{out} = 1.65 V	57	79		dB	
		T _{min} < T _{op} < T _{max}	53				
A _{vd}	Large signal voltage gain	R _L = 10 kΩ, V _{out} = 0.5 V to 2.8 V	88	98			
		T _{min} < T _{op} < T _{max}	83				
V _{OH}	High-level output voltage, V _{OH} = V _{CC} - V _{out}	R _L = 10 kΩ		6	35	mV	
		R _L = 10 kΩ, T _{mi.} < T _{op} < T _{max}			50		
V _{OL}	Low-level output voltage	R _L = 10 kΩ		7	35		
		R _L = 10 kΩ, T _{min} < T _{op} < T _{max}			50		
I _{out}	I _{sink}	V _o = 3.3 V	23	45		mA	
		T _{min} < T _{op} < T _{max}	20				
	I _{source}	V _o = 0 V	23	38			
		T _{min} < T _{op} < T _{max}	20				
I _{CC}	Supply current (per operator)	No load, V _{out} = 1.75 V	43	55	64	μA	
		T _{min} < T _{op} < T _{max}			66		
AC performance							
GBP	Gain bandwidth product	R _L = 10 kΩ, C _L = 100 pF		2.2		MHz	
Gain	Minimum gain for stability	Phase margin = 60 °, R _f = 10 kΩ, R _L = 10 kΩ, C _L = 20 pF		4		V/V	
				-3			
SR	Slew rate	R _L = 10 kΩ, C _L = 100 pF, V _{out} = 0.5 V to 2.8 V		0.9		V/μs	

Notes:

⁽¹⁾Guaranteed by design.

Table 7: Electrical characteristics at $V_{CC+} = 5\text{ V}$ with $V_{CC-} = 0\text{ V}$, $V_{icm} = V_{CC}/2$, $T_{amb} = 25\text{ }^{\circ}\text{C}$, and R_L connected to $V_{CC}/2$ (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit	
DC performance							
V _{io}	Offset voltages	TSV639x			3	mV	
		TSV639xA			0.8		
		TSV6393AIST (MiniSO10)			1		
		T _{min} < T _{op} < T _{max} , TSV639x			4.5		
		T _{min} < T _{op} < T _{max} , TSV639xA			2		
		T _{min} < T _{op} < T _{max} , TSV6393AIST			2.2		
DV _{io}	Input offset voltage drift			2		μV/°C	
I _{io}	Input offset current, V _{out} = V _{CC} /2			1	10 ⁽¹⁾	pA	
		T _{min} < T _{op} < T _{max}		1	100		
I _{ib}	Input bias current, V _{out} = V _{CC} /2			1	10 ⁽¹⁾		100
		T _{min} < T _{op} < T _{max}		1	100		
CMR	Common mode rejection ratio 20 log (ΔV _{ic} /ΔV _{io})	0 V to 5 V, V _{out} = 2.5 V	60	80		dB	
		T _{min} < T _{op} < T _{max}	55				
SVR	Supply voltage rejection ratio 20 log (ΔV _{CC} /ΔV _{io})	V _{CC} = 1.8 to 5 V	75	93			
		T _{min} < T _{op} < T _{max}	73				
A _{vd}	Large signal voltage gain	R _L = 10 kΩ, V _{out} = 0.5 V to 4.5 V	89	98			
		T _{min} < T _{op} < T _{max}	84				
EMIRR	EMI rejection ratio, EMIRR = -20 log (V _{RFpeak} /ΔV _{io})	V _{RF} = 100 mV _{rms} , f = 400 MHz		61			
		V _{RF} = 100 mV _{rms} , f = 900 MHz		85			
		V _{RF} = 100 mV _{rms} , f = 1800 MHz		92			
		V _{RF} = 100 mV _{rms} , f = 2400 MHz		83			
V _{OH}	High-level output voltage, V _{OH} = V _{CC} - V _{out}	R _L = 10 kΩ		7	35	mV	
		R _L = 10 kΩ, T _{min} < T _{op} < T _{max}			50		
V _{OL}	Low-level output voltage	R _L = 10 kΩ		6	35		
		R _L = 10 kΩ, T _{min} < T _{op} < T _{max}			50		
I _{out}	I _{sink}	V _o = 5 V	40	65		mA	
		T _{min} < T _{op} < T _{max}	35				
	I _{source}	V _o = 0 V	40	72			
		T _{min} < T _{op} < T _{max}	35				
I _{CC}	Supply current (per operator)	No load, V _{out} = V _{CC} /2	50	60	69	μA	
		T _{min} < T _{op} < T _{max}			72		
AC performance							
GBP	Gain bandwidth product	R _L = 10 kΩ, C _L = 100 pF		2.4		MHz	
Gain	Minimum gain for stability	Phase margin = 60 °, R _f = 10 kΩ, R _L = 10 kΩ, C _L = 20 pF,		4		V/V	
				-3			
SR	Slew rate	R _L = 10 kΩ, C _L = 100 pF		1.1		V/μs	

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
e_n	Equivalent input noise voltage	$f = 1 \text{ kHz}$		60		$\text{nV}/\sqrt{\text{Hz}}$
		$f = 10 \text{ kHz}$		33		
THD+N	Total harmonic distortion + noise	$V_{CC} = 5 \text{ V}$, $f_{in} = 1 \text{ kHz}$, $A_{CL} = -10$, $R_L = 100 \text{ k}\Omega$, $V_{icm} = V_{CC}/2$, $BW = 22 \text{ kHz}$, $V_{out} = 1 \text{ V}_{rms}$		0.015		%

Notes:

(1) Guaranteed by design.

