

## 2.2V to 5V video buffer with SAG correction

### Features

- Very low consumption
- Standby mode available
- Internal reconstruction filter
- Internal gain of 6dB
- Rail-to-rail output
- Tested with +2.5V and +3.3V single supply
- Operation supply from +2.2V to +5.5V
- SAG correction
- Excellent video performance
  - Differential gain 0.5%
  - Differential phase 0.5°
  - Group delay=10ns
- Specified for 150Ω load
- Input DC level shifter
- Min. and max. limits are tested in full production

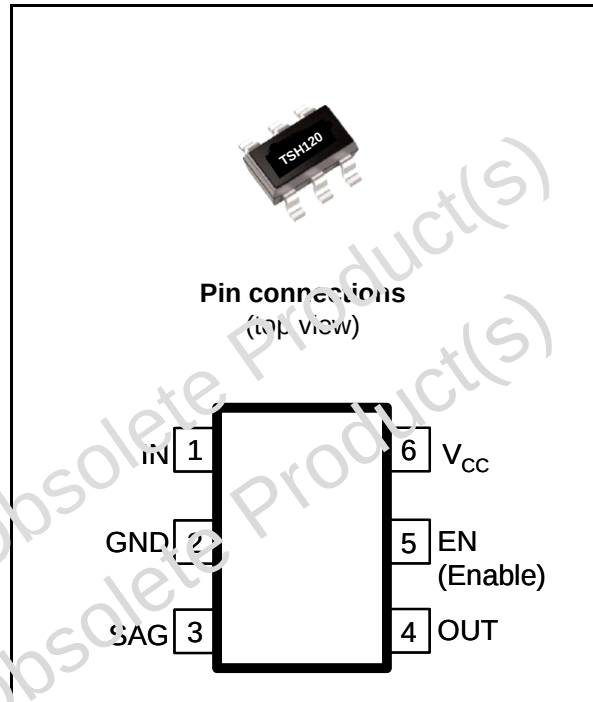
### Applications

- Camera phones
- Digital still camera
- Digital video camera
- Set-top box and D\ D video outputs

### Description

The TSH120 is a video buffer that includes a voltage feedback amplifier with an internal gain of 6dB, rail-to-rail output, internal input biasing and SAG correction. A power down function offers a sleep mode with ultra low consumption.

The TSH120 also features an internal reconstruction filter in order to attenuate the parasitic 27MHz frequency from the clock of the video DAC.



The TSH120 is a single operator available in a tiny SC70 plastic package for space saving.

# 1 Absolute maximum ratings

**Table 1. Absolute maximum ratings**

| Symbol     | Parameter                                                                                                                        | Value       | Unit |
|------------|----------------------------------------------------------------------------------------------------------------------------------|-------------|------|
| $V_{CC}$   | Supply voltage <sup>(1)</sup>                                                                                                    | 6           | V    |
| $V_{in}$   | Input voltage range <sup>(2)</sup>                                                                                               | 2           | V    |
| $T_{oper}$ | Operating free air temperature range                                                                                             | -40 to +105 | °C   |
| $T_{stg}$  | Storage temperature                                                                                                              | -65 to +150 | °C   |
| $T_j$      | Maximum junction temperature                                                                                                     | 150         | °C   |
| $R_{thja}$ | Thermal resistance junction to ambient                                                                                           | 430         | °C/W |
| $R_{thjc}$ | Thermal resistance junction to case                                                                                              | 58          | °C/W |
| $P_{max}$  | Maximum power dissipation <sup>(3)</sup> for $T_j=150^{\circ}\text{C}$<br>$T_a=+25^{\circ}\text{C}$<br>$T_a=+85^{\circ}\text{C}$ | 290<br>150  | mW   |
| ESD        | HBM: human body model <sup>(4)</sup><br>except pin-4<br>pin-4                                                                    | 2<br>1.5    | kV   |
|            | MM: machine model <sup>(5)</sup>                                                                                                 | 200         | V    |
|            | Latch-up immunity                                                                                                                | 200         | mA   |

1. All voltage values are measured with respect to the ground pin.
2. The magnitude of input and output voltage must never exceed  $V_{CC} + 0.3\text{V}$ .
3. Short-circuits can cause excessive heating. Destructive dissipation can result from short-circuits on amplifiers.
4. Human body model: A 100pF capacitor is charged to the specified voltage, then discharged through a 1.5kΩ resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
5. Machine model: A 200pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5Ω). This is done for all couples of connected pin combinations while the other pins are floating. This is a minimum value.

