



# TSH60,61,62,63,64

## Wide-Band, Low-Power Operational Amplifiers with Standby

- 5V,  $\pm 5V$  specifications
- Gain-bandwidth product: 60MHz
- Slew-rate: 80V/ $\mu s$
- Output current: up to 45mA
- Input/output rail-to-rail
- Specified for 150 $\Omega$  load
- Low distortion, THD: 0.1%
- SO packages

### Description

The TSH6x series offers single, dual, triple and quad operational amplifiers featuring high video performances.

The TSH6x op-amps can be used in consumer video applications, such as set-top boxes, DVD players and recorders, or TVs, as either video buffers or video line drivers. Their performances guarantee excellent video quality, enhancing the performance of your video solution.

Running at single supply voltage from 5V to 12V, amplifiers feature large output voltage swing and high output current capability to drive standard 150 $\Omega$  loads.

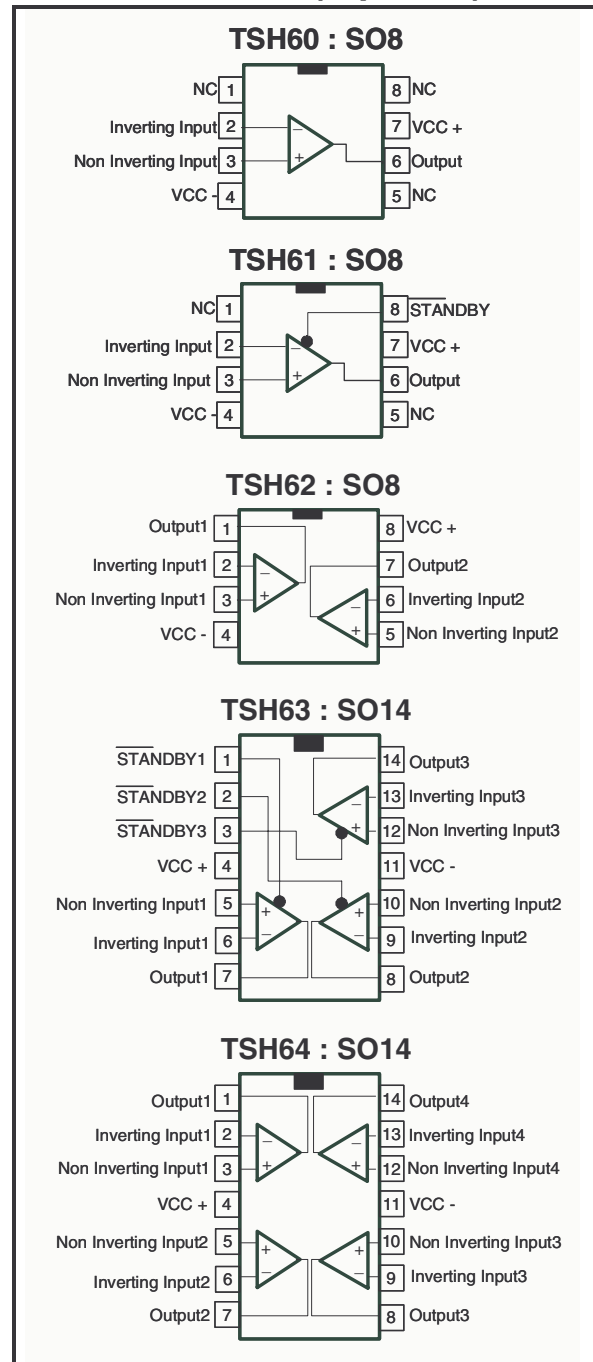
The TSH61 and TSH63 also feature standby inputs, allowing the op amps to be put into a standby mode with low power consumption and high output impedance.

For easy integration into video applications, the TSH6x series is proposed in standard SO8 and SO14 packages.