Table 8: Shutdown characteristics at $V_{CC} = 5 \text{ V}$

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
DC performance						
I_{CC}	Supply current in shutdown mode (all operators)	$\overline{\text{SHDN}} = V_{CC}^-$		5	50	nA
		$T_{min} < T_{op} < 85 \text{ }^\circ\text{C}$			200	
		$T_{min} < T_{op} < 125 \text{ }^\circ\text{C}$			1.5	μA
t_{on}	Amplifier turn-on time	$R_L = 2 \text{ k}\Omega$, $V_{out} = (V_{CC}^-) \text{ V to } (V_{CC}^-) + 0.2 \text{ V}$		200		ns
t_{off}	Amplifier turn-off time	$R_L = 2 \text{ k}\Omega$, $V_{out} = (V_{CC}^+) - 0.5 \text{ V to } (V_{CC}^+) - 0.7 \text{ V}$		20		
V_{IH}	$\overline{\text{SHDN}}$ logic high		2			V
V_{IL}	$\overline{\text{SHDN}}$ logic low				0.8	V
I_{IH}	$\overline{\text{SHDN}}$ current high	$\overline{\text{SHDN}} = V_{CC}^+$		10		pA
I_{IL}	$\overline{\text{SHDN}}$ current low	$\overline{\text{SHDN}} = V_{CC}^-$		10		
I_{OLeak}	Output leakage in shutdown mode	$\overline{\text{SHDN}} = V_{CC}^-$		50		
		$T_{min} < T_{op} < 125 \text{ }^\circ\text{C}$		1		nA

4 Electrical characteristic curves

Figure 2: Supply current vs. supply voltage
at $V_{icm} = V_{CC}/2$

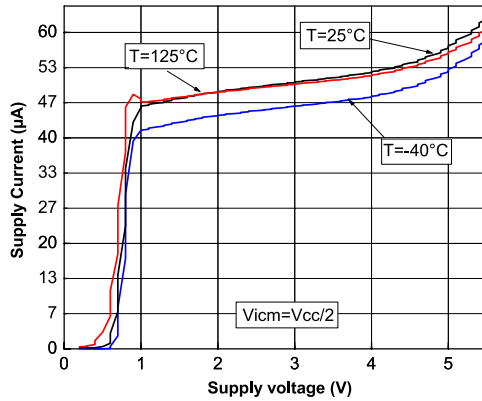


Figure 3: Output current vs. output voltage
at $V_{CC} = 1.5\text{ V}$

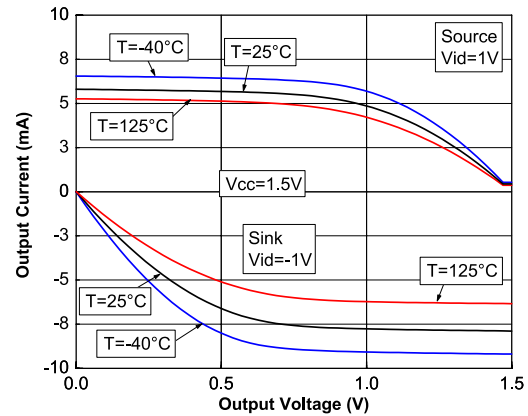


Figure 4: Output current vs. output voltage
at $V_{CC} = 5\text{ V}$

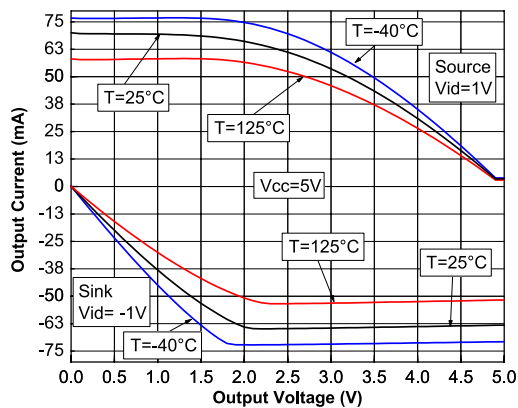


Figure 5: Closed loop response for gain = -10,
at $V_{CC} = 1.5\text{ V}$ and $V_{CC} = 5\text{ V}$

