



# 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.

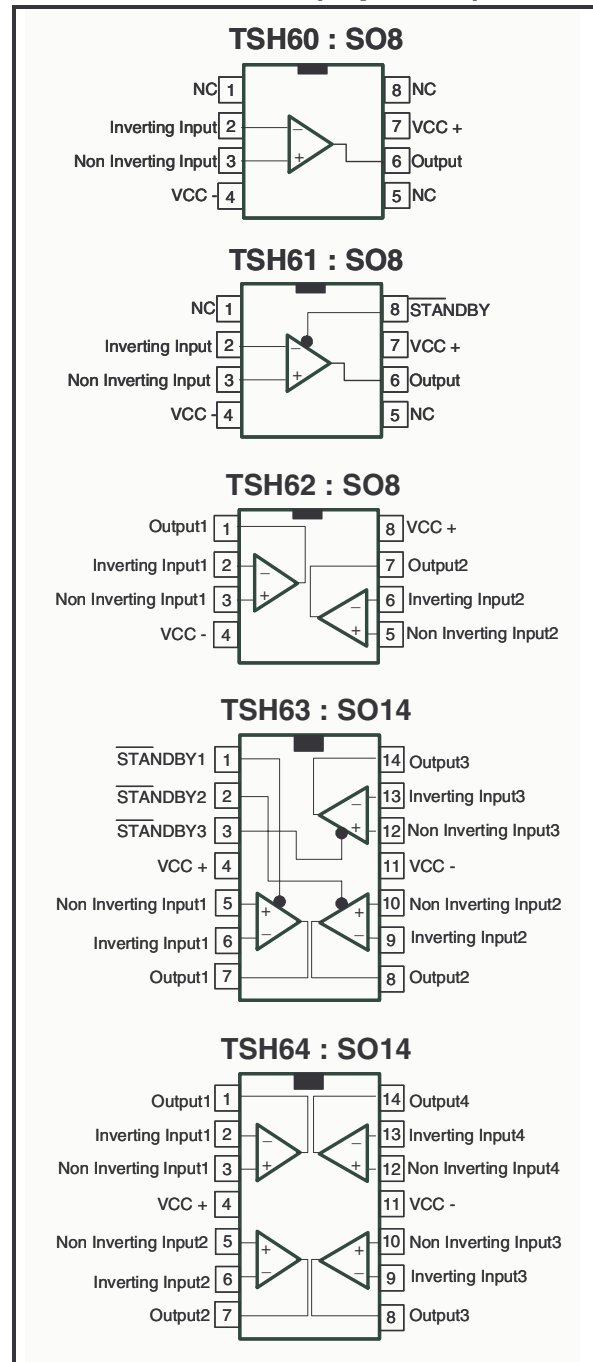
The TSH61 and TSH63 also feature standby inputs, allowing the op amps to be put into a standby mode with low power consumption and high output impedance.

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<br>SO14  | 28<br>22    |      |
| $R_{thja}$ | Thermal Resistance Junction to Ambient Area        |             | °C/W |
|            | SO8<br>SO14  | 157<br>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 $V_{CC}^-$<br>pin 1,2 or 3 (TSH63) to $V_{CC}^-$ |                  | 20       | 55                 | $\mu\text{A}$                   |
| $Z_{out}$      | Output Impedance ( $R_{out}/C_{out}$ )                  | $R_{out}$<br>$C_{out}$  |                  | 10<br>17 |                    | $\text{M}\Omega$<br>$\text{pF}$ |
| $T_{on}$       | 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 |         |         |
|---|---|---|-----------------|---------|---------|
| $\overline{\text{pin 1}}$<br>( $\overline{\text{STBY OP1}}$ ) | $\overline{\text{pin 2}}$<br>( $\overline{\text{STBY OP2}}$ ) | $\overline{\text{pin 3}}$<br>( $\overline{\text{STBY OP3}}$ ) | 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