### Applications

- Standard definition video buffers
- Set-top boxes
- DVD players and recorders
- Analog and digital TVs

### Pin connections (top view)



# 1 Order Codes

Type	Temperature Range	Packages	Packing	Marking
TSH60CD/CDT	0°C to 70°C	SO8	Tube or Tape & Reel	TSH60C
TSH61CD/CDT				TSH61C
TSH62CD/CDT		TSH62C		
TSH63CD/CDT		TSH63C		
TSH64CD/CDT		TSH64C		

## 2 Absolute Maximum Ratings and Operating Conditions

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{CC}$	Supply Voltage <sup>(1)</sup>	14	V
$V_{id}$	Differential Input Voltage <sup>(2)</sup>	$\pm 2$	V
$V_i$	Input Voltage <sup>(3)</sup>	$\pm 6$	V
$T_{oper}$	Operating Free Air Temperature Range	0 to +70	°C
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_j$	Maximum Junction Temperature	150	°C
$R_{thjc}$	Thermal Resistance Junction to Case <sup>(4)</sup>		°C/W
	SO8 SO14	28 22	
$R_{thja}$	Thermal Resistance Junction to Ambient Area		°C/W
	SO8 SO14	157 125	
ESD	HumanBodyModel	2	kV

1. All voltages values, except differential voltage are with respect to network ground terminal
2. Differential voltages are non-inverting input terminal with respect to the inverting terminal
3. The magnitude of input and output must never exceed  $V_{CC} + 0.3V$
4. Short-circuits can cause excessive heating

**Table 2. Operating conditions**

Symbol	Parameter	Value	Unit
$V_{CC}$	Supply Voltage	4.5 to 12	V
$V_{IC}$	Common Mode Input Voltage Range	$V_{CC}^-$ to $(V_{CC}^+ - 1.1)$	V

### 3 Standby Mode

**Table 3.**  $V_{CC}^+$  (positive supply voltage),  $V_{CC}^-$  (negative supply voltage, or ground),  $T_{amb} = 25^{\circ}\text{C}$  (unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{low}$	Standby Low Level		$V_{CC}^-$		$(V_{CC}^- + 0.8)$	V
$V_{high}$	Standby High Level		$(V_{CC}^- + 2)$		$(V_{CC}^+)$	V
$I_{CC\ STBY}$	Current Consumption per Operator when STANDBY is Active	pin 8 (TSH61) to $V_{CC}^-$ pin 1,2 or 3 (TSH63) to $V_{CC}^-$		20	55	$\mu\text{A}$
$Z_{out}$	Output Impedance ( $R_{out}/C_{out}$ )	$R_{out}$ $C_{out}$		10 17		$\text{M}\Omega$ $\text{pF}$
$T_{on}$	Time from Standby Mode to Active Mode			2		$\mu\text{s}$
$T_{off}$	Time from Active Mode to Standby Mode	Down to $I_{CC\ STBY} = 10\mu\text{A}$		10		$\mu\text{s}$

TSH61 Standby Control pin 8 ( $\overline{\text{STBY}}$ )		Operator Status	
$V_{low}$		Standby	
$V_{high}$		Active	

TSH63 Standby Control			Operator Status		
$\overline{\text{pin 1}}$ ( $\overline{\text{STBY OP1}}$ )	$\overline{\text{pin 2}}$ ( $\overline{\text{STBY OP2}}$ )	$\overline{\text{pin 3}}$ ( $\overline{\text{STBY OP3}}$ )	OP1	OP1	OP3
$V_{low}$	x	x	Standby	x	x
$V_{high}$	x	x	Active	x	x
x	$V_{low}$	x	x	Standby	x
x	$V_{high}$		x	Active	x
x	x	$V_{low}$	x	x	Standby
x	x	$V_{high}$	x	x	Active