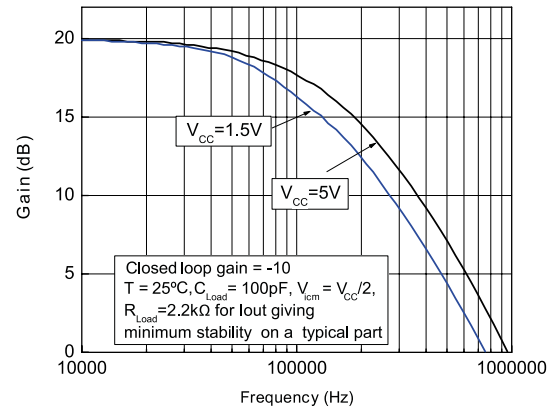


Figure 6: Closed loop response for gain = -3
at $V_{CC} = 1.5\text{ V}$

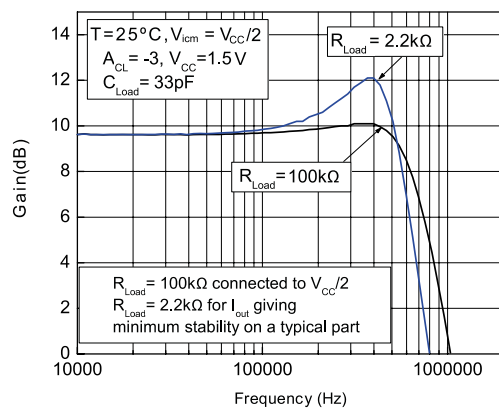


Figure 7: Closed loop response for gain = -3
at $V_{CC} = 5\text{ V}$

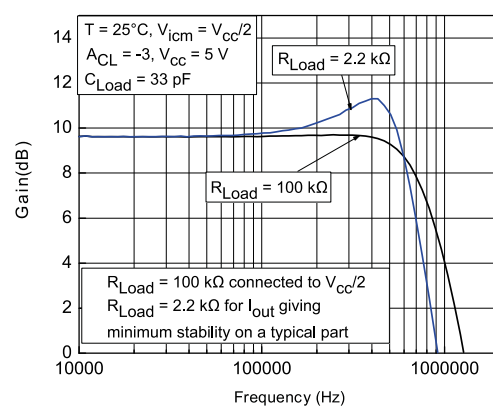


Figure 8: Positive slew rate vs. supply voltage in closed loop

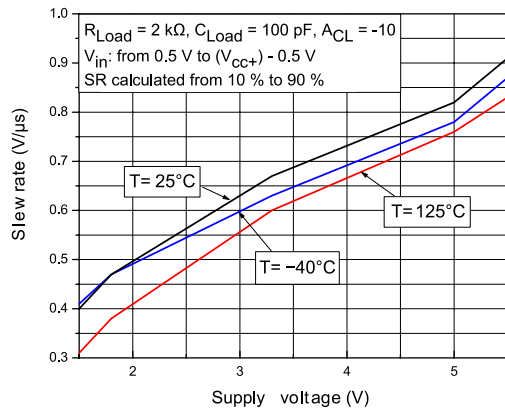


Figure 9: Negative slew rate vs. supply voltage in closed loop

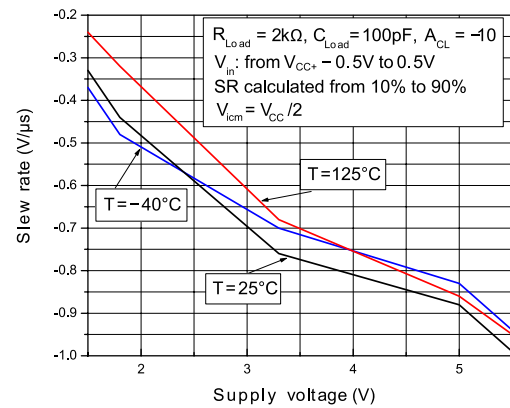


Figure 10: Slew rate vs. supply voltage in open loop

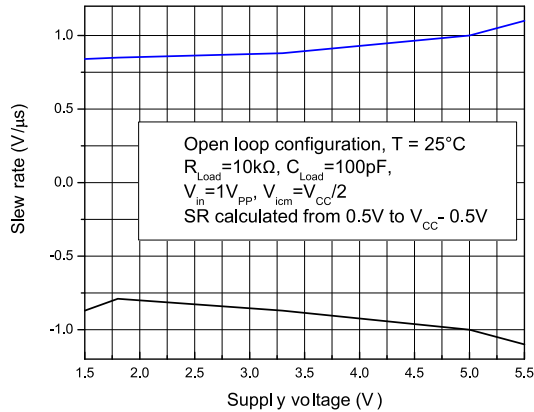


Figure 11: Slew rate timing in open loop

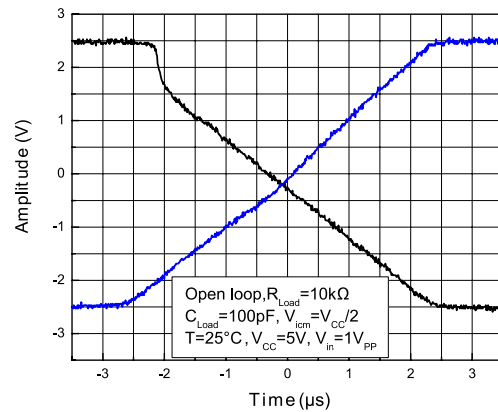


Figure 12: Slew rate timing in closed loop

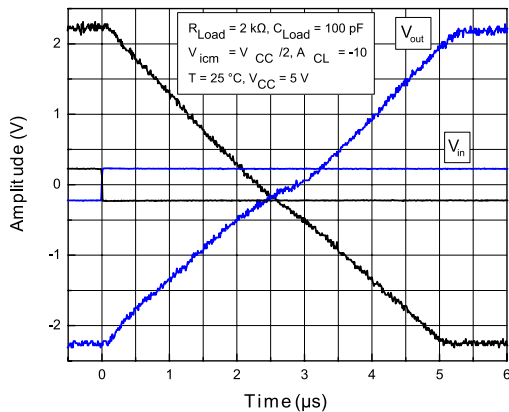


Figure 13: Noise vs. frequency

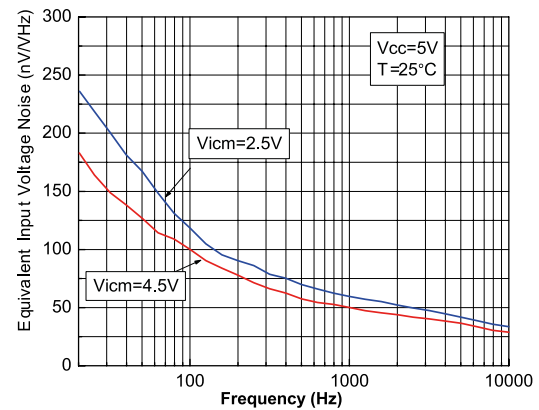
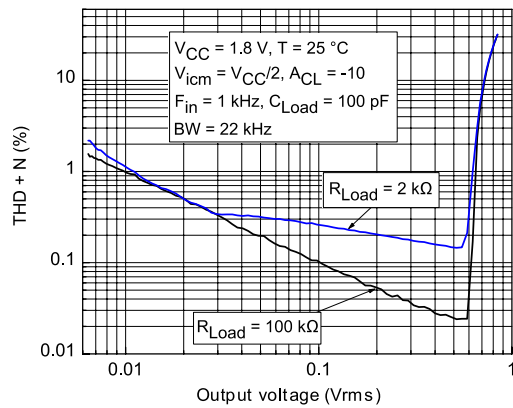
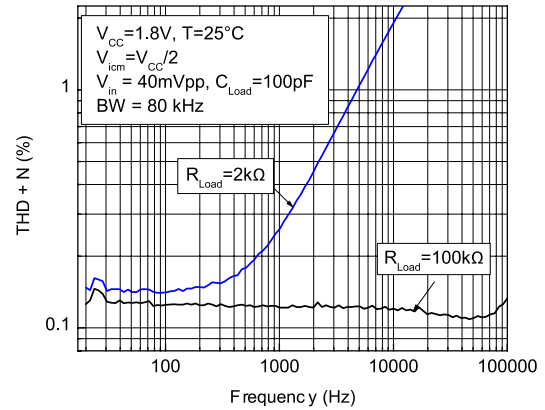
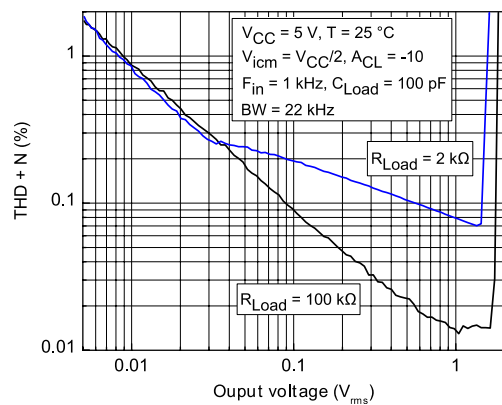
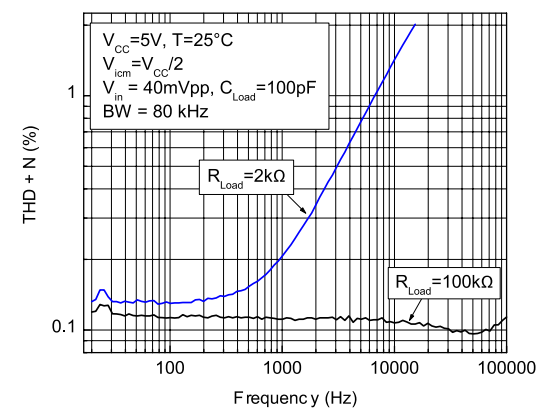
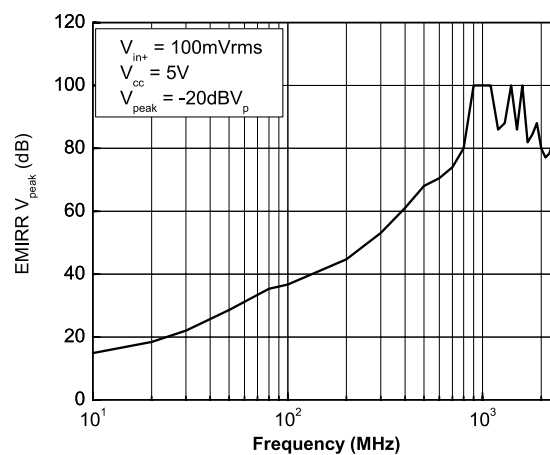