**Table 2. Operating conditions**

| Symbol   | Parameter                     | Value      | Unit |
|----------|-------------------------------|------------|------|
| $V_{CC}$ | Supply voltage <sup>(1)</sup> | 2.2 to 5.5 | V    |

1. Tested in full production at +2.5V and +3.3V single supply voltage.

## 2 Electrical characteristics

**Table 3. Electrical characteristics for  $V_{CC} = +2.5V$  and  $+3.3V$ ,  $T_{amb} = 25^{\circ}C$  (unless otherwise specified)**

| Symbol                                         | Parameter                                                                     | Test conditions                                                                                                                                          | Min.         | Typ.          | Max. | Unit  |
|------------------------------------------------|-------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|---------------|------|-------|
| DC performance                                 |                                                                               |                                                                                                                                                          |              |               |      |       |
| V <sub>dc</sub>                                | Output DC level shift                                                         | R <sub>L</sub> = 150Ω                                                                                                                                    | 94           | 129           | 158  | mV    |
|                                                |                                                                               | T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>                                                                                                   |              | 403           |      | μV/°C |
| I <sub>ib</sub>                                | Input bias current                                                            | V <sub>CC</sub> = +3.3V<br>T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>                                                                        | -880         | -550<br>-650  |      | nA    |
|                                                |                                                                               | V <sub>CC</sub> = +2.5V<br>T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>                                                                        | -840         | -550<br>-620  |      |       |
| G                                              | Internal voltage gain                                                         | V <sub>in</sub> =1V<br>T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>                                                                            | 5.95         | 6.1<br>6.05   | 6.2  | dB    |
| PSRR                                           | Power supply rejection ratio<br>20 log (ΔV <sub>CC</sub> /ΔV <sub>out</sub> ) | ΔV <sub>CC</sub> =±100mV at 1MHz                                                                                                                         |              | 55            |      | dB    |
| I <sub>CC</sub>                                | Current consumption                                                           | No load, V <sub>in</sub> =+0.5V<br>V <sub>CC</sub> =+3.3V<br>T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>                                      |              | 5.8<br>6.7    | 6.6  | mA    |
|                                                |                                                                               | No load, V <sub>in</sub> =+0.5V<br>V <sub>CC</sub> =+2.5V<br>T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>                                      |              | 5.8<br>6.7    | 6.3  | mA    |
| Enable/standby (EN pin)                        |                                                                               |                                                                                                                                                          |              |               |      |       |
| I <sub>STBY</sub>                              | Consumption in standby mode                                                   | V <sub>CC</sub> =+3.3V                                                                                                                                   |              |               | 4    | μA    |
|                                                |                                                                               | V <sub>CC</sub> =+2.5V                                                                                                                                   |              |               | 2    |       |
| V <sub>STBY-low</sub>                          | Standby low level                                                             | Standby mode                                                                                                                                             |              |               | +0.3 | V     |
| V <sub>STBY-high</sub>                         | Standby high level                                                            | Enable mode                                                                                                                                              | +0.8         |               |      | V     |
| T <sub>on</sub>                                | Time from standby to enable                                                   |                                                                                                                                                          |              | 5             |      | μs    |
| T <sub>off</sub>                               | Time from enable to standby                                                   |                                                                                                                                                          |              | 5             |      | μs    |
| Dynamic performance and output characteristics |                                                                               |                                                                                                                                                          |              |               |      |       |
| FR                                             | Frequency response                                                            | V <sub>out</sub> =2V <sub>pp</sub> , R <sub>L</sub> = 150Ω<br>V <sub>CC</sub> =+3.3V, F=4.5MHz<br>T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub> | -0.4         | -0.1<br>-0.48 | 0.4  | dB    |
|                                                |                                                                               | V <sub>out</sub> =2V <sub>pp</sub> , R <sub>L</sub> = 150Ω<br>V <sub>CC</sub> =+2.5V, F=4.5MHz                                                           |              | 0             |      |       |
|                                                |                                                                               | V <sub>CC</sub> =+3.3V, F=27MHz<br>T <sub>min</sub> ≤ T <sub>amb</sub> ≤ T <sub>max</sub>                                                                | -20          | -25<br>-23    |      |       |
| V <sub>OH</sub>                                | High level output voltage                                                     | V <sub>CC</sub> =+3.3V, R <sub>L</sub> =150Ω<br>V <sub>CC</sub> =+2.5V, R <sub>L</sub> =150Ω                                                             | 3.13<br>2.36 | 3.21<br>2.42  |      | V     |

