

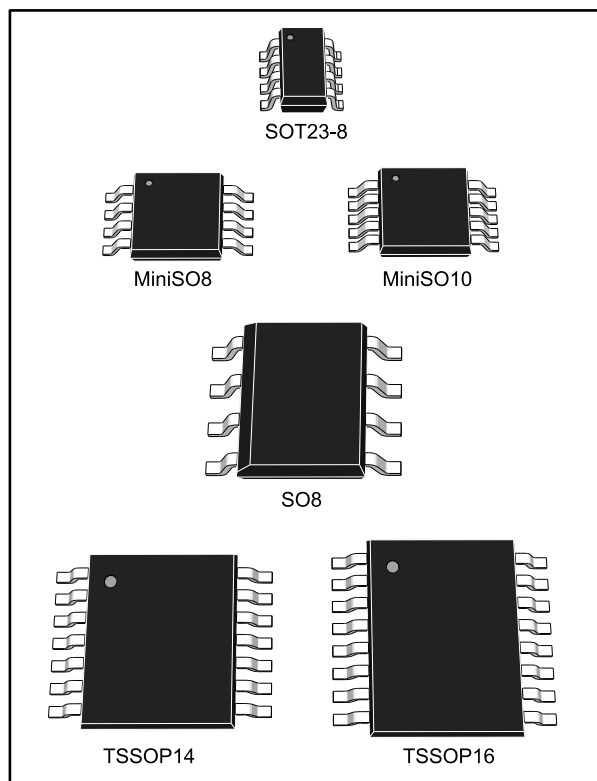


# THE DATASHEET OF TSV6392ILT



## Micropower (60 $\mu$ 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  $\mu$ 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  $\mu$ 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  $\mu$ 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

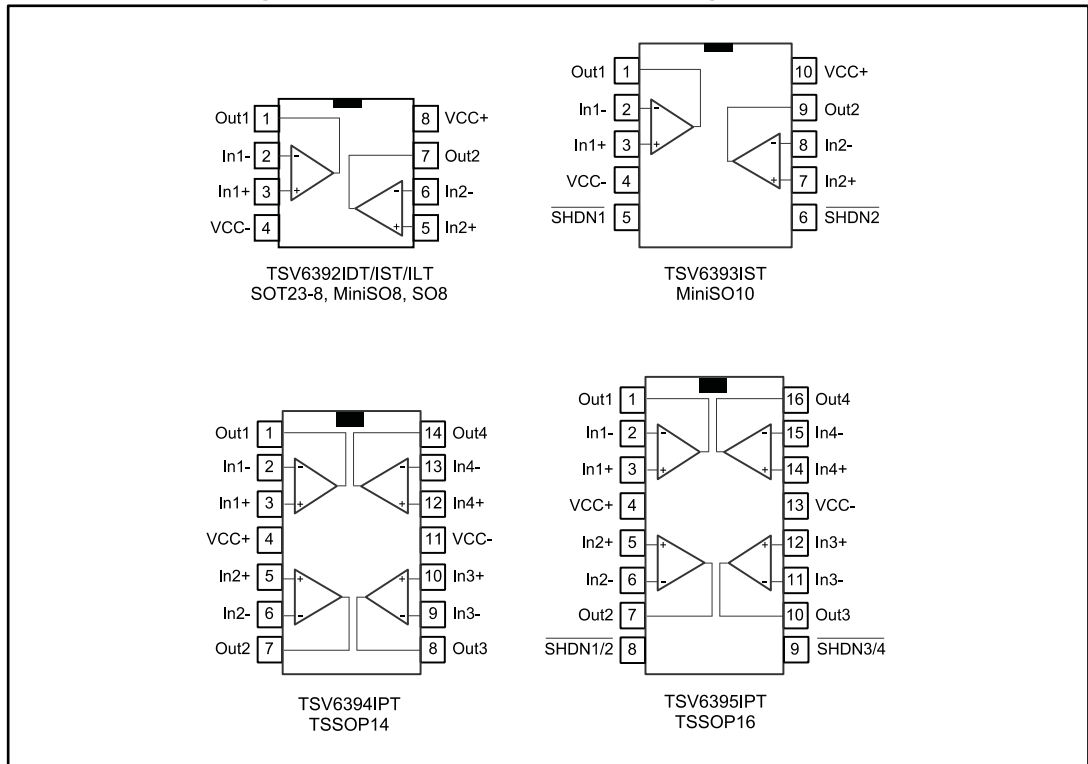
Reference	Dual version		Quad version	
	Without standby	With standby	Without standby	With standby
TSV639x	TSV6392	TSV6393	TSV6394	TSV6395
TSV639xA	TSV6392A	TSV6393A	TSV6394A	TSV6395A

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# 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 <sup>(1)</sup>	6	V	
$V_{id}$	Differential input voltage <sup>(2)</sup>	$\pm V_{CC}$		
$V_{in}$	Input voltage <sup>(3)</sup>	$(V_{CC}^-) - 0.2$ to $(V_{CC}^+) + 0.2$		
$I_{in}$	Input current <sup>(4)</sup>	10	mA	
$\overline{SHDN}$	Shutdown voltage <sup>(3)</sup>	$(V_{CC}^-) - 0.2$ 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 <sup>(5/6)</sup>	SOT23-8	105	°C/W
		MiniSO8	190	
		MiniSO10	113	
		SO8	125	
		TSSOP14	100	
		TSSOP16	95	
ESD	HBM: human body model <sup>(7)</sup>	4	kV	
	MM: machine model <sup>(8)</sup>	300	V	
	CDM: charged device model <sup>(9)</sup>	1.5	kV	
	Latch-up immunity	200	mA	