Figure 14: Distortion and noise vs. output voltage at $V_{CC} = 1.8\text{ V}$ Figure 15: Distortion and noise vs. frequency at $V_{CC} = 1.8\text{ V}$ Figure 16: Distortion and noise vs. output voltage at $V_{CC} = 5\text{ V}$ Figure 17: Distortion and noise vs. frequency at $V_{CC} = 5\text{ V}$ Figure 18: EMIRR vs. frequency at $V_{CC} = 5\text{ V}$, $T = 25^\circ\text{C}$ 

5 Application information

5.1 Operating voltages

The TSV639x can operate from 1.5 to 5.5 V. Their parameters are fully specified for 1.8, 3.3 and 5 V power supplies. However, the parameters are very stable in the full V_{CC} range and several characterization curves show the TSV639x characteristics at 1.5 V. Additionally, the main specifications are guaranteed in extended temperature ranges from -40 °C to 125 °C.

5.2 Rail-to-rail input

The TSV639x are built with two complementary PMOS and NMOS input differential pairs. The devices have a rail-to-rail input, and the input common mode range is extended from $(V_{CC}^+) - 0.1$ V to $(V_{CC}^+) + 0.1$ V. The transition between the two pairs appears at $(V_{CC}^+) - 0.7$ V. In the transition region, the performance of CMR, SVR, V_{io} (Figure 19 and Figure 20) and THD is slightly degraded.

Figure 19: Input offset voltage vs input common-mode at $V_{CC} = 1.5$ V

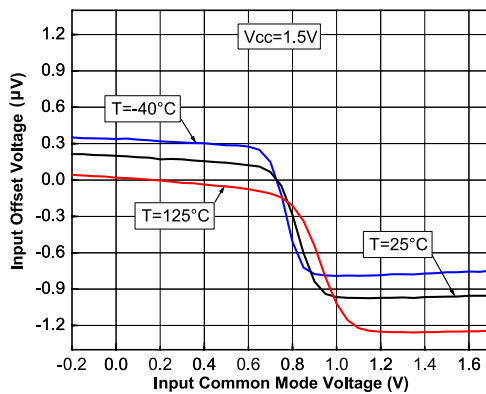
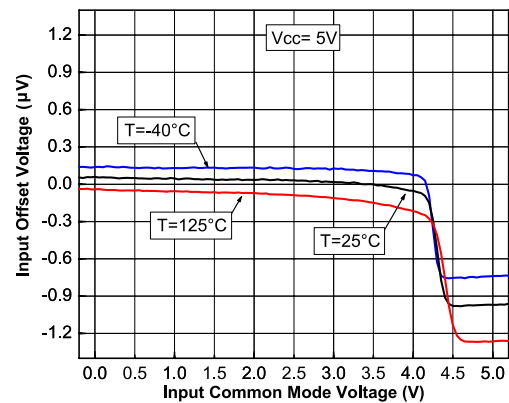


Figure 20: Input offset voltage vs input common-mode at $V_{CC} = 5$ V



The devices are guaranteed without phase reversal.

5.3 Rail-to-rail output

The operational amplifiers' output levels can go close to the rails: 35 mV maximum above and below the rail when connected to a 10 kΩ resistive load to $V_{CC}/2$.

5.4 Shutdown function (TSV6393 - TSV6395)

The operational amplifiers are enabled when the $\overline{\text{SHDN}}$ pin is pulled high. To disable the amplifiers, the $\overline{\text{SHDN}}$ must be pulled down to V_{CC}^- . When in shutdown mode, the amplifiers' output is in a high impedance state. The $\overline{\text{SHDN}}$ pin must never be left floating but tied to V_{CC}^+ or V_{CC}^- .

The turn-on and turn-off times are calculated for an output variation of 200 mV ([Figure 21](#) and [Figure 22](#) show the test configurations).