## 4 Electrical Characteristics

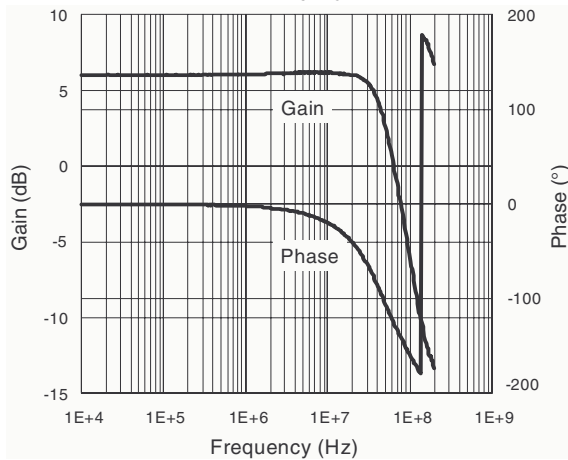
**Table 4.**  $V_{CC^+} = 5V$ ,  $V_{CC^-} = GND$ ,  $V_{ic} = 2.5V$ ,  $T_{amb} = 25^{\circ}C$  (unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$ V_{io} $	Input Offset Voltage	$T_{amb} = 25^{\circ}C$ $T_{min.} < T_{amb} < T_{max.}$		1.5	10 12	mV
$I_{ib}$	Input Bias Current			6		$\mu A$
$C_{in}$	Input Capacitance			0.3		pF
$I_{CC}$	Supply Current per Operator			8.2		mA
CMRR	Common Mode Rejection Ratio ( $\delta V_{ic}/\delta V_{io}$ )	$+0.1 < V_{ic} < 3.9V$ & $V_{out} = 2.5V$		85		dB
PSRR	Power Supply Rejection Ratio ( $\delta V_{CC}/\delta V_{out}$ )	Positive & Negative Rail		70		dB
$A_{vd}$	Large Signal Voltage Gain	$R_L = 150\Omega$ to 1.5V $V_{out} = 1V$ to 4V		78		dB
$I_o$	Output Short Circuit Current Source	$V_{id} = +1$ , $V_{out}$ to 1.5V $V_{id} = -1$ , $V_{out}$ to 1.5V ISource1 Sink		45 45		mA
$V_{oh}$	High Level Output Voltage	$R_L = 150\Omega$ to GND $R_L = 150\Omega$ to 2.5V		4.36 4.66		V
$V_{ol}$	Low Level Output Voltage	$R_L = 150\Omega$ to GND $R_L = 150\Omega$ to 2.5V		48 220	100 400	mV
Bw	Bandwidth @-3dB	$A_{VCL} = +1$ $R_L = 150\Omega$ to 2.5V		60		MHz
SR	Slew Rate	$A_{VCL} = +2$ $R_L = 150\Omega$ to 2.5V		86		V/ $\mu s$
$\phi_m$	Phase Margin	$R_L = 150\Omega$ to 2.5V		40		$^{\circ}$
THD	Total Harmonic Distortion	$A_{VCL} = +2$ , $F = 4MHz$ $R_L = 150\Omega$ to 2.5V $V_{out} = 1V_{pp}$ $V_{out} = 2V_{pp}$		-57 -51		dB
$\Delta G$	Differential gain	$A_{VCL} = +2$ , $R_L = 150\Omega$ to 2.5V $F = 4.5MHz$ , $V_{out} = 2V_{pp}$		0.5		%
Df	Differential phase	$A_{VCL} = +2$ , $R_L = 150\Omega$ to 2.5V $F = 4.5MHz$ , $V_{out} = 2V_{pp}$		0.5		$^{\circ}$
Gf	Gain Flatness	$F = DC$ to 6MHz, $A_{VCL} = +2$		0.2		dB
Vo1/Vo2	Channel Separation	$F = 1MHz$ to 10MHz		65		dB

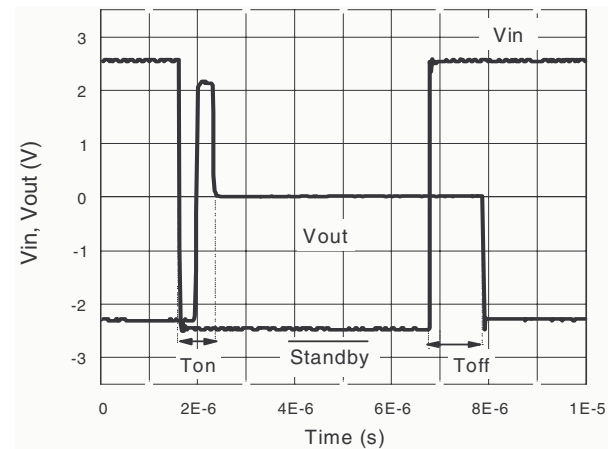
Table 5.  $V_{CC}^+ = 5V$ ,  $V_{CC}^- = -5V$ ,  $V_{IC} = GND$ ,  $T_{amb} = 25^\circ C$  (unless otherwise specified)