**Notes:**

- <sup>(1)</sup>All voltage values, except the differential voltage are with respect to the network ground terminal.
- <sup>(2)</sup>Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
- <sup>(3)</sup> $V_{CC} - V_{in}$  must not exceed 6 V,  $V_{in}$  must not exceed 6 V.
- <sup>(4)</sup>The input current must be limited by a resistor in-series with the inputs.
- <sup>(5)</sup> $R_{th}$  are typical values.
- <sup>(6)</sup>Short-circuits can cause excessive heating and destructive dissipation.
- <sup>(7)</sup>Human body model: 100 pF discharged through a 1.5 kΩ resistor between two pins of the device, done for all couples of pin combinations with other pins floating.
- <sup>(8)</sup>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.
- <sup>(9)</sup>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
<b>DC performance</b>						
$V_{io}$	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		$\mu\text{V}/^{\circ}\text{C}$
$I_{io}$	Input offset current, $V_{out} = V_{CC}/2$			1	10 <sup>(1)</sup>	pA
		$T_{min} < T_{op} < T_{max}$		1	100	
$I_{ib}$	Input bias current, $V_{out} = V_{CC}/2$			1	10 <sup>(1)</sup>	pA
		$T_{min} < T_{op} < T_{max}$		1	100	
CMR	Common mode rejection ratio $20 \log (\Delta V_{ic}/\Delta V_{io})$	$0\text{ V to }1.8\text{ V}$ , $V_{out} = 0.9\text{ V}$	53	74		dB
		$T_{min} < T_{op} < T_{max}$	51			
$A_{vd}$	Large signal voltage gain	$R_L = 10\text{ k}\Omega$ , $V_{out} = 0.5\text{ V to }1.3\text{ V}$	85	95		dB
		$T_{min} < T_{op} < T_{max}$	80			
$V_{OH}$	High-level output voltage, $V_{OH} = V_{CC} - V_{out}$	$R_L = 10\text{ k}\Omega$		5	35	mV
		$R_L = 10\text{ k}\Omega$ , $T_{min} < T_{op} < T_{max}$			50	
$V_{OL}$	Low-level output voltage	$R_L = 10\text{ k}\Omega$		4	35	mV
		$R_L = 10\text{ k}\Omega$ , $T_{min} < T_{op} < T_{max}$			50	
$I_{out}$	$I_{sink}$	$V_o = 1.8\text{ V}$	6	12		mA
		$T_{min} < T_{op} < T_{max}$	4			
	$I_{source}$	$V_o = 0\text{ V}$	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	$\mu\text{A}$
		$T_{min} < T_{op} < T_{max}$			62	
<b>AC performance</b>						
GBP	Gain bandwidth product	$R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$		2		MHz
Gain	Minimum gain for stability	Phase margin = $60^{\circ}$ , $R_f = 10\text{ k}\Omega$ , $R_L = 10\text{ k}\Omega$ , $C_L = 20\text{ pF}$		4		V/V
				-3		
SR	Slew rate	$R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , $V_{out} = 0.5\text{ V to }1.3\text{ V}$		0.7		$\text{V}/\mu\text{s}$
$e_n$	Equivalent input noise voltage	$f = 1\text{ kHz}$		60		$\text{nV}/\sqrt{\text{Hz}}$
		$f = 10\text{ kHz}$		33		

**Notes:**

<sup>(1)</sup>Guaranteed by design.



Table 5: Shutdown characteristics VCC = 1.8 V

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
<b>DC performance</b>						
$I_{CC}$	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	$\mu\text{A}$
$t_{on}$	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		
		$T_{min} < T_{op} < 125\text{ }^\circ\text{C}$		1		nA

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
<b>DC performance</b>						
$V_{io}$	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		$\mu\text{V}/^{\circ}\text{C}$
$I_{io}$	Input offset current			1	10 <sup>(1)</sup>	pA
		$T_{min} < T_{op} < T_{max}$		1	100	
$I_{ib}$	Input bias current			1	10 <sup>(1)</sup>	pA
		$T_{min} < T_{op} < T_{max}$		1	100	
CMR	Common mode rejection ratio $20 \log (\Delta V_{ic}/\Delta V_{io})$	$0\text{ V to } 3.3\text{ V}$ , $V_{out} = 1.65\text{ V}$	57	79		dB
		$T_{min} < T_{op} < T_{max}$	53			
$A_{vd}$	Large signal voltage gain	$R_L = 10\text{ k}\Omega$ , $V_{out} = 0.5\text{ V to } 2.8\text{ V}$	88	98		dB
		$T_{min} < T_{op} < T_{max}$	83			
$V_{OH}$	High-level output voltage, $V_{OH} = V_{CC} - V_{out}$	$R_L = 10\text{ k}\Omega$		6	35	mV
		$R_L = 10\text{ k}\Omega$ , $T_{min} < T_{op} < T_{max}$			50	
$V_{OL}$	Low-level output voltage	$R_L = 10\text{ k}\Omega$		7	35	mV
		$R_L = 10\text{ k}\Omega$ , $T_{min} < T_{op} < T_{max}$			50	
$I_{out}$	$I_{sink}$	$V_o = 3.3\text{ V}$	23	45		mA
		$T_{min} < T_{op} < T_{max}$	20			
	$I_{source}$	$V_o = 0\text{ V}$	23	38		
		$T_{min} < T_{op} < T_{max}$	20			
$I_{CC}$	Supply current (per operator)	No load, $V_{out} = 1.75\text{ V}$	43	55	64	$\mu\text{A}$
		$T_{min} < T_{op} < T_{max}$			66	
<b>AC performance</b>						
GBP	Gain bandwidth product	$R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$		2.2		MHz
Gain	Minimum gain for stability	Phase margin = $60^{\circ}$ , $R_f = 10\text{ k}\Omega$ , $R_L = 10\text{ k}\Omega$ , $C_L = 20\text{ pF}$		4		V/V
				-3		
SR	Slew rate	$R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , $V_{out} = 0.5\text{ V to } 2.8\text{ V}$		0.9		V/ $\mu\text{s}$

**Notes:**

<sup>(1)</sup>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
<b>DC performance</b>						
$V_{io}$	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		$\mu\text{V}/^{\circ}\text{C}$
$I_{io}$	Input offset current, $V_{out} = V_{CC}/2$			1	10 <sup>(1)</sup>	pA
		$T_{min} < T_{op} < T_{max}$		1	100	
$I_{ib}$	Input bias current, $V_{out} = V_{CC}/2$			1	10 <sup>(1)</sup>	pA
		$T_{min} < T_{op} < T_{max}$		1	100	
CMR	Common mode rejection ratio $20 \log (\Delta V_{ic}/\Delta V_{io})$	$0\text{ V to }5\text{ V}$ , $V_{out} = 2.5\text{ V}$	60	80		dB
		$T_{min} < T_{op} < T_{max}$	55			
SVR	Supply voltage rejection ratio $20 \log (\Delta V_{CC}/\Delta V_{io})$	$V_{CC} = 1.8\text{ to }5\text{ V}$	75	93		dB
		$T_{min} < T_{op} < T_{max}$	73			
$A_{vd}$	Large signal voltage gain	$R_L = 10\text{ k}\Omega$ , $V_{out} = 0.5\text{ V to }4.5\text{ V}$	89	98		dB
		$T_{min} < T_{op} < T_{max}$	84			
EMIRR	EMI rejection ratio, $EMIRR = -20 \log (V_{RFpeak}/\Delta V_{io})$	$V_{RF} = 100\text{ mV}_{rms}$ , $f = 400\text{ MHz}$		61		dB
		$V_{RF} = 100\text{ mV}_{rms}$ , $f = 900\text{ MHz}$		85		
		$V_{RF} = 100\text{ mV}_{rms}$ , $f = 1800\text{ MHz}$		92		
		$V_{RF} = 100\text{ mV}_{rms}$ , $f = 2400\text{ MHz}$		83		
$V_{OH}$	High-level output voltage, $V_{OH}$ $= V_{CC} - V_{out}$	$R_L = 10\text{ k}\Omega$		7	35	mV
		$R_L = 10\text{ k}\Omega$ , $T_{min} < T_{op} < T_{max}$			50	
$V_{OL}$	Low-level output voltage	$R_L = 10\text{ k}\Omega$		6	35	mV
		$R_L = 10\text{ k}\Omega$ , $T_{min} < T_{op} < T_{max}$			50	
$I_{out}$	$I_{sink}$	$V_o = 5\text{ V}$	40	65		mA
		$T_{min} < T_{op} < T_{max}$	35			
	$I_{source}$	$V_o = 0\text{ V}$	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	$\mu\text{A}$
		$T_{min} < T_{op} < T_{max}$			72	
<b>AC performance</b>						
GBP	Gain bandwidth product	$R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$		2.4		MHz
Gain	Minimum gain for stability	Phase margin = $60^{\circ}$ , $R_f = 10\text{ k}\Omega$ , $R_L = 10\text{ k}\Omega$ , $C_L = 20\text{ pF}$ ,		4		V/V
				-3		
SR	Slew rate	$R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$		1.1		V/ $\mu\text{s}$