Figure 21: Test configuration for turn-on time (Vout pulled down)

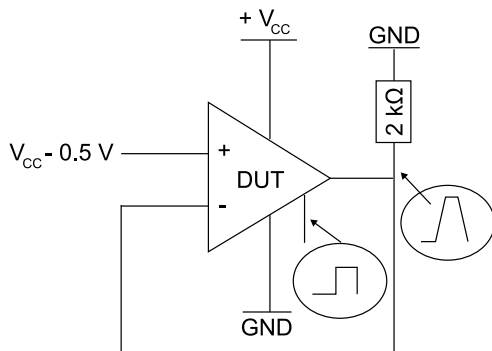


Figure 22: Test configuration for turn-off time (Vout pulled down)

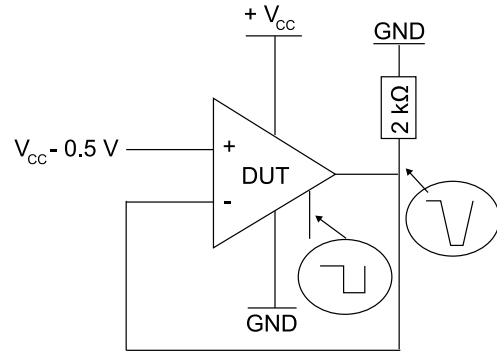


Figure 23: Turn-on time, $V_{\text{CC}} = 5 \text{ V}$, Vout pulled down, $T = 25^\circ \text{C}$

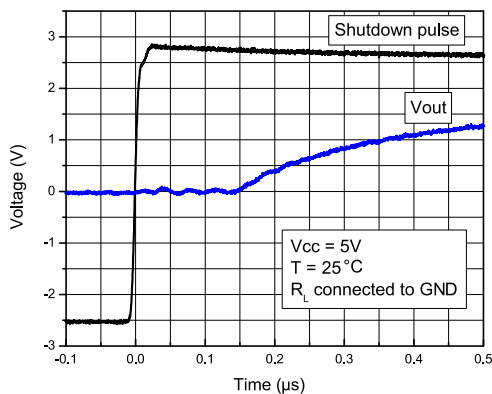
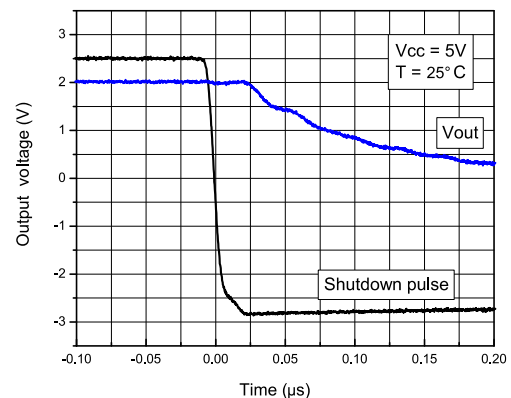


Figure 24: Turn-off time, $V_{\text{CC}} = 5 \text{ V}$, Vout pulled down, $T = 25^\circ \text{C}$



5.5 Optimization of DC and AC parameters

These devices use an innovative approach to reduce the spread of the main DC and AC parameters. An internal adjustment achieves a very narrow spread of the current consumption (60 μ A typical, min/max at $\pm 17\%$). Parameters linked to the current consumption value, such as GBP, SR and A_{vd} , benefit from this narrow dispersion.

5.6 Driving resistive and capacitive loads

These products are micropower, low-voltage operational amplifiers optimized to drive rather large resistive loads, above 2 k Ω . For lower resistive loads, the THD level may significantly increase.

The amplifiers have a relatively low internal compensation capacitor, making them very fast while consuming very little. They are ideal when used in a non-inverting configuration or in an inverting configuration in the following conditions.

- $|Gain| \geq 3$ in an inverting configuration ($C_L = 20$ pF, $R_L = 100$ k Ω) or $|gain| \geq 10$ ($C_L = 100$ pF, $R_L = 100$ k Ω)
- $Gain \geq 4$ in a non-inverting configuration ($C_L = 20$ pF, $R_L = 100$ k Ω) or $gain \geq 11$ ($C_L = 100$ pF, $R_L = 100$ k Ω)

As these operational amplifiers are not unity gain stable, for a low closed-loop gain, it is recommended to use the TSV63x (60 μ A, 880 kHz) which is unity gain stable.

Table 9: Related products

Part #	I _{cc} (μ A) at 5 V	GBP (MHz)	SR (V/ μ s)	Minimum gain for stability (C _{Load} = 100 pF)
TSV62-2-3-4-5	29	0.42	0.14	1
TSV629-2-3-4-5	29	1.3	0.5	11
TSV63-2-3-4-5	60	0.88	0.34	1
TSV639-2-3-4-5	60	2.4	1.1	11

5.7 PCB layouts

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

5.8 Macromodel

Two accurate macromodels (with or without shutdown feature) of the TSV639x are available on STMicroelectronics' web site at www.st.com. This model is a trade-off between accuracy and complexity (that is, time simulation) of the TSV639x operational amplifiers. It emulates the nominal performances of a typical device within the specified operating conditions mentioned in the datasheet. It also helps to validate a design approach and to select the right operational amplifier, *but it does not replace on-board measurements*.

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 SOT23-8 package information