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
$ V_{io} $	Input Offset Voltage	$T_{min.} < T_{amb} < T_{max.}$		1.2	10 12	mV
$I_{ib}$	Input Bias Current			6		$\mu A$
$C_{in}$	Input Capacitance			0.7		pF
$I_{CC}$	Supply Current per Operator			9.8		mA
CMRR	Common Mode Rejection Ratio ( $\delta V_{ic}/\delta V_{io}$ )	$-4.9 < V_{ic} < 3.9V$ & $V_{out} = GND$		94		dB
PSRR	Power Supply Rejection Ratio ( $\delta V_{CC}/\delta V_{out}$ )	Positive & Negative Rail		70		dB
$A_{vd}$	Large Signal Voltage Gain	$R_L = 150\Omega$ to GND $V_{out} = -4$ to $+4$		80		dB
$I_o$	Output Short Circuit Current Source	$V_{id} = +1$ , $V_{out}$ to 1.5V $V_{id} = -1$ , $V_{out}$ to 1.5V  Source  Sink		45 45		mA
$V_{oh}$	High Level Output Voltage	$R_L = 150\Omega$ to GND		4.36		V
$V_{ol}$	Low Level Output Voltage	$R_L = 150\Omega$ to GND		-4.63	-4.4	mV
Bw	Bandwidth @-3dB	$A_{VCL} = +1$ $R_L = 150\Omega$ to GND		74		MHz
SR	Slew Rate	$A_{VCL} = +2$ $R_L = 150\Omega$ to GND		98		V/ $\mu s$
$\phi_m$	Phase Margin	$R_L = 150\Omega$ to GND		40		$^\circ$
THD	Total Harmonic Distortion	$A_{VCL} = +2$ , $F = 4MHz$ $R_L = 150\Omega$ to GND $V_{out} = 1V_{pp}$ $V_{out} = 2V_{pp}$		-57 -51		dB
$\Delta G$	Differential gain	$A_{VCL} = +2$ , $R_L = 150\Omega$ to GND $F = 4.5MHz$ , $V_{out} = 2V_{pp}$		0.5		%
Df	Differential phase	$A_{VCL} = +2$ , $R_L = 150\Omega$ to GND $F = 4.5MHz$ , $V_{out} = 2V_{pp}$		0.5		$^\circ$
Gf	Gain Flatness	$F = DC$ to 6MHz, $A_{VCL} = +2$		0.2		dB
Vo1/Vo2	Channel Separation	$F = 1MHz$ to 10MHz		65		dB

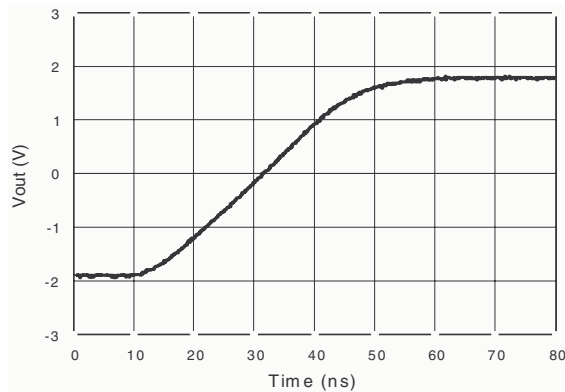
**Figure 1. Closed loop gain and phase vs. frequency (Gain = +2,  $V_{CC} = \pm 2.5V$ ,  $R_L = 150\Omega$ ,  $T_{amb} = 25^\circ C$ )**