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$e_n$	Equivalent input noise voltage	$f = 1 \text{ kHz}$		60		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
<b>DC performance</b>						
$I_{CC}$	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
$t_{on}$	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

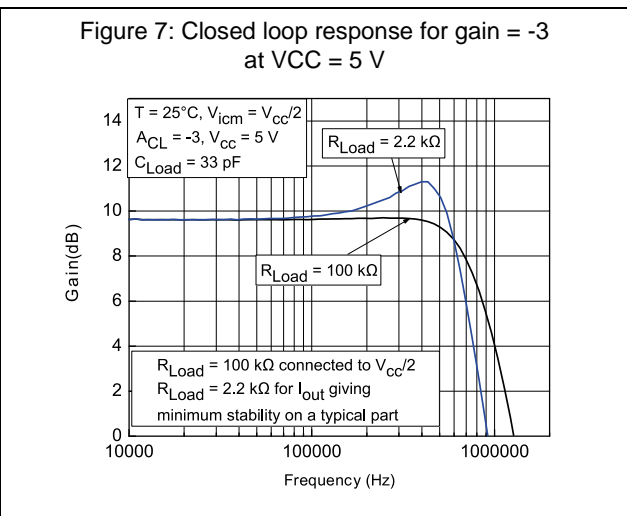
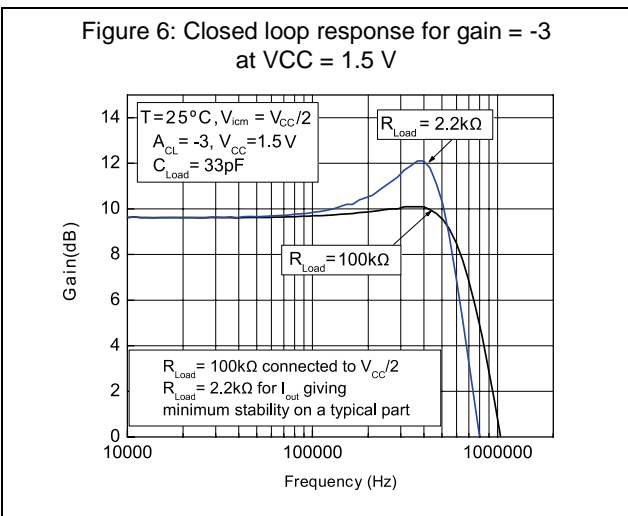
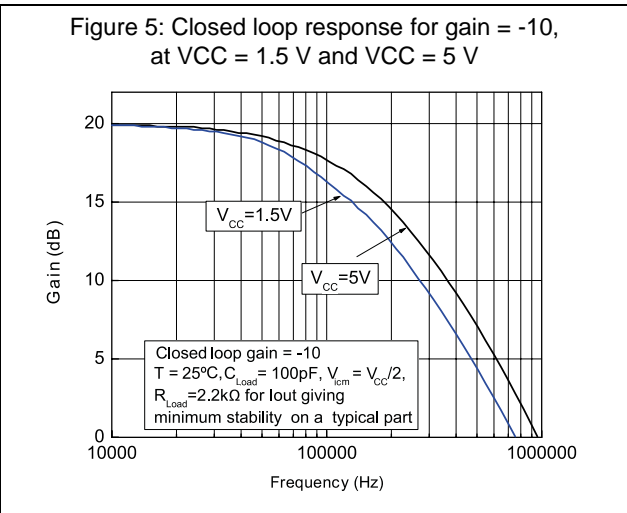
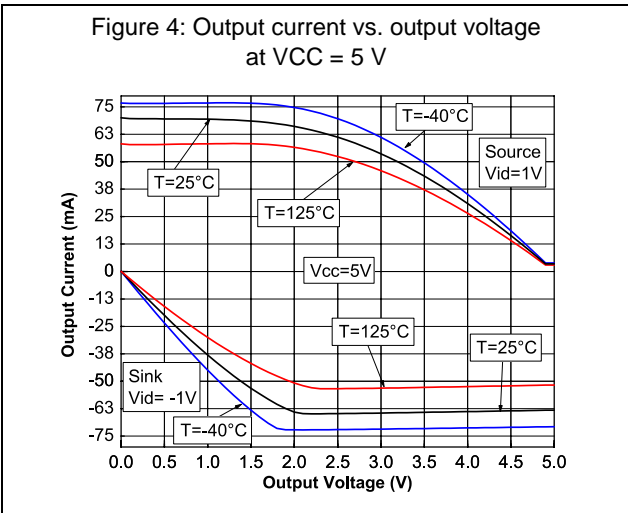
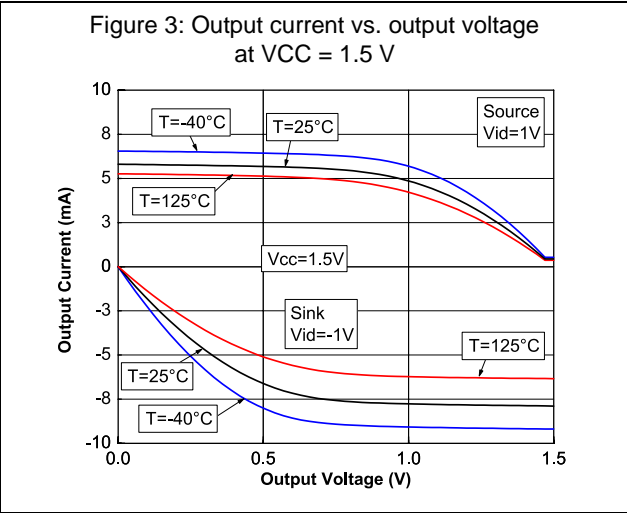
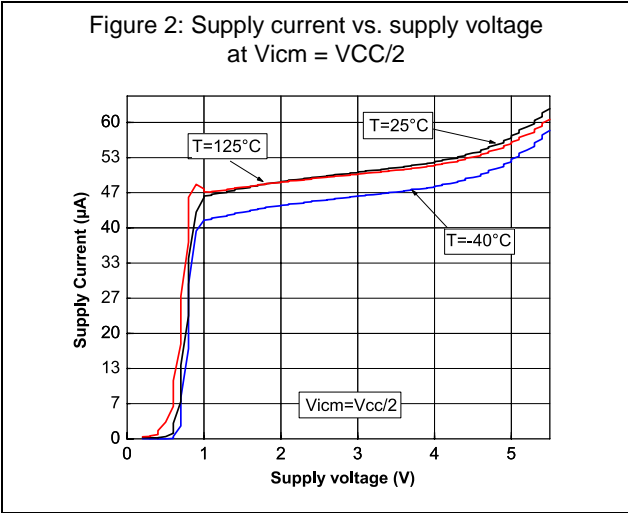