Figure 25: SOT23-8 package outline

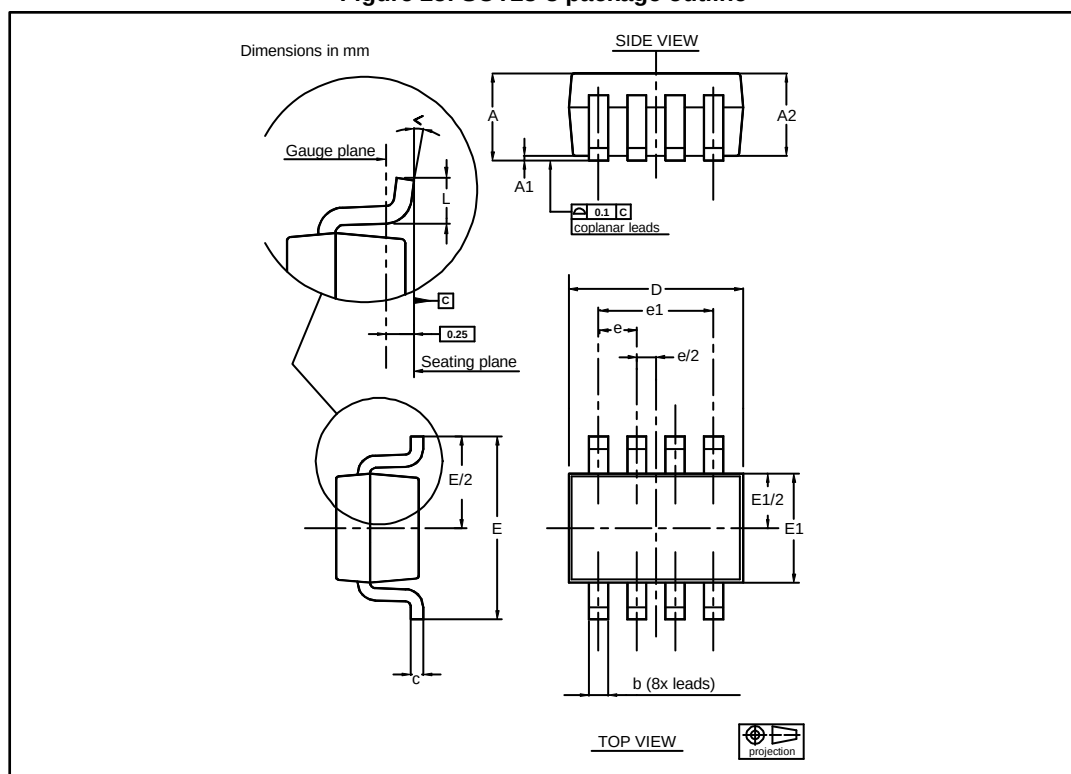


Table 10: SOT23-8 mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.45			0.057
A1			0.15			0.006
A2	0.90		1.30	0.035		0.051
b	0.22		0.38	0.009		0.015
c	0.08		0.22	0.003		0.009
D	2.80		3.00	0.110		0.118
E	2.60		3.00	0.102		0.118
E1	1.50		1.75	0.059		0.069
e		0.65			0.026	
e1		1.95			0.077	
L	0.30		0.60	0.012		0.024
<	0 °		8 °	0 °		8 °