**Table 3. Electrical characteristics for  $V_{CC} = +2.5V$  and  $+3.3V$ ,  $T_{amb} = 25^{\circ}C$  (unless otherwise specified) (continued)**

| Symbol       | Parameter                    | Test conditions                                                                                  | Min. | Typ.     | Max.   | Unit   |
|--------------|------------------------------|--------------------------------------------------------------------------------------------------|------|----------|--------|--------|
| $V_{OL}$     | Low level output voltage     | $V_{in} = -100mV$ , $R_L = 150\Omega$<br>$V_{CC} = +3.3V$<br>$T_{min} \leq T_{amb} \leq T_{max}$ |      | 5<br>5.6 | 34     | mV     |
|              |                              | $V_{in} = -100mV$ , $R_L = 150\Omega$<br>$V_{CC} = +2.5V$<br>$T_{min} \leq T_{amb} \leq T_{max}$ |      | 5<br>5.5 | 33     |        |
| $I_{out}$    | $I_{source}$                 | $V_{CC} = +3.3V$ , output to GND                                                                 |      | 30       |        | mA     |
| $\Delta G$   | Differential gain            | $V_{CC} = +3.3V$ , $R_L = 150\Omega$                                                             |      | 0.5      |        | %      |
| $\Delta\phi$ | Differential phase           | $V_{CC} = +3.3V$ , $R_L = 150\Omega$                                                             |      | 0.5      |        | °      |
| Gd           | Group delay                  | 10kHz to 6MHz                                                                                    |      |          | 10 (1) | ns     |
| <b>Noise</b> |                              |                                                                                                  |      |          |        |        |
| eN           | Total output noise           | $F = 100kHz$ , no load                                                                           |      | 25       |        | nV/√Hz |
| SNR          | Output signal to noise ratio | $V_{CC} = +3.3V$ , $R_L = 150\Omega$<br>$V_{out} = 2V_{pp}$ from 0 to 6MHz                       |      | 60       |        | dB     |