Figure 8: Positive slew rate vs. supply voltage in closed loop

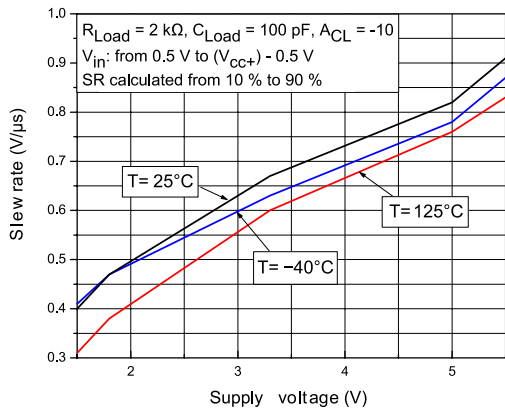


Figure 9: Negative slew rate vs. supply voltage in closed loop

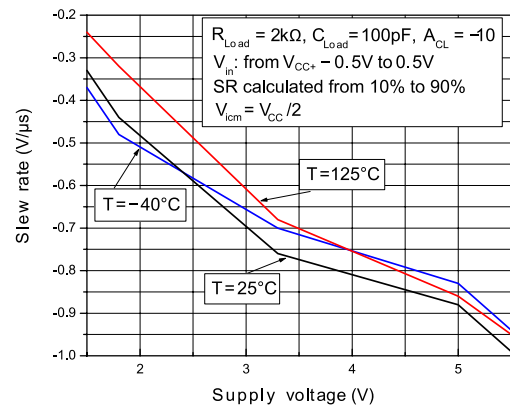


Figure 10: Slew rate vs. supply voltage in open loop

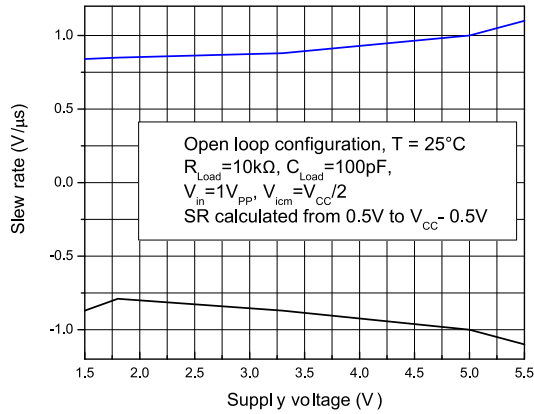


Figure 11: Slew rate timing in open loop

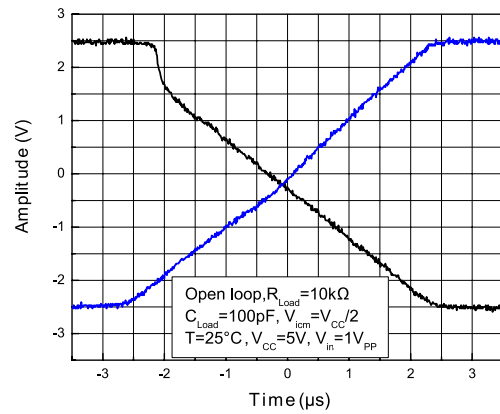


Figure 12: Slew rate timing in closed loop

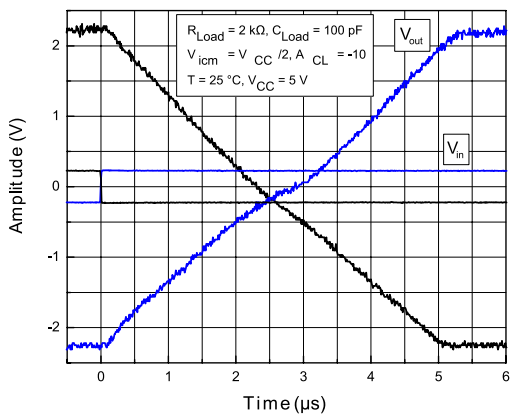


Figure 13: Noise vs. frequency

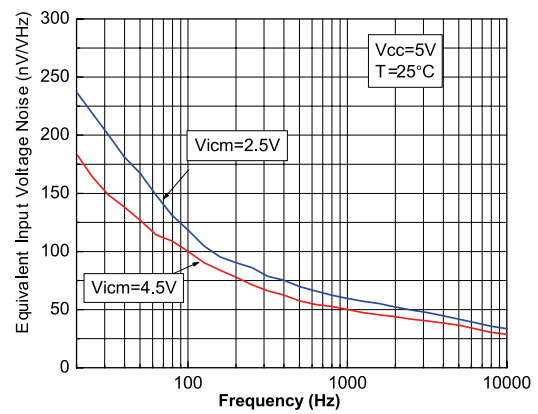


Figure 14: Distortion and noise vs. output voltage at  $V_{CC} = 1.8\text{ V}$

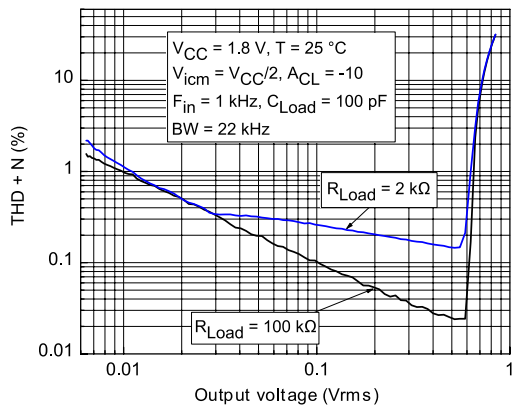