6.2 MiniSO8 package information

Figure 26: MiniSO8 package outline

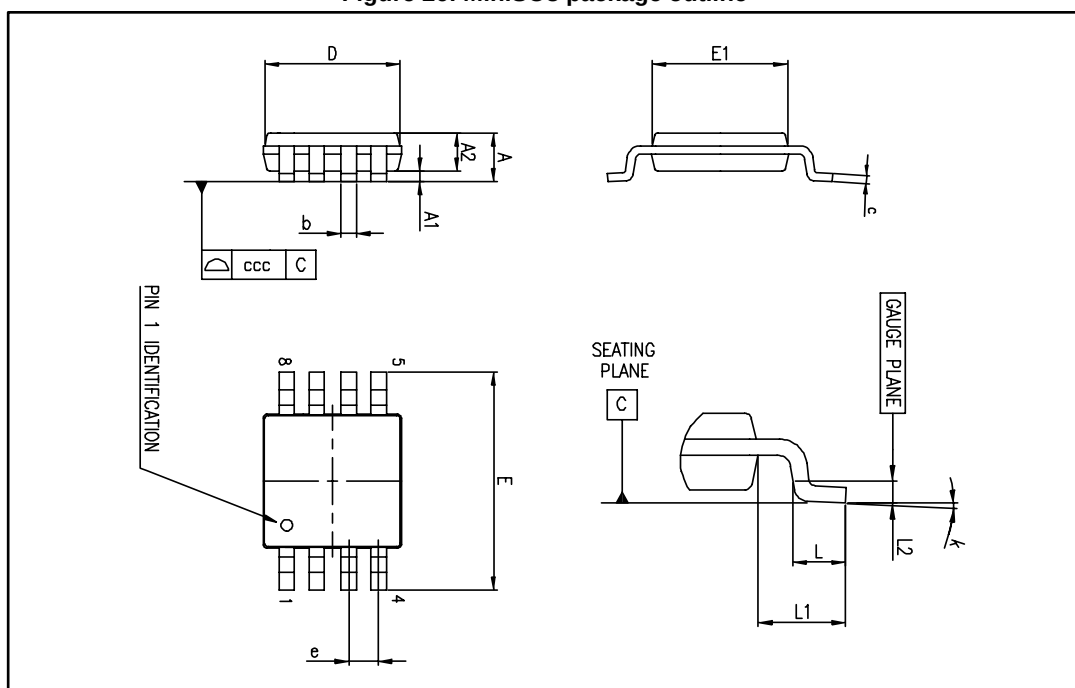


Table 11: MiniSO8 mechanical data

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

6.3 MiniSO10 package information

Figure 27: MiniSO10 package outline

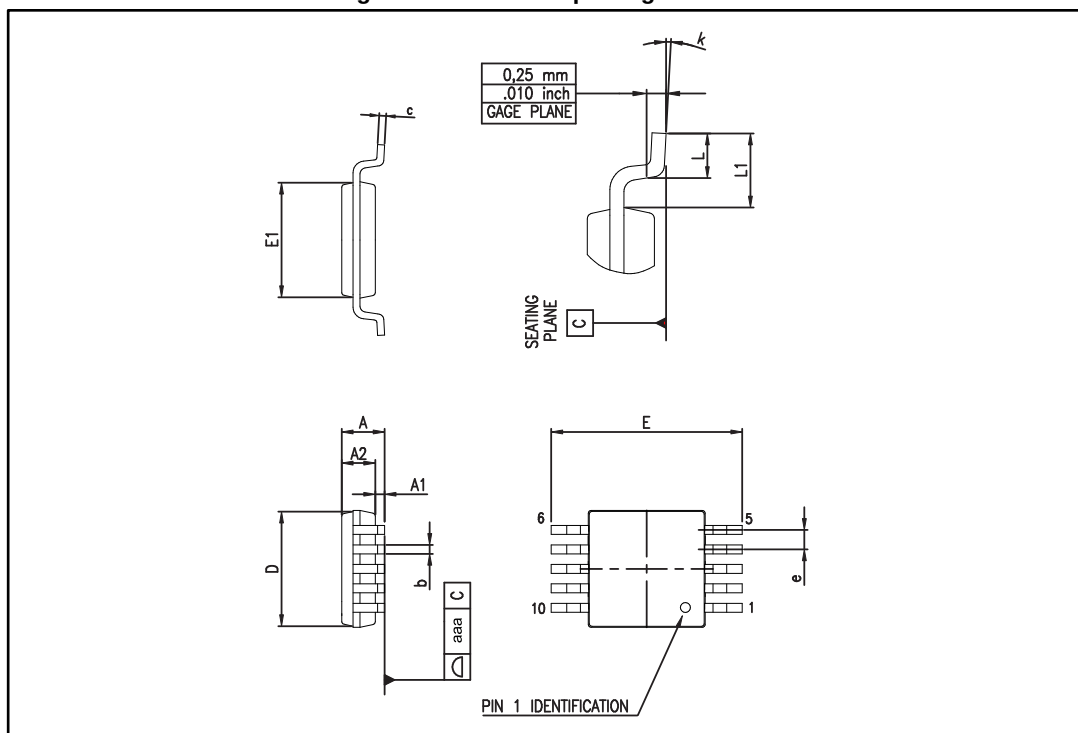


Table 12: MiniSO10 mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.10			0.043
A1	0.05	0.10	0.15	0.002	0.004	0.006
A2	0.78	0.86	0.94	0.031	0.034	0.037
b	0.25	0.33	0.40	0.010	0.013	0.016
c	0.15	0.23	0.30	0.006	0.009	0.012
D	2.90	3.00	3.10	0.114	0.118	0.122
E	4.75	4.90	5.05	0.187	0.193	0.199
E1	2.90	3.00	3.10	0.114	0.118	0.122
e		0.50			0.020	
L	0.40	0.55	0.70	0.016	0.022	0.028
L1		0.95			0.037	
k	0 °	3 °	6 °	0 °	3 °	6 °
aaa			0.10			0.004