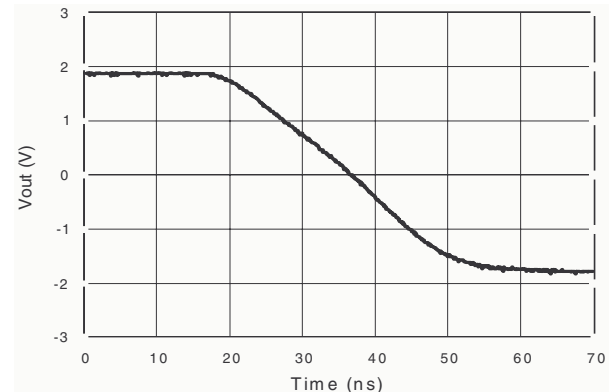
**Figure 2. Standby mode -  $T_{on}$ ,  $T_{off}$  ( $V_{CC} = \pm 2.5V$ , open loop)**



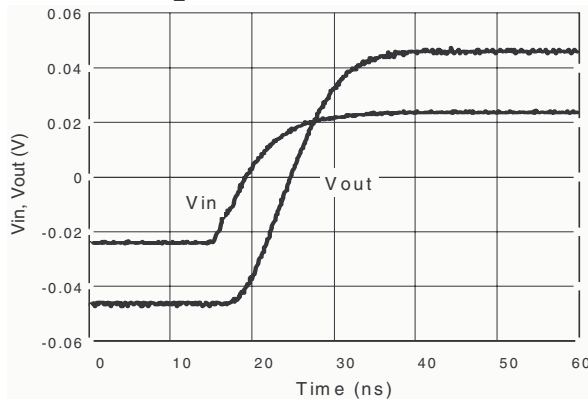
**Figure 3. Large signal measurement - positive slew rate (Gain = 2,  $V_{CC} = \pm 2.5V$ ,  $R_L = 150\Omega/5.6pF$ ,  $V_{in} = 1V_{pk}$ )**



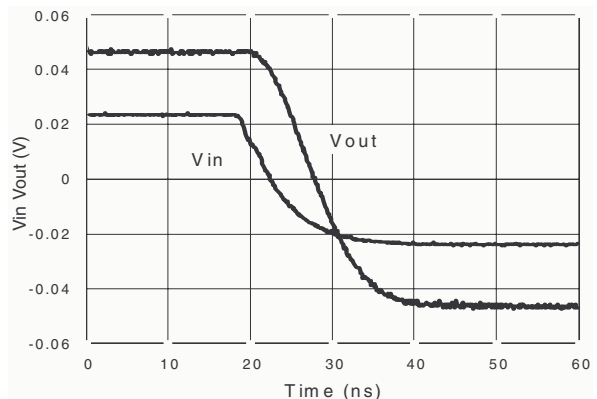
**Figure 4. Large signal measurement - negative slew rate (Gain = 2,  $V_{CC} = \pm 2.5V$ ,  $R_L = 150\Omega/5.6pF$ ,  $V_{in} = 1V_{pk}$ )**



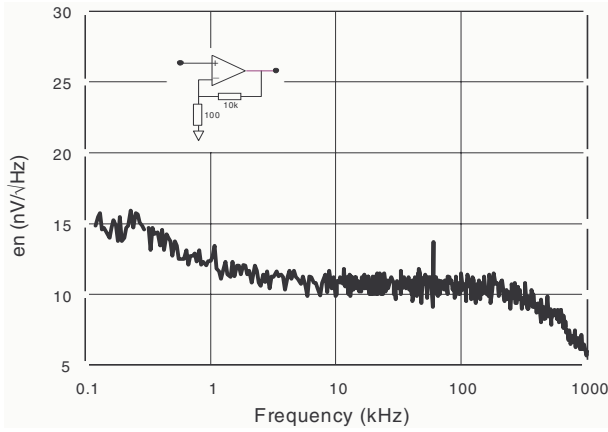
**Figure 5. Small signal measurement - rise time (Gain = 2,  $V_{CC} = \pm 2.5V$ ,  $Z_L = 150\Omega$ ,  $V_{in} = 25mV_{pk}$ )**