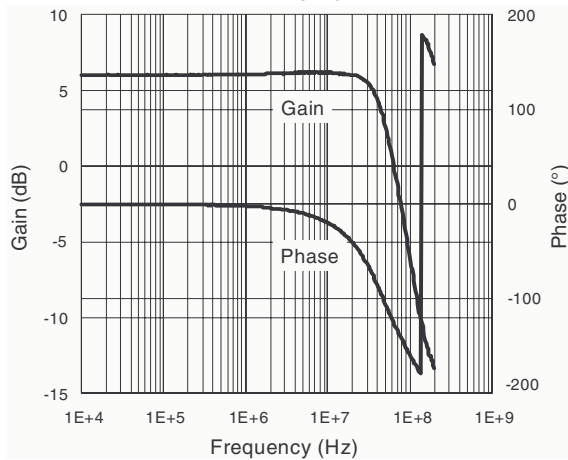
**Table 4.**  $V_{CC^+} = 5V$ ,  $V_{CC^-} = GND$ ,  $V_{ic} = 2.5V$ ,  $T_{amb} = 25^{\circ}C$  (unless otherwise specified)

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

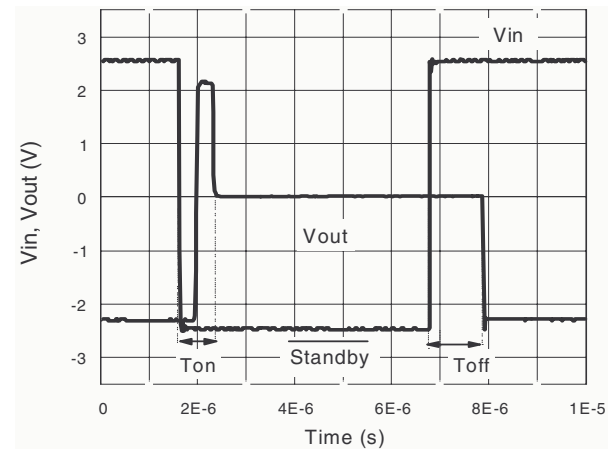
Table 5.  $V_{CC}^+ = 5V$ ,  $V_{CC}^- = -5V$ ,  $V_{IC} = GND$ ,  $T_{amb} = 25^\circ C$  (unless otherwise specified)

| Symbol     | Parameter  | Test Condition  | Min. | Typ.       | Max.     | Unit       |
|------------|--|---|------|------------|----------|------------|
| $ V_{io} $ | Input Offset Voltage   | $T_{min.} < T_{amb} < T_{max.}$   |      | 1.2        | 10<br>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<br>( $\delta V_{ic}/\delta V_{io}$ )   | $-4.9 < V_{ic} < 3.9V$ & $V_{out} = GND$  |      | 94         |          | dB         |
| PSRR       | Power Supply Rejection Ratio<br>( $\delta V_{CC}/\delta V_{out}$ ) | Positive & Negative Rail  |      | 70         |          | dB         |
| $A_{vd}$   | Large Signal Voltage Gain  | $R_L = 150\Omega$ to GND<br>$V_{out} = -4$ to $+4$  |      | 80         |          | dB         |
| $I_o$      | Output Short Circuit Current Source                                | $V_{id} = +1$ , $V_{out}$ to 1.5V<br>$V_{id} = -1$ , $V_{out}$ to 1.5V<br> Source <br>Sink            |      | 45<br>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  | $A_{VCL} = +1$<br>$R_L = 150\Omega$ to GND  |      | 74         |          | MHz        |
| SR         | Slew Rate  | $A_{VCL} = +2$<br>$R_L = 150\Omega$ to GND  |      | 98         |          | V/ $\mu s$ |
| $\phi_m$   | Phase Margin   | $R_L = 150\Omega$ to GND  |      | 40         |          | $^\circ$   |
| THD        | Total Harmonic Distortion  | $A_{VCL} = +2$ , $F = 4MHz$<br>$R_L = 150\Omega$ to GND<br>$V_{out} = 1V_{pp}$<br>$V_{out} = 2V_{pp}$ |      | -57<br>-51 |          | dB         |
| $\Delta G$ | Differential gain  | $A_{VCL} = +2$ , $R_L = 150\Omega$ to GND<br>$F = 4.5MHz$ , $V_{out} = 2V_{pp}$                       |      | 0.5        |          | %          |
| Df         | Differential phase   | $A_{VCL} = +2$ , $R_L = 150\Omega$ to GND<br>$F = 4.5MHz$ , $V_{out} = 2V_{pp}$                       |      | 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         |