Figure 15: Distortion and noise vs. frequency at  $V_{CC} = 1.8\text{ V}$

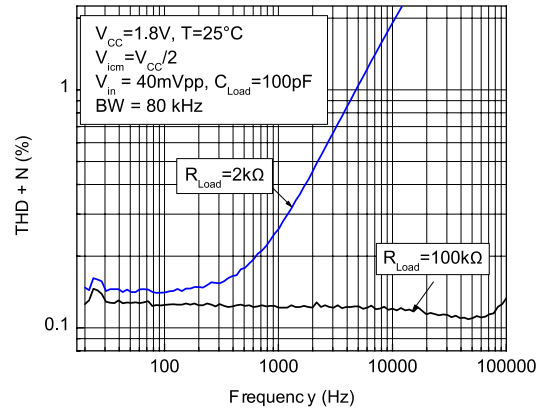


Figure 16: Distortion and noise vs. output voltage at  $V_{CC} = 5\text{ V}$

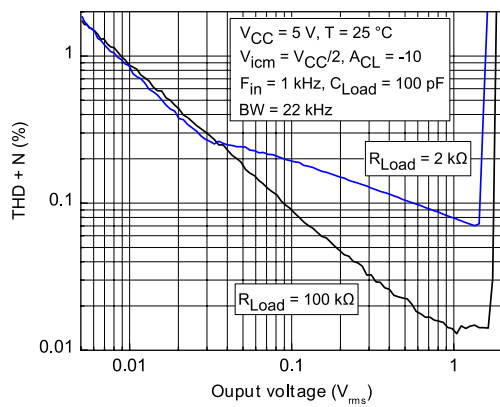


Figure 17: Distortion and noise vs. frequency at  $V_{CC} = 5\text{ V}$

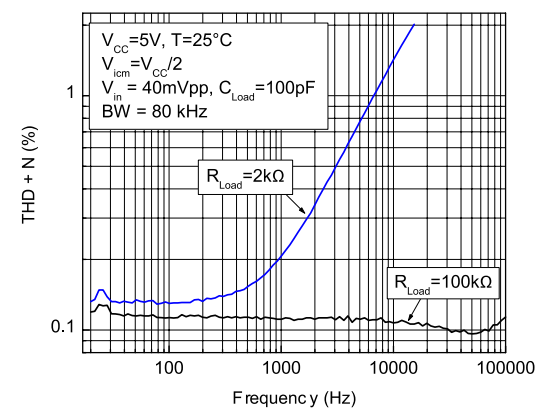
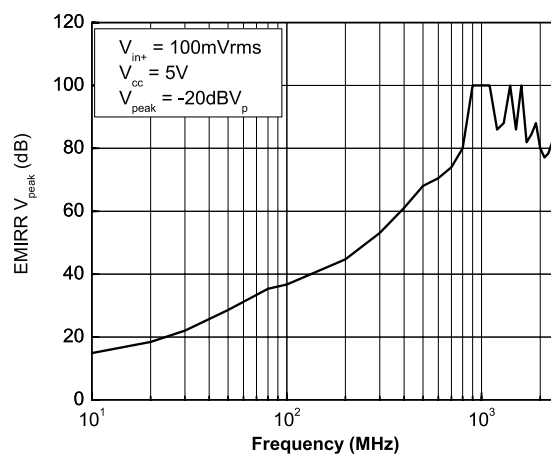


Figure 18: EMIRR vs. frequency at  $V_{CC} = 5\text{ V}, T = 25^\circ\text{C}$



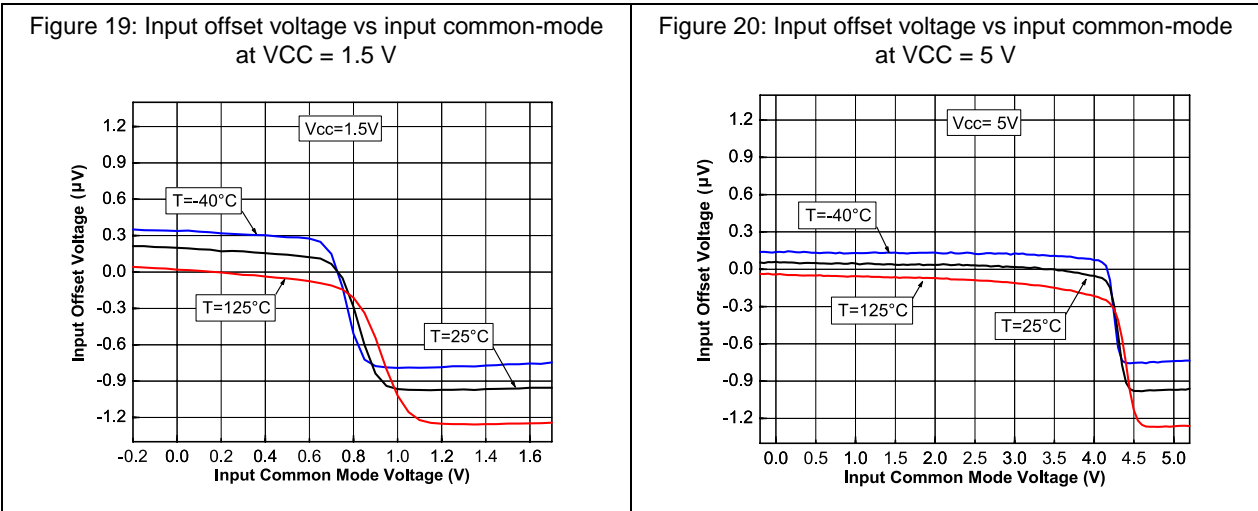
## 5 Application information

### 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.



The devices are guaranteed without phase reversal.