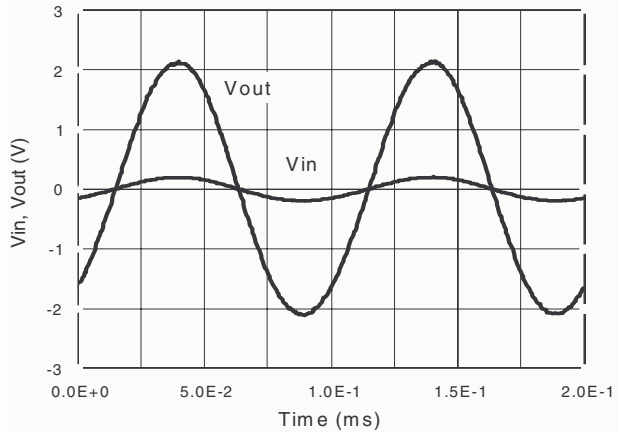
**Figure 6. Small signal measurement - fall time (Gain = 2,  $V_{CC} = \pm 2.5V$ ,  $Z_L = 150\Omega$ ,  $V_{in} = 25mV_{pk}$ )**



**Figure 7. Equivalent noise voltage**  
(Gain = 100,  $V_{CC} = \pm 2.5V$ , no load)



**Figure 8. Maximum output swing**  
(Gain = 11,  $V_{CC} = \pm 2.5V$ ,  $R_L = 150\Omega$ )

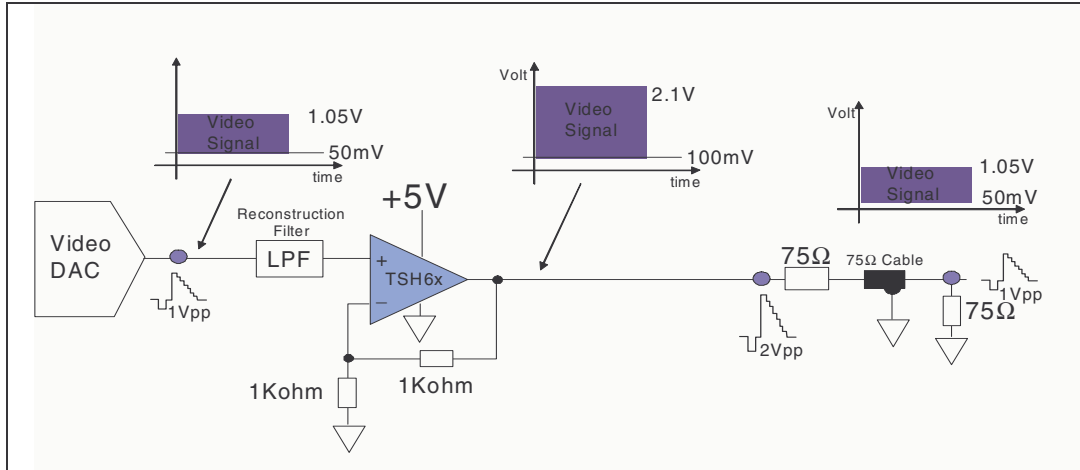




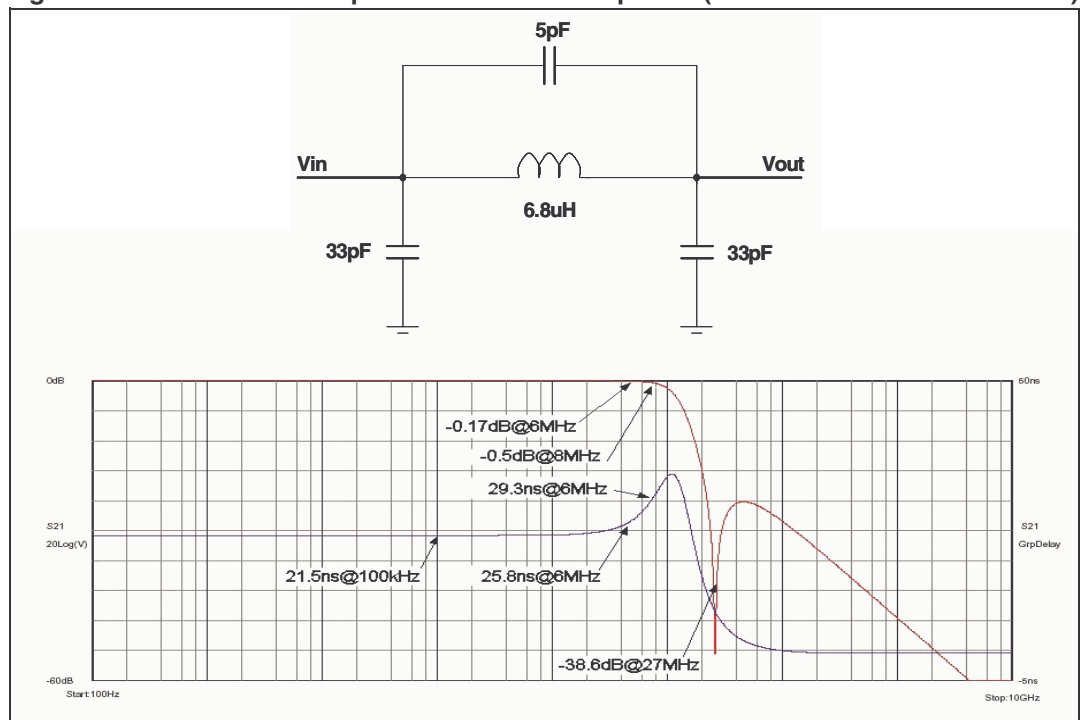