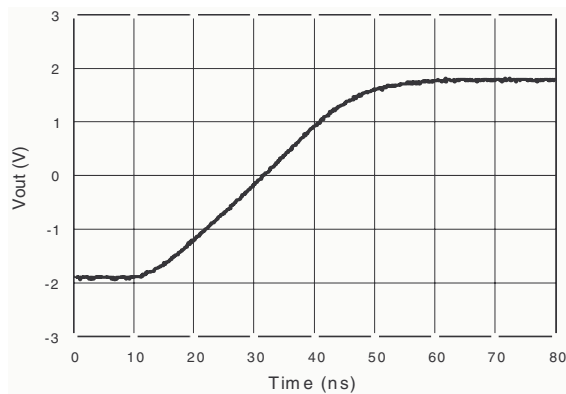
**Figure 1. Closed loop gain and phase vs. frequency (Gain = +2,  $V_{CC} = \pm 2.5V$ ,  $R_L = 150\Omega$ ,  $T_{amb} = 25^\circ C$ )**



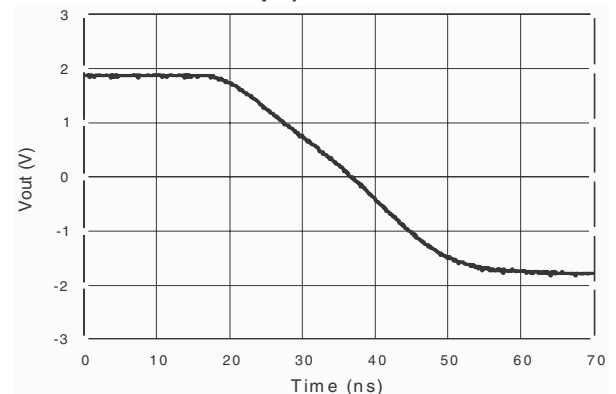
**Figure 2. Standby mode -  $T_{on}$ ,  $T_{off}$  ( $V_{CC} = \pm 2.5V$ , open loop)**



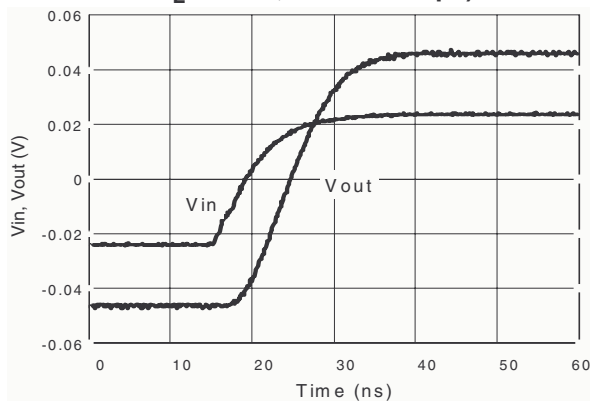
**Figure 3. Large signal measurement - positive slew rate (Gain = 2,  $V_{CC} = \pm 2.5V$ ,  $R_L = 150\Omega/5.6pF$ ,  $V_{in} = 1V_{pk}$ )**



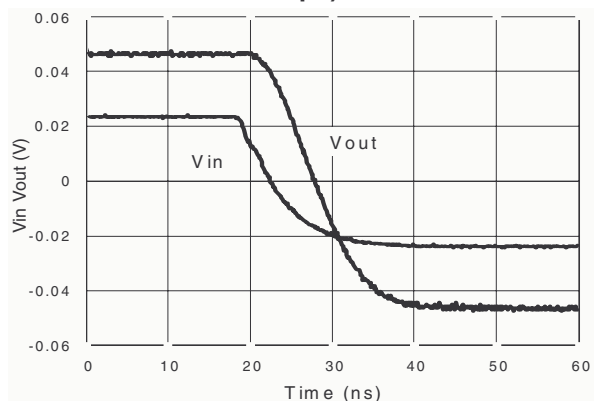
**Figure 4. Large signal measurement - negative slew rate (Gain = 2,  $V_{CC} = \pm 2.5V$ ,  $R_L = 150\Omega/5.6pF$ ,  $V_{in} = 1V_{pk}$ )**



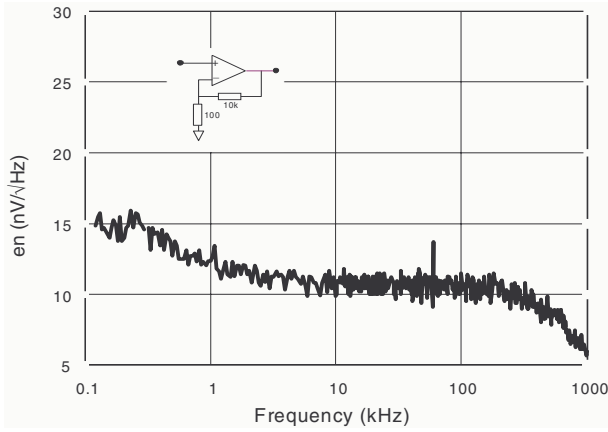
**Figure 5. Small signal measurement - rise time (Gain = 2,  $V_{CC} = \pm 2.5V$ ,  $Z_L = 150\Omega$ ,  $V_{in} = 25mV_{pk}$ )**



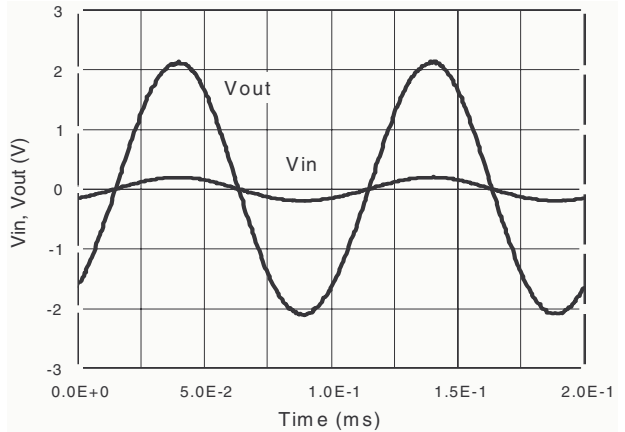
**Figure 6. Small signal measurement - fall time (Gain = 2,  $V_{CC} = \pm 2.5V$ ,  $Z_L = 150\Omega$ ,  $V_{in} = 25mV_{pk}$ )**