6.4 SO8 package information

Figure 28: SO8 package outline

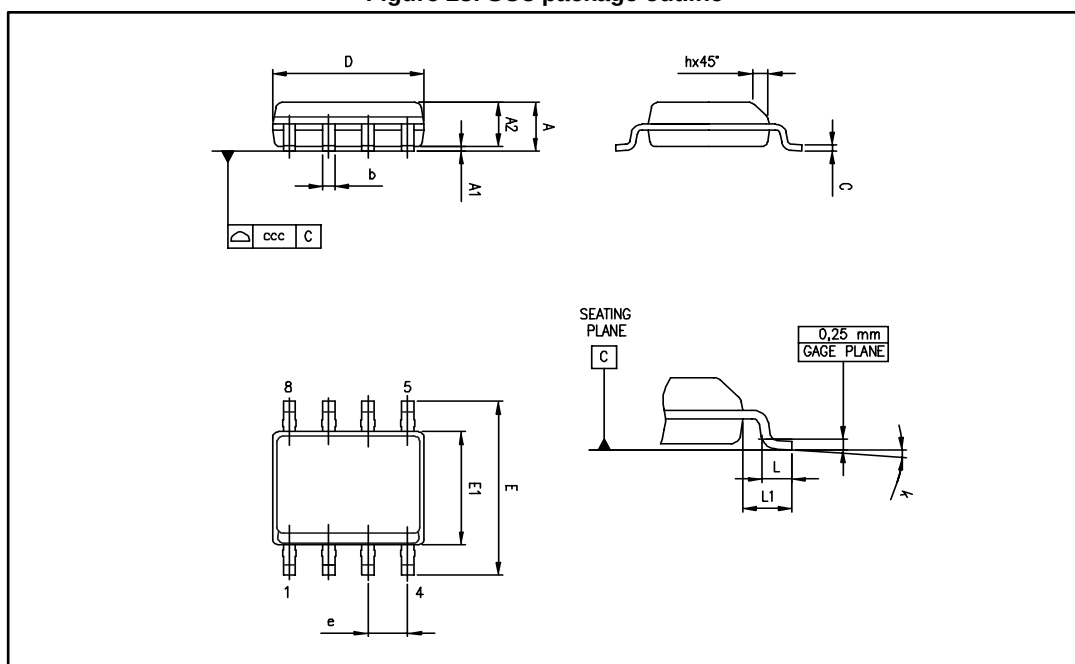


Table 13: SO8 mechanical data

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

6.5 TSSOP14 package information

Figure 29: TSSOP14 package outline

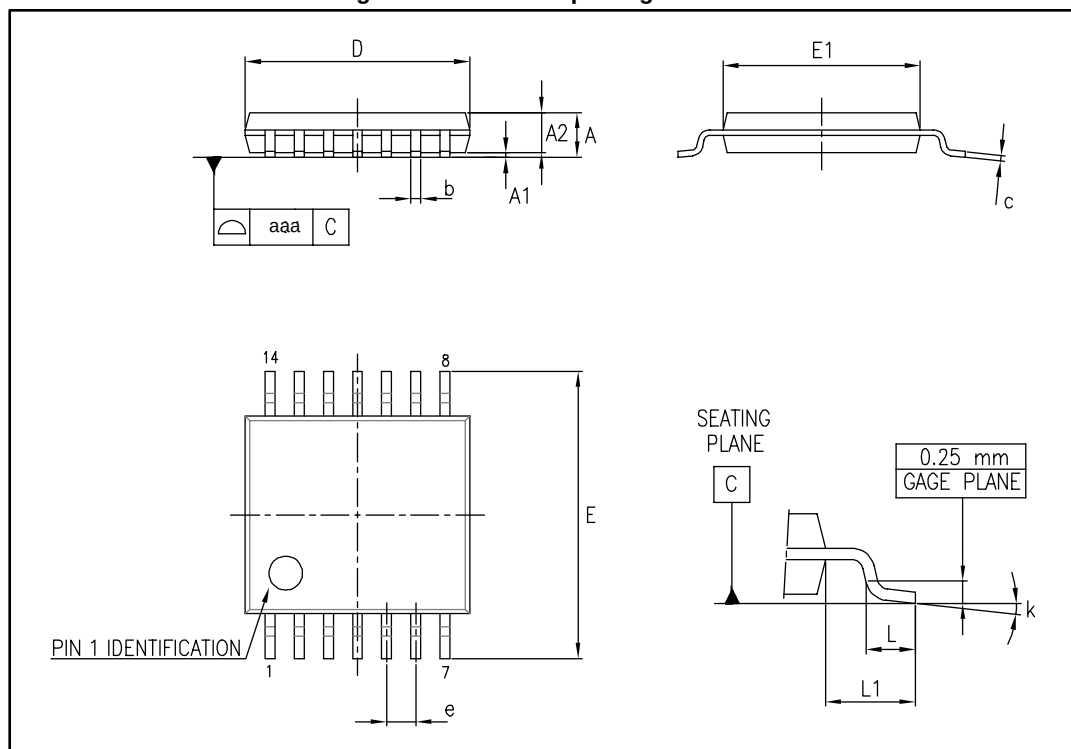


Table 14: TSSOP14 mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.047
A1	0.05		0.15	0.002	0.004	0.006
A2	0.80	1.00	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	4.90	5.00	5.10	0.193	0.197	0.201
E	6.20	6.40	6.60	0.244	0.252	0.260
E1	4.30	4.40	4.50	0.169	0.173	0.176
e		0.65			0.0256	
L	0.45	0.60	0.75	0.018	0.024	0.030
L1		1.00			0.039	
k	0°		8°	0°		8°
aaa			0.10			0.004

6.6 TSSOP16 package information

Figure 30: TSSOP16 package outline

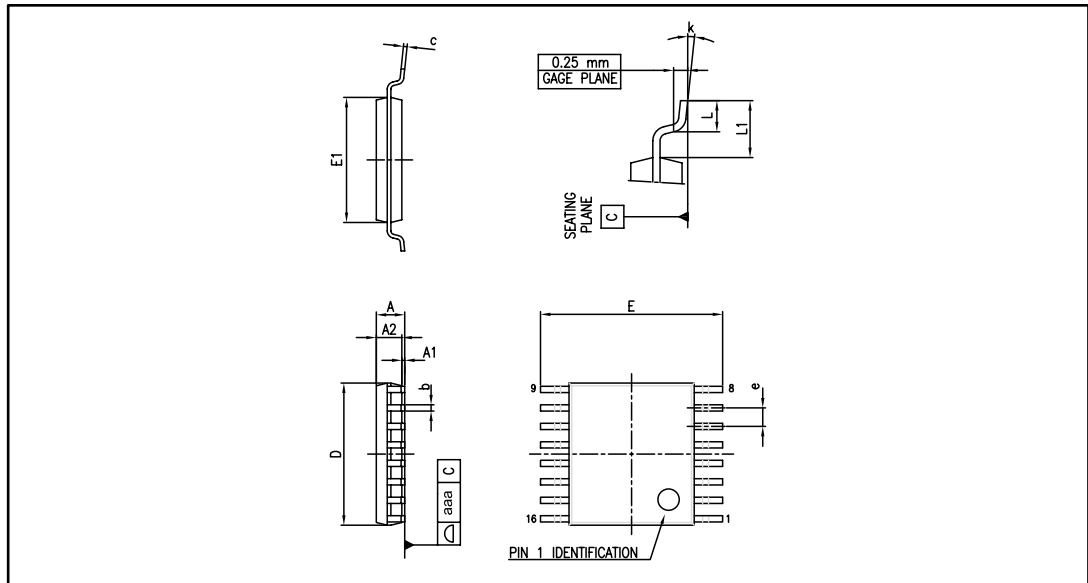


Table 15: TSSOP16 mechanical data

Ref	Dimensions					
	Millimeters			Inches		
	Min	Typ	Max	Min	Typ	Max
A			1.20			0.047
A1	0.05		0.15	0.002		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.012
c	0.09		0.20	0.004		0.008
D	4.90	5.00	5.10	0.193	0.197	0.201
E	6.20	6.40	6.60	0.244	0.252	0.260
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.026	
k	0°		8°	0°		8°
L	0.45	0.60	0.75	0.018	0.024	0.030
L1		1.00			0.039	
aaa			0.10			0.004

7 Ordering information

Table 16: Order codes

Order code	Temperature range	Package	Packing	Marking
TSV6392IDT	-40 °C to 125 °C	SO8	Tape and reel	V6392I
TSV6392AIDT				V632AI
TSV6392IST		MiniSO8		K111
TSV6392AIST				K146
TSV6392ILT		SOT23-8		K111
TSV6393IST		MiniSO10		K111
TSV6393AIST				K145
TSV6394IPT		TSSOP14		V6394I
TSV6394AIPT				V6394AI
TSV6395IPT		TSSOP16		V6395I
TSV6395AIPT				V6395AI

8 Revision history

Table 17: Document revision history

Date	Revision	Changes
18-Jan-2010	1	Initial release
29-Feb-2016	2	Updated layout Table 4 , Table 6 , and Table 7 : for V_{OH} , added $V_{OH} = V_{CC} - V_{out}$ to the parameter column; moved the values in the “min” column to the “max” column. Table 10: “SOT23-8 mechanical data” : added angle information to “Inches” columns. Table 16: “Order codes” : removed obsolete order codes TSV6392ID and TSV6392AID.

IMPORTANT NOTICE – PLEASE READ CAREFULLY

STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, enhancements, modifications, and improvements to ST products and/or to this document at any time without notice. Purchasers should obtain the latest relevant information on ST products before placing orders. ST products are sold pursuant to ST's terms and conditions of sale in place at the time of order acknowledgement.

Purchasers are solely responsible for the choice, selection, and use of ST products and ST assumes no liability for application assistance or the design of Purchasers' products.

No license, express or implied, to any intellectual property right is granted by ST herein.

Resale of ST products with provisions different from the information set forth herein shall void any warranty granted by ST for such product.

ST and the ST logo are trademarks of ST. All other product or service names are the property of their respective owners.

Information in this document supersedes and replaces information previously supplied in any prior versions of this document.

© 2016 STMicroelectronics – All rights reserved