# 5 Video Applications

TSH6x operational amplifiers can be used to buffer standard definition video signals on 75-ohm video lines. An example of a video channel is shown below. A typical third-order filter and its response are also shown.

**Figure 9. Implementation of a video driver on a video DAC output**



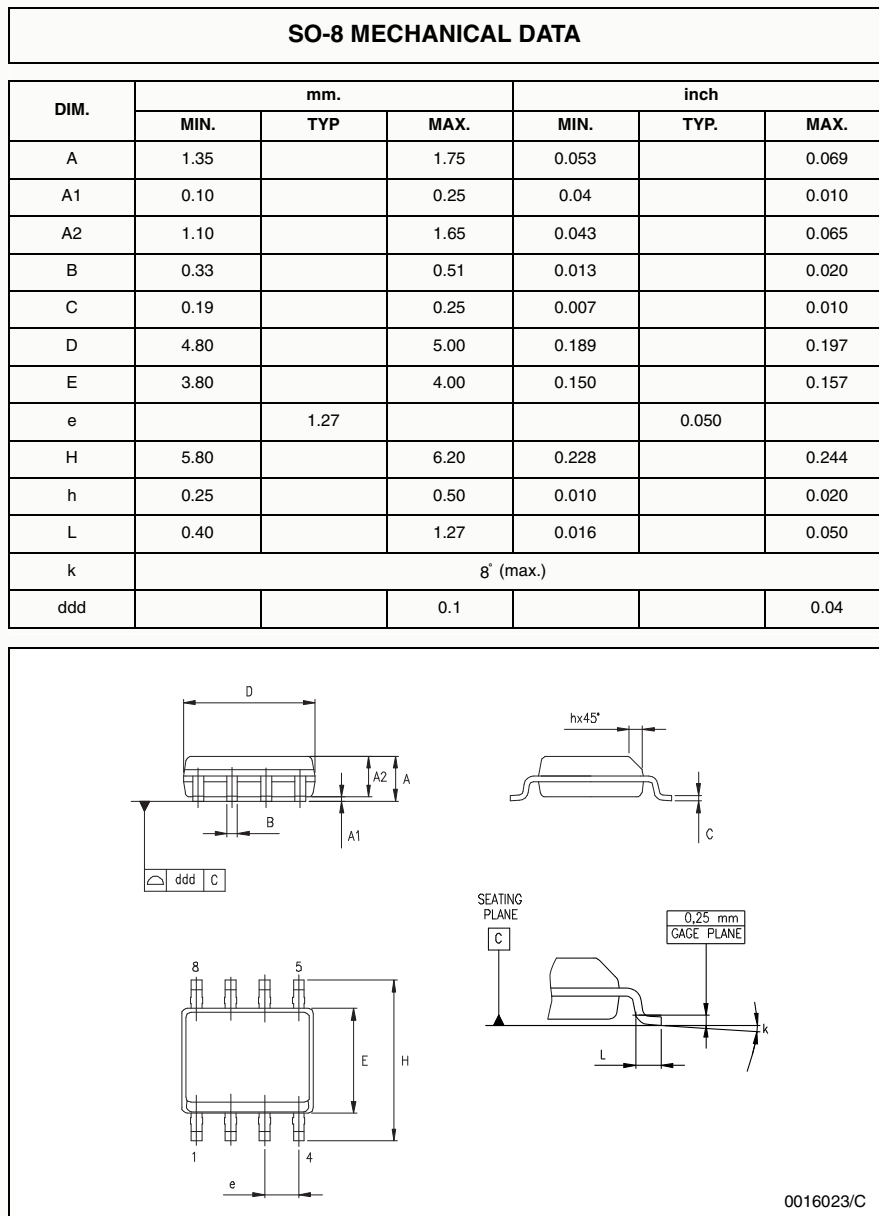
**Figure 10. Third order low-pass filter and its response (for standard definition video)**