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



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

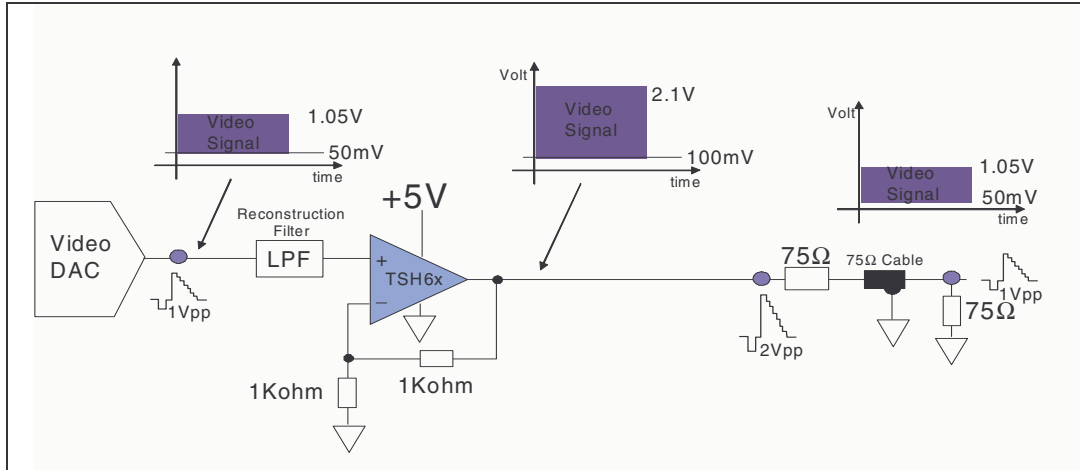




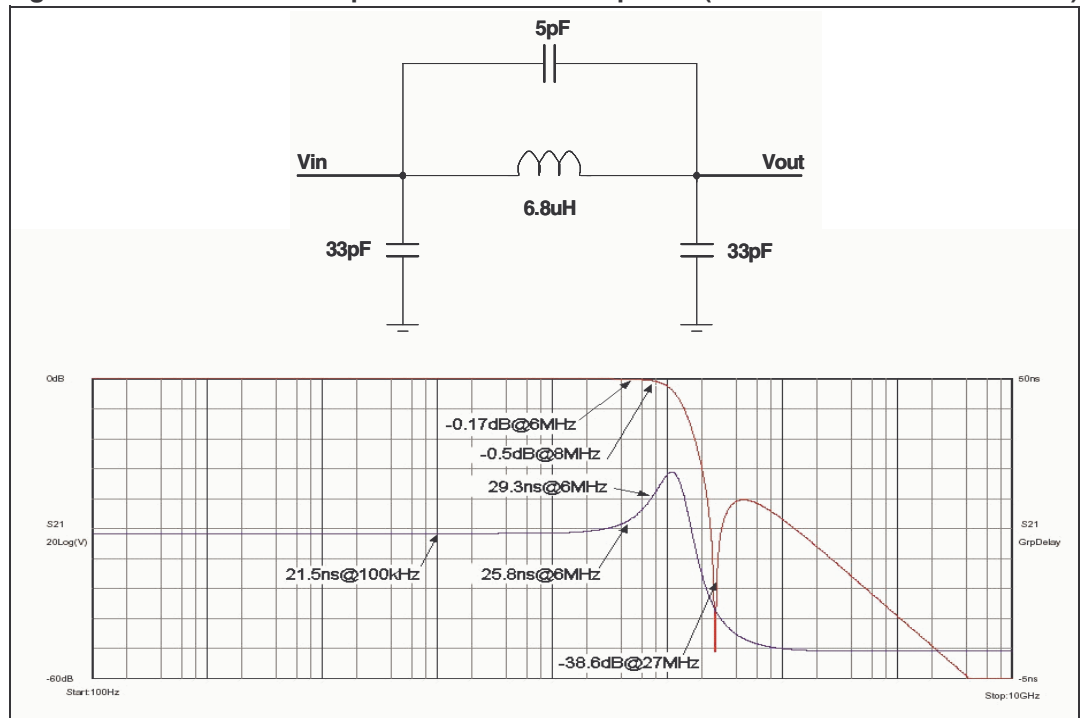
# 5 Video Applications

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**



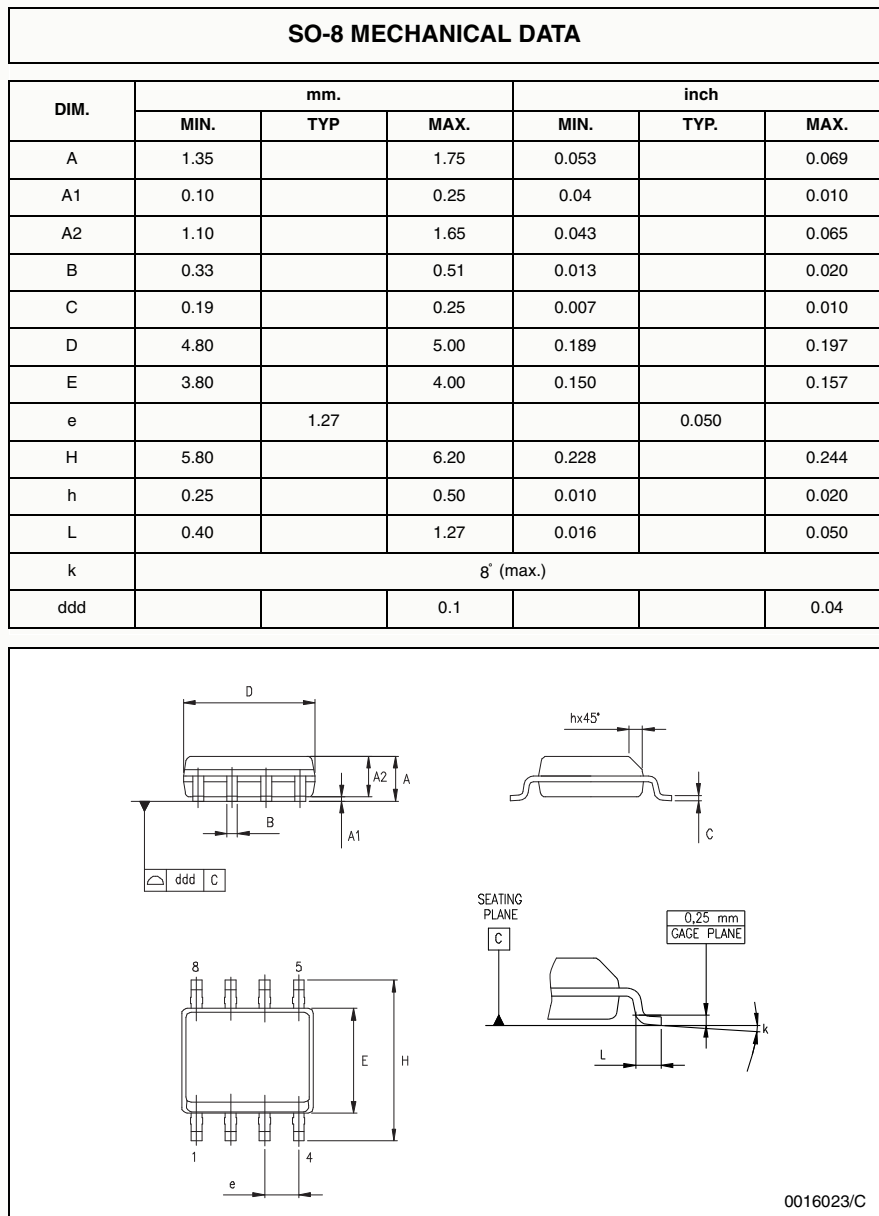
**Figure 10. Third order low-pass filter and its response (for standard definition video)**



## 6 Package Mechanical Data

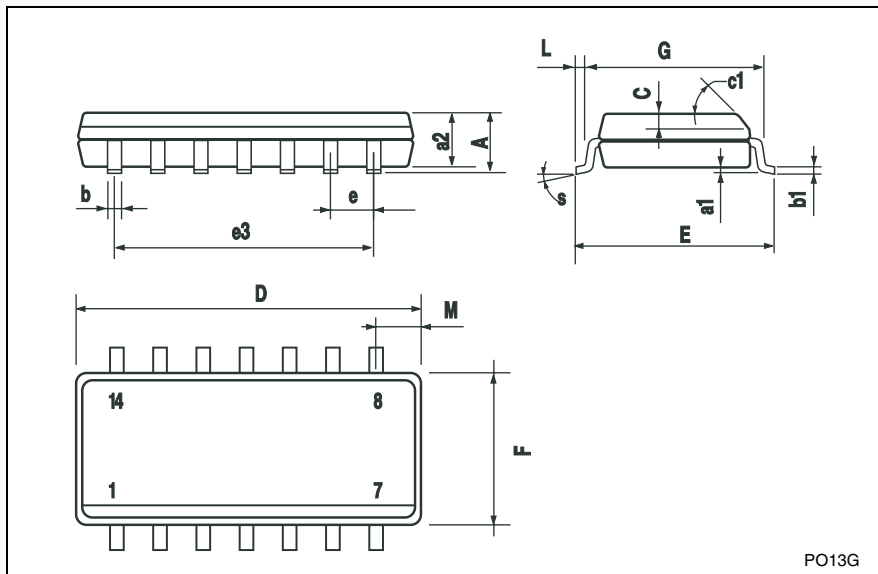
In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings 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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