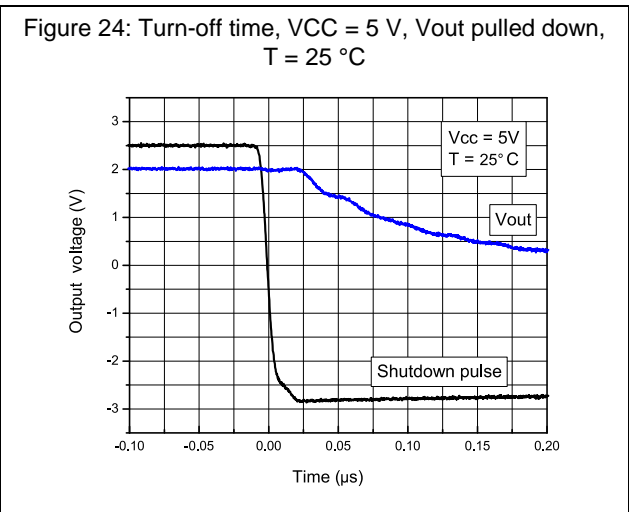
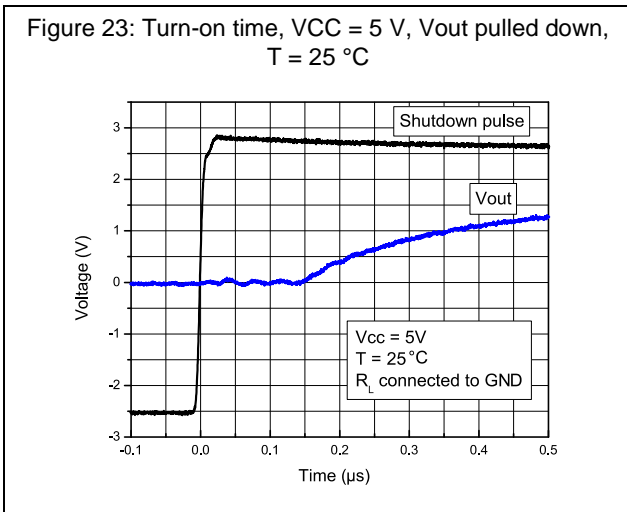
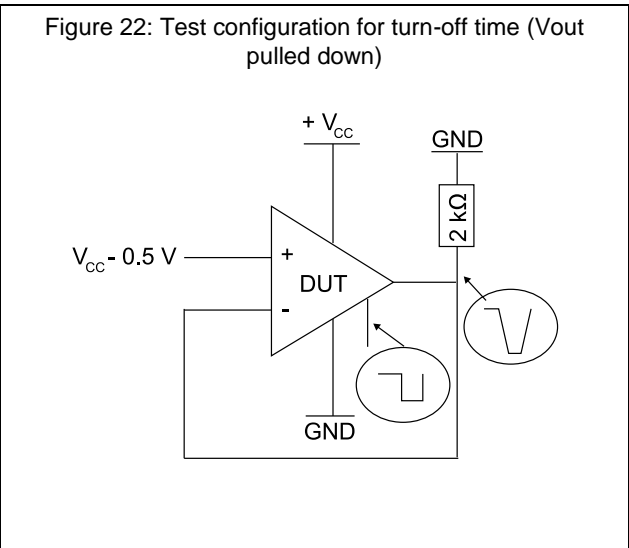
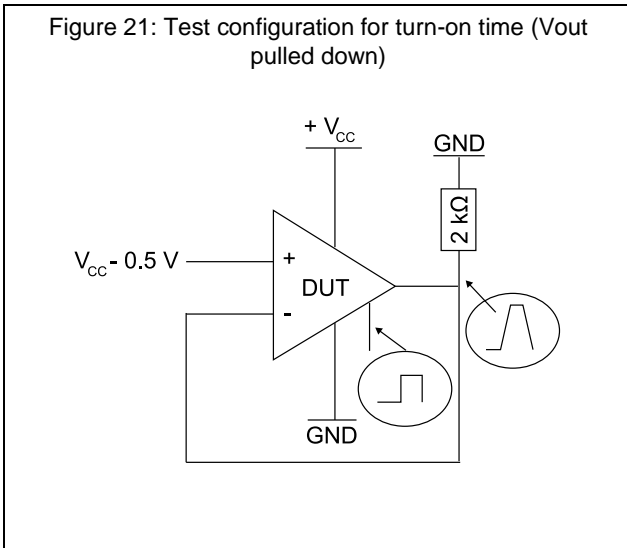
### 5.3 Rail-to-rail output

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).



## 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  $\mu\text{A}$  typical, min/max at  $\pm 17\%$ ). Parameters linked to the current consumption value, such as GBP, SR and  $A_{\text{vdi}}$ , 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 $\Omega$ . 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 $\Omega$ ) or  $|gain| \geq 10$  ( $C_L = 100$  pF,  $R_L = 100$  k $\Omega$ )
- $Gain \geq 4$  in a non-inverting configuration ( $C_L = 20$  pF,  $R_L = 100$  k $\Omega$ ) or  $gain \geq 11$  ( $C_L = 100$  pF,  $R_L = 100$  k $\Omega$ )

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

Table 9: Related products

Part #	I <sub>cc</sub> ( $\mu\text{A}$ ) at 5 V	GBP (MHz)	SR (V/ $\mu\text{s}$ )	Minimum gain for stability (C <sub>Load</sub> = 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](http://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<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK<sup>®</sup> is an ST trademark.