## 6 Package Mechanical Data

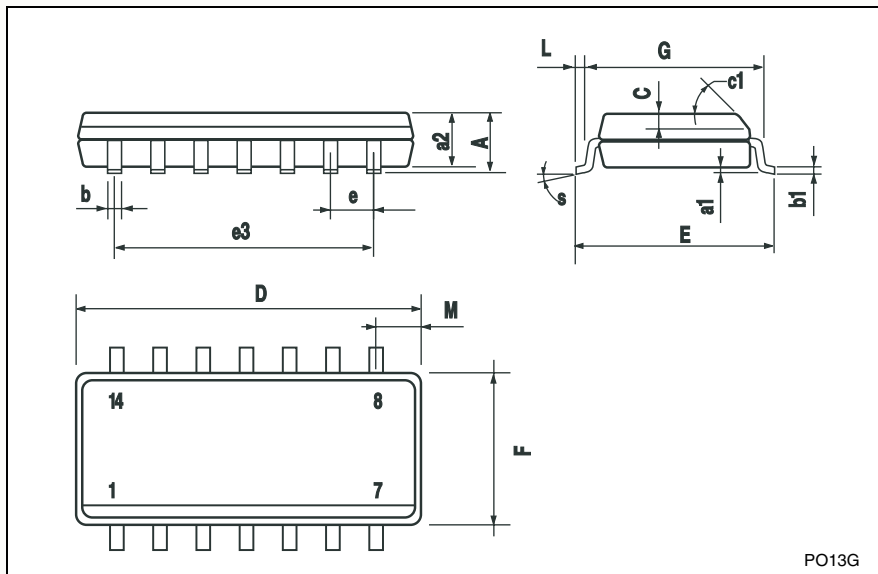
In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com).

### 6.1 SO-8 package



## 6.2 SO-14 package

SO-14 MECHANICAL DATA						
DIM.	mm.			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			1.75			0.068
a1	0.1		0.2	0.003		0.007
a2			1.65			0.064
b	0.35		0.46	0.013		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.019	
c1	45° (typ.)					
D	8.55		8.75	0.336		0.344
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F	3.8		4.0	0.149		0.157
G	4.6		5.3	0.181		0.208
L	0.5		1.27	0.019		0.050
M			0.68			0.026
S	8° (max.)					



PO13G

## 7 Revision History

**Table 6. Document revision history**

Date	Revision	Changes
March 2006	1	First Release.

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