1. Guaranteed by design. The parameter is not tested.

Figure 1. Frequency response

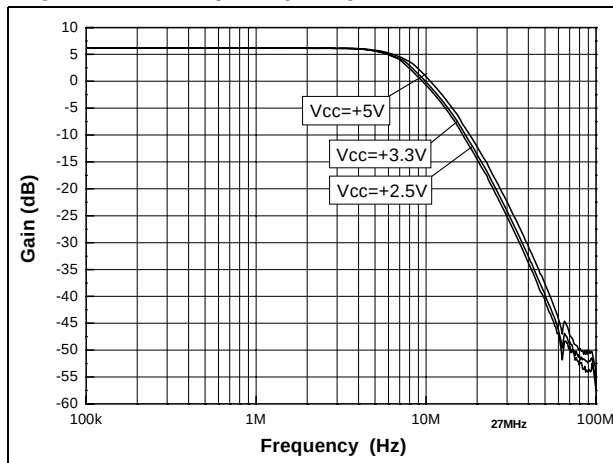


Figure 2. Gain flatness

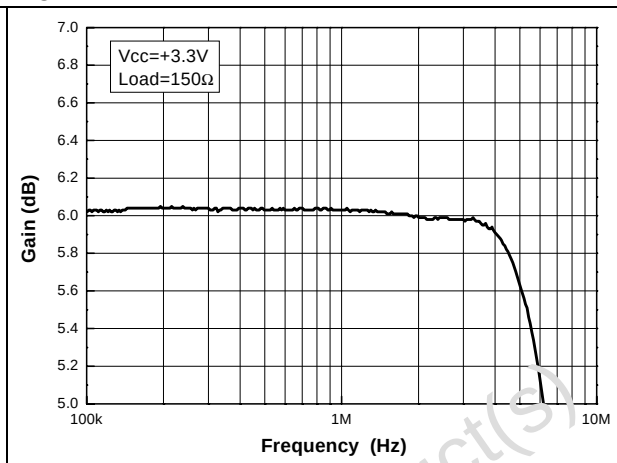


Figure 3. Total input noise vs. frequency

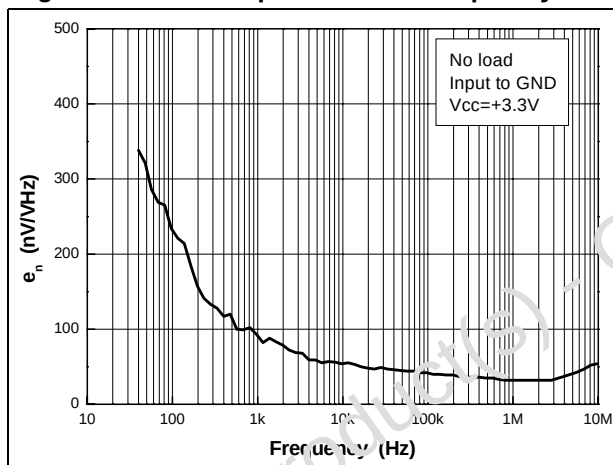


Figure 4. Distortion on 150Ω load

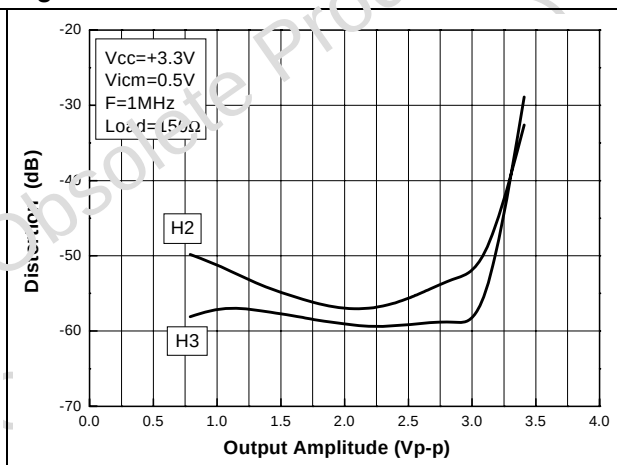


Figure 5. Output voltage swing vs. supply

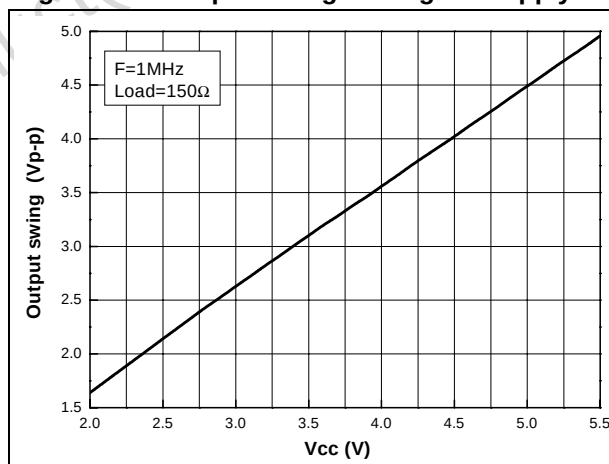


Figure 6. Quiescent current vs. supply

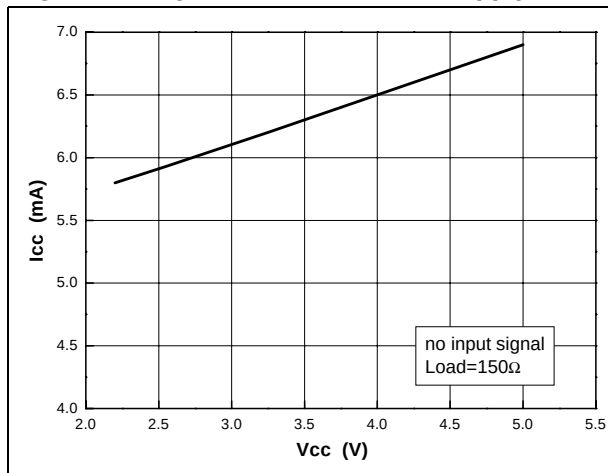
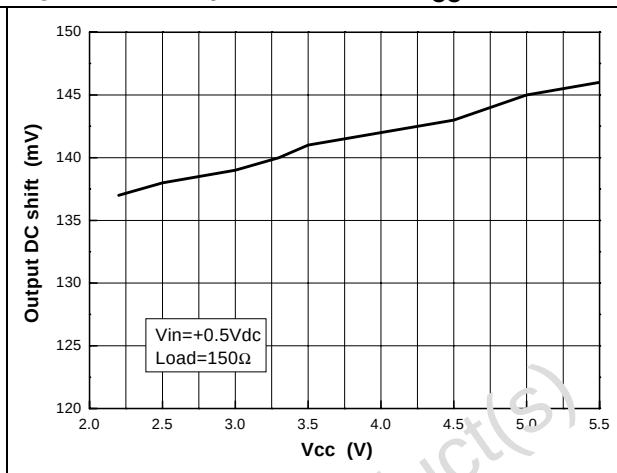
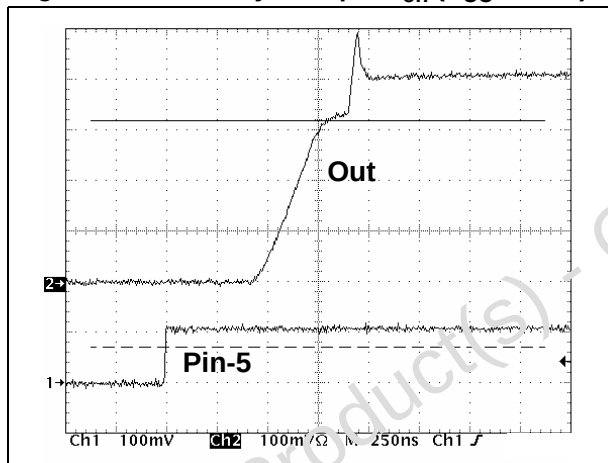
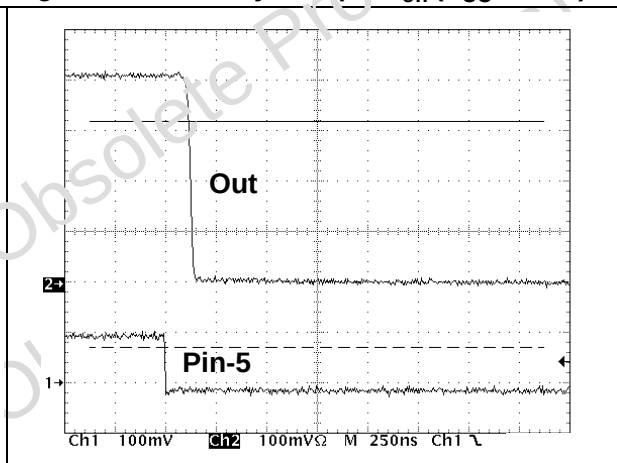
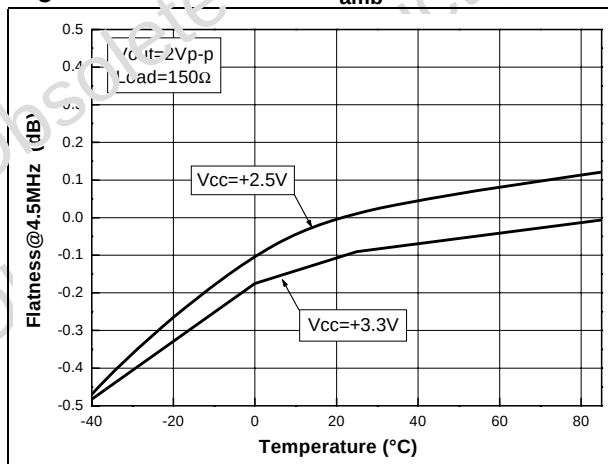
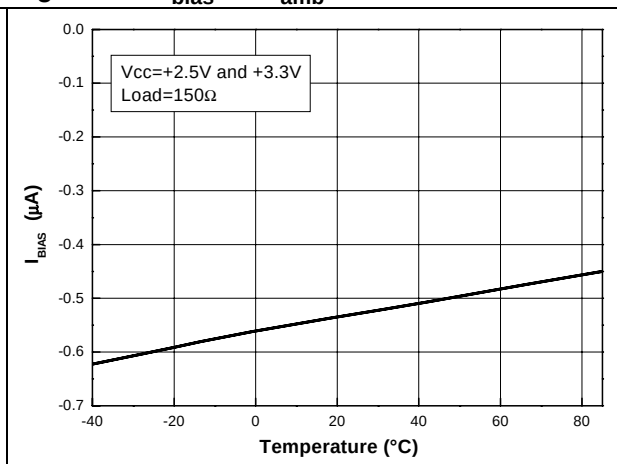
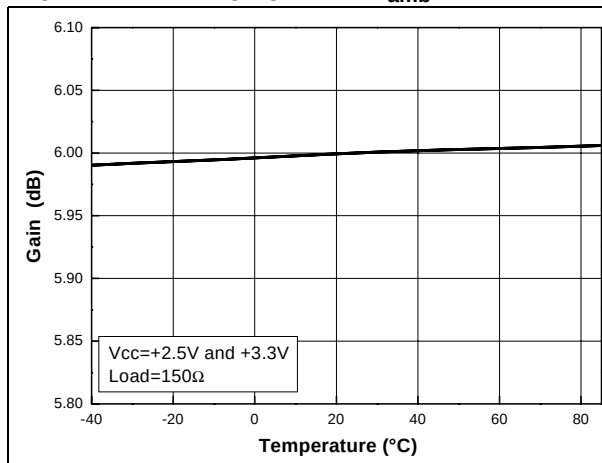
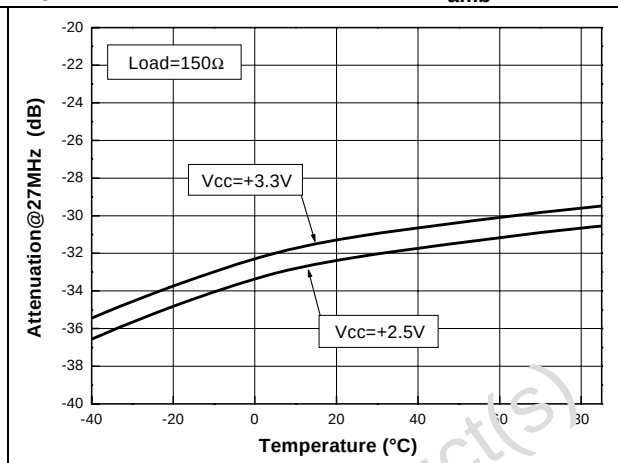
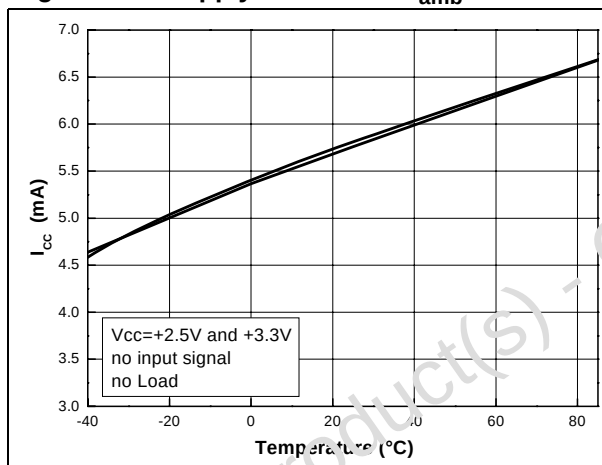
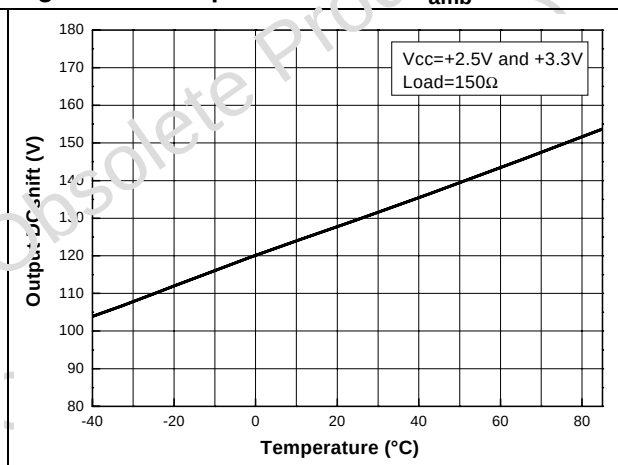
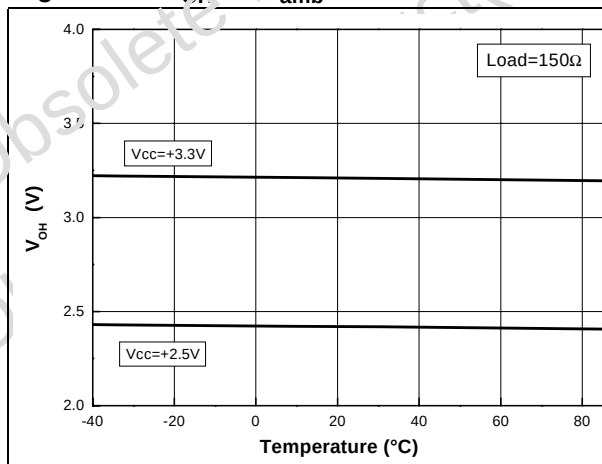
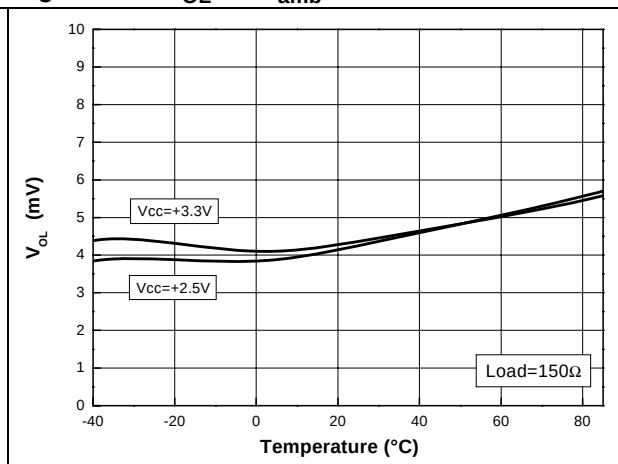
Figure 7. Output DC shift vs. V<sub>CC</sub>Figure 8. Standby - Output T<sub>on</sub> (V<sub>CC</sub>=+3.3V)Figure 9. Standby - Output T<sub>off</sub> (V<sub>CC</sub>=+3.3V)Figure 10. Flatness vs. T<sub>amb</sub>Figure 11. I<sub>bias</sub> vs. T<sub>amb</sub>

Figure 12. Voltage gain vs.  $T_{amb}$ Figure 13. Filter attenuation vs.  $T_{amb}$ Figure 14. Supply current vs.  $T_{amb}$ Figure 15. Output DC shift vs.  $T_{amb}$ Figure 16.  $V_{OH}$  vs.  $T_{amb}$ Figure 17.  $V_{OL}$  vs.  $T_{amb}$ 

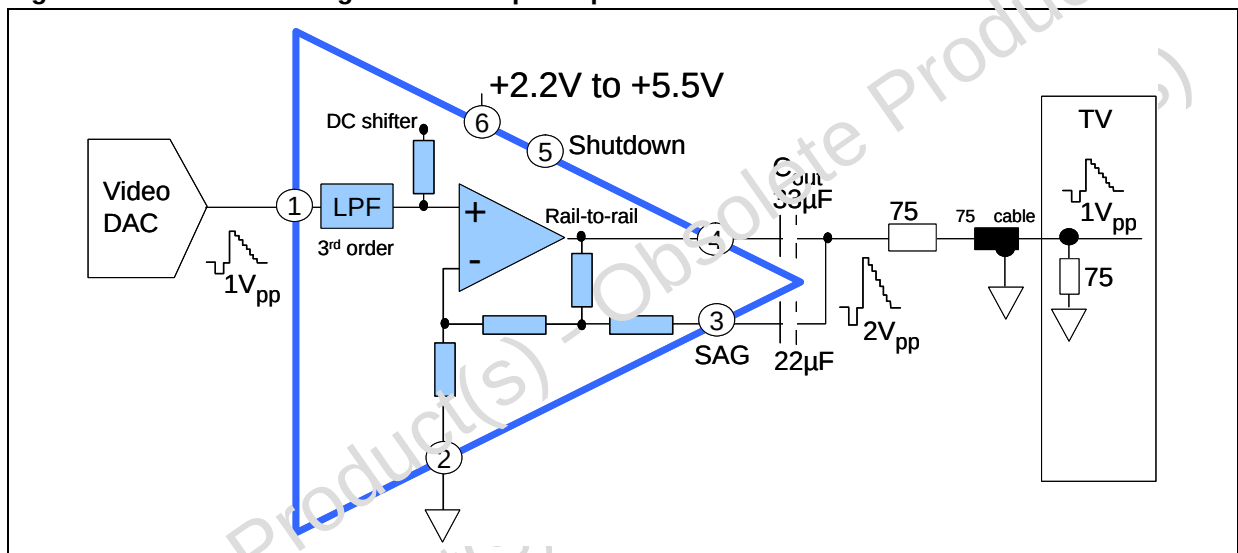
### 3 Implementation in the application

This section explains how the TSH120 video buffer operates in a typical application.

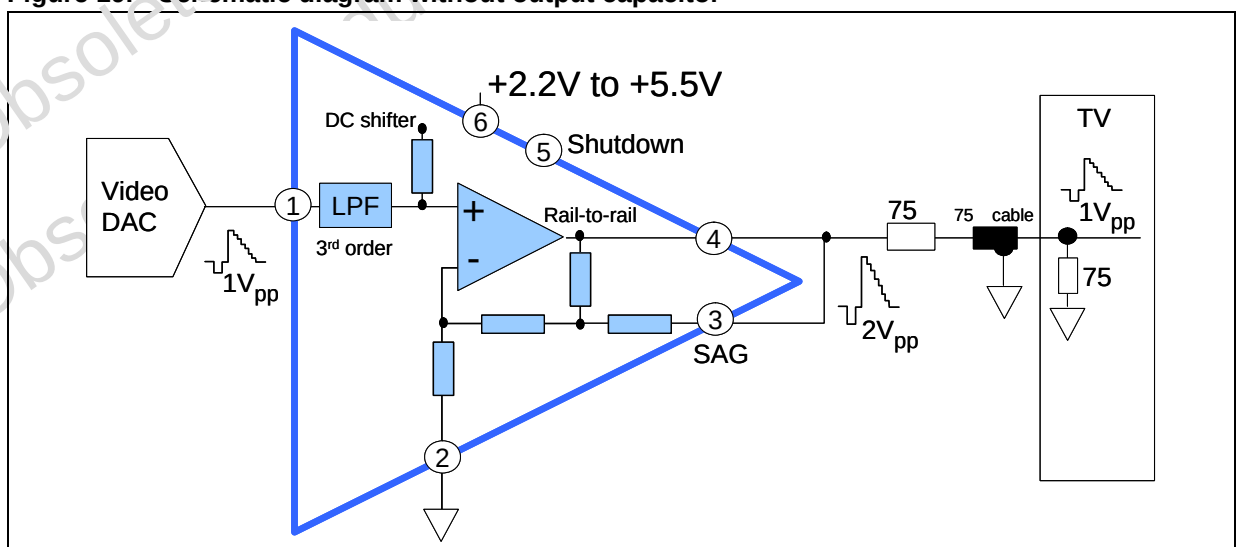
On the input, a DC level shifter optimizes the position of the video signal with no clamping on the output rails. The filter is a reconstruction filter. It is used to attenuate the DAC's sampling frequency which causes a parasitic signal in the video spectrum (typically at 27MHz in the case of standard video). This function must be achieved while keeping a low group delay.

On the output, the SAG correction decreases  $C_{out}$  while keeping a very low frequency pole (see [Figure 18](#)). Nevertheless, the output can be directly connected to the line without any capacitor. In this case, both OUT and SAG pins are connected together and the equivalent gain of the buffer remains 6dB (see [Figure 19](#)).

**Figure 18. Schematic diagram with output capacitor**



**Figure 19. Schematic diagram without output capacitor**





## 4 Power supply considerations

Correct power supply bypassing is very important for optimizing performance in the high-frequency range. A bypass capacitor greater than  $10\mu\text{F}$  is necessary to minimize the distortion. For better quality bypassing at higher frequencies, a capacitor of  $10\text{nF}$  must be added as close as possible to the IC pin of  $V_{CC}$ .

**Figure 20. Circuit for power supply bypassing**

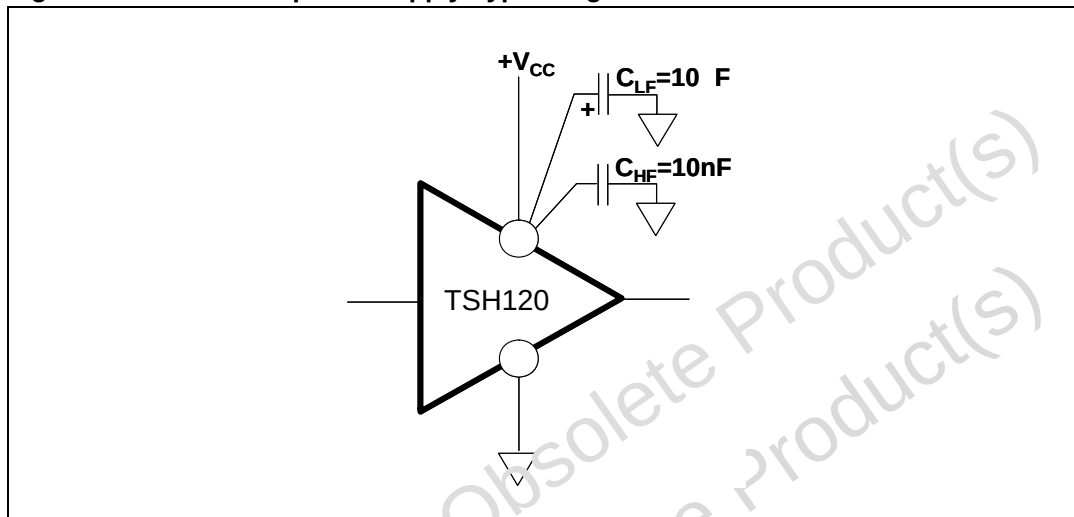
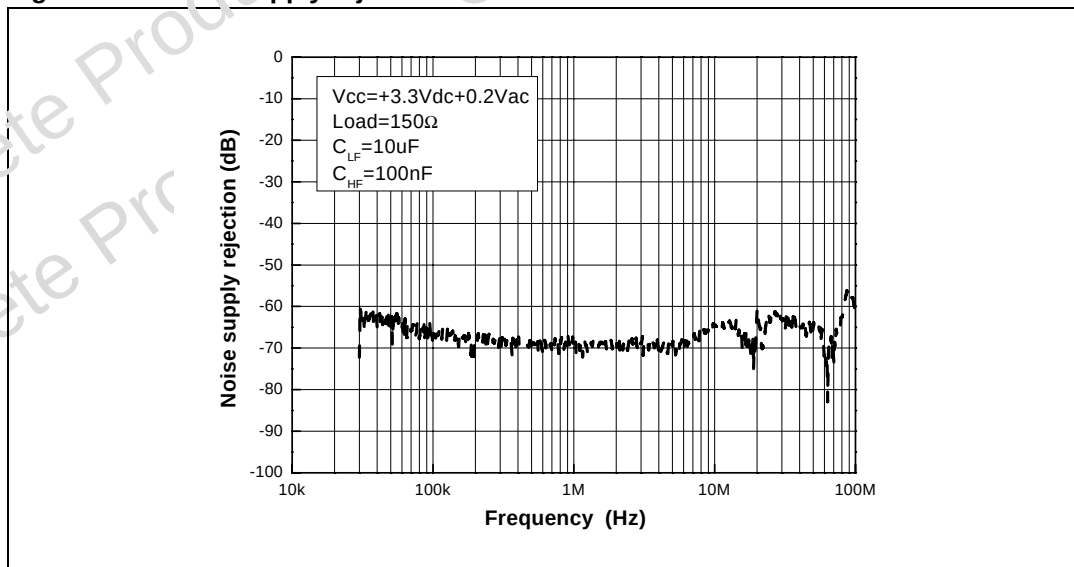


Figure 21 shows the noise supply rejection improvement with bypass capacitors expressed by:

$$20 \log (\Delta V_{\text{out}} / \Delta V_{CC}).$$

**Figure 21. Noise supply rejection**



## 5 Package information

In order to meet environmental requirements, STMicroelectronics offers these devices in ECOPACK<sup>®</sup> 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 STMicroelectronics trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com).

**Figure 22. SC70-6 (or SOT323-6) package footprint (in millimeters)**