## 6.1 SOT23-8 package information

Figure 25: SOT23-8 package outline

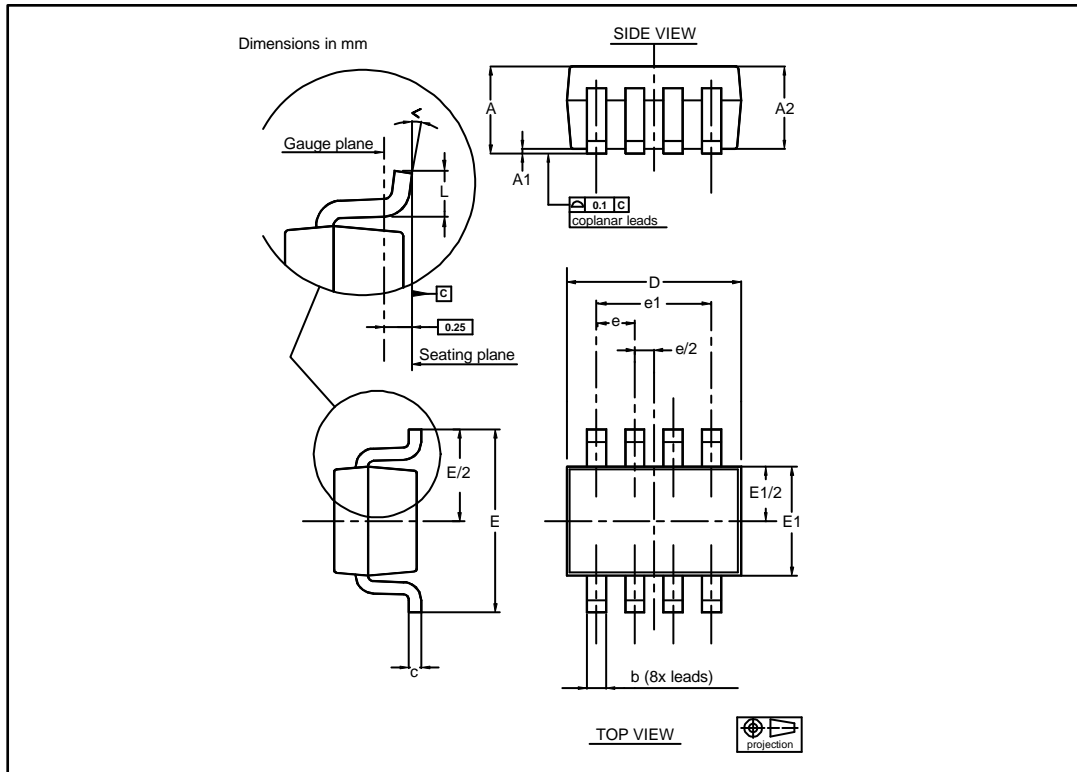


Table 10: SOT23-8 mechanical data

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

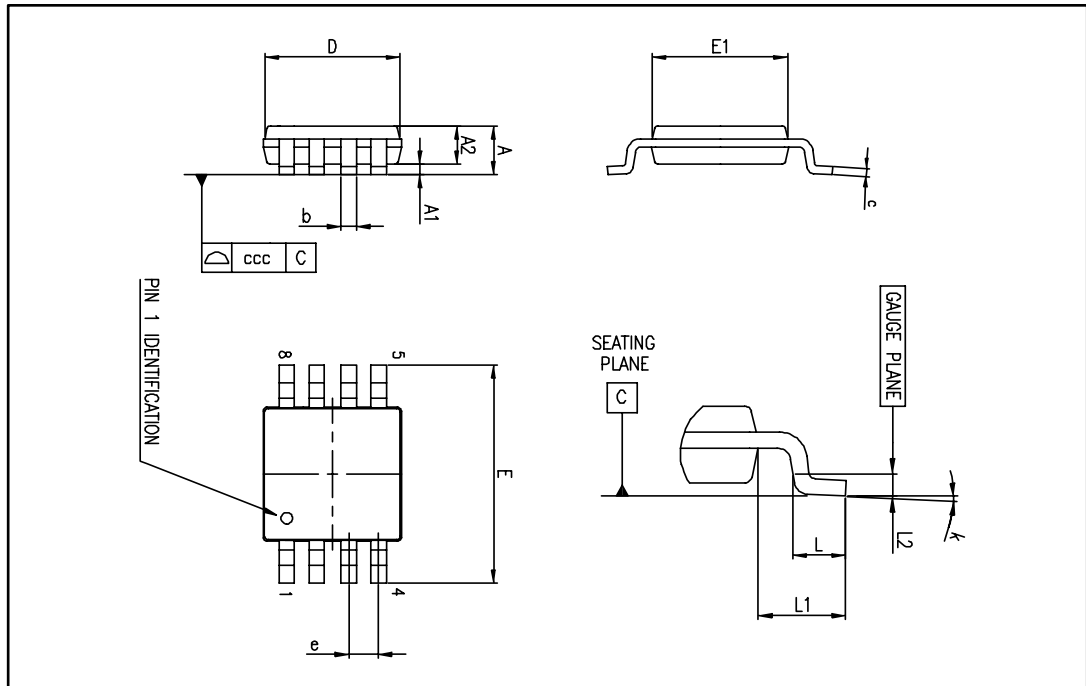


Table 11: MiniSO8 mechanical data

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

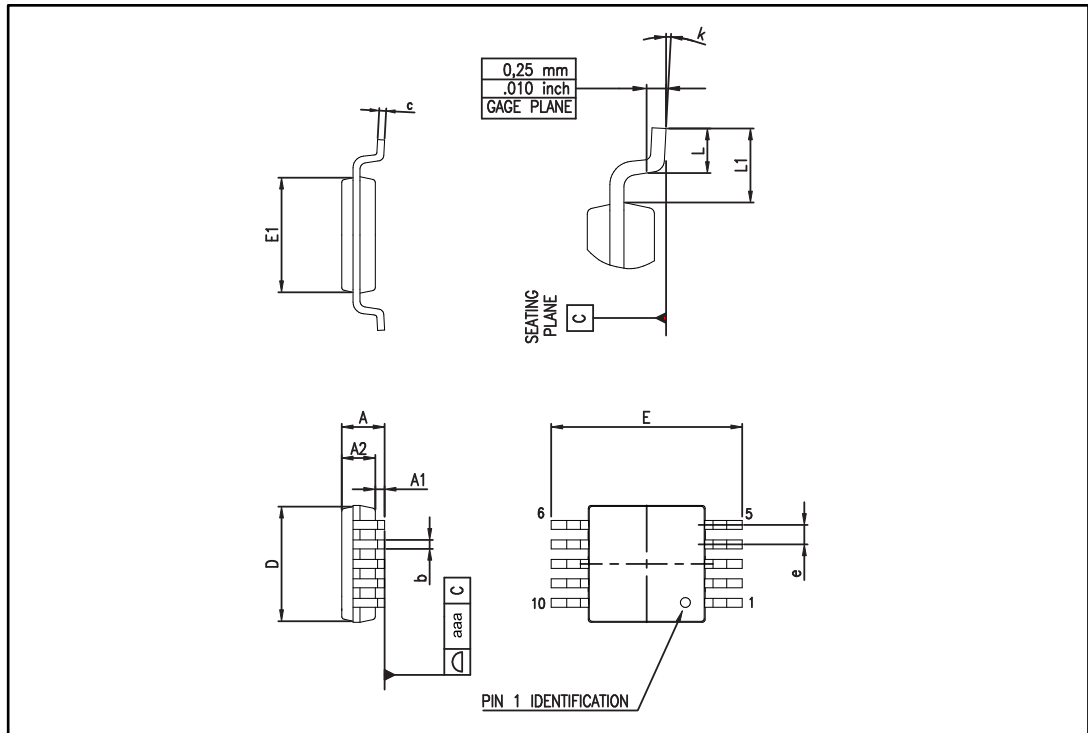


Table 12: MiniSO10 mechanical data

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

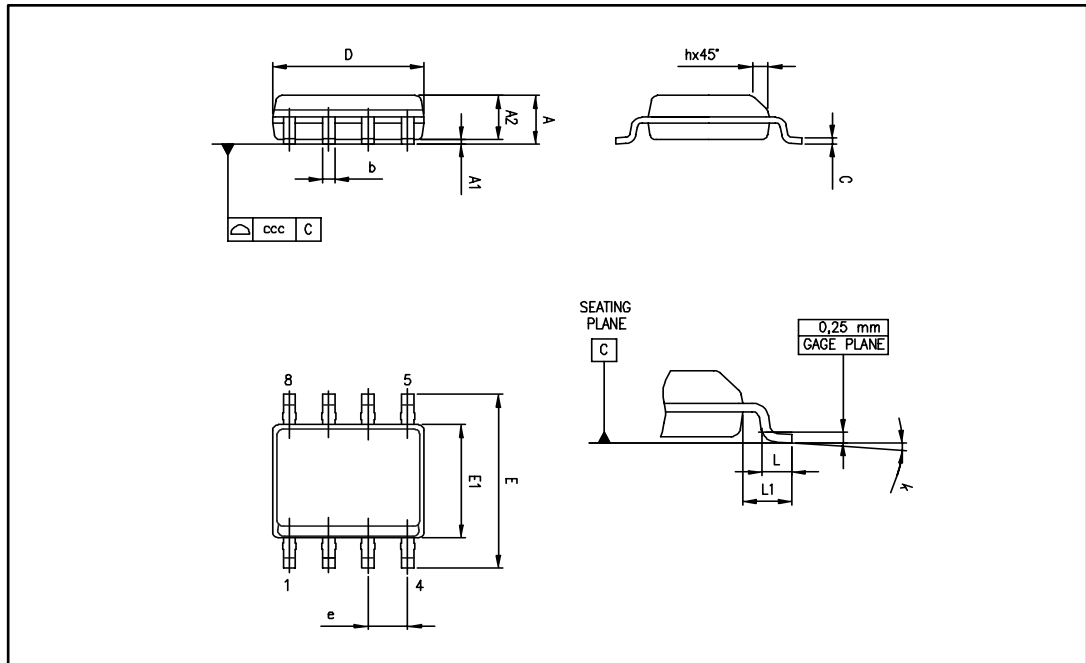


Table 13: SO8 mechanical data

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

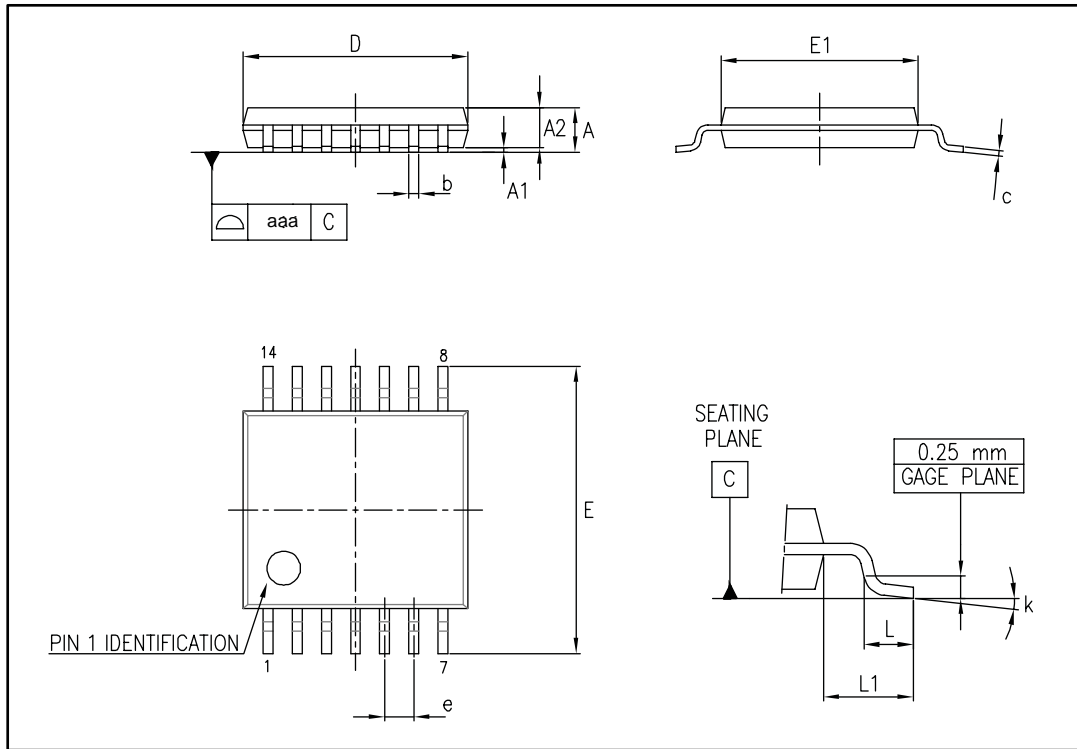


Table 14: TSSOP14 mechanical data

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

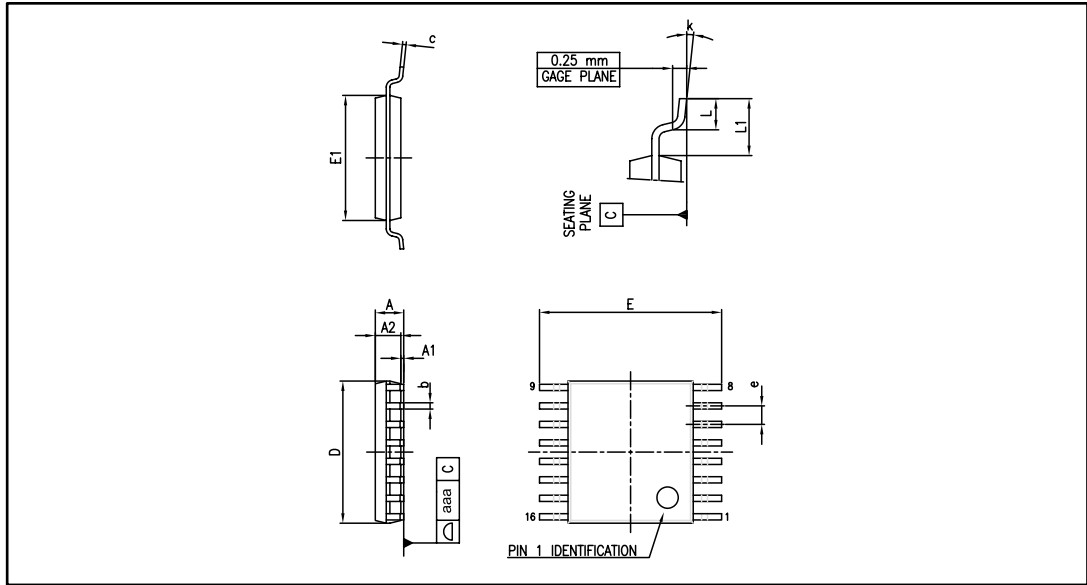


Table 15: TSSOP16 mechanical data

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 <i>Table 4, Table 6, and Table 7</i> : 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. <i>Table 10: "SOT23-8 mechanical data"</i> : added angle information to “Inches” columns. <i>Table 16: "Order codes"</i> : removed obsolete order codes TSV6392ID and TSV6392AID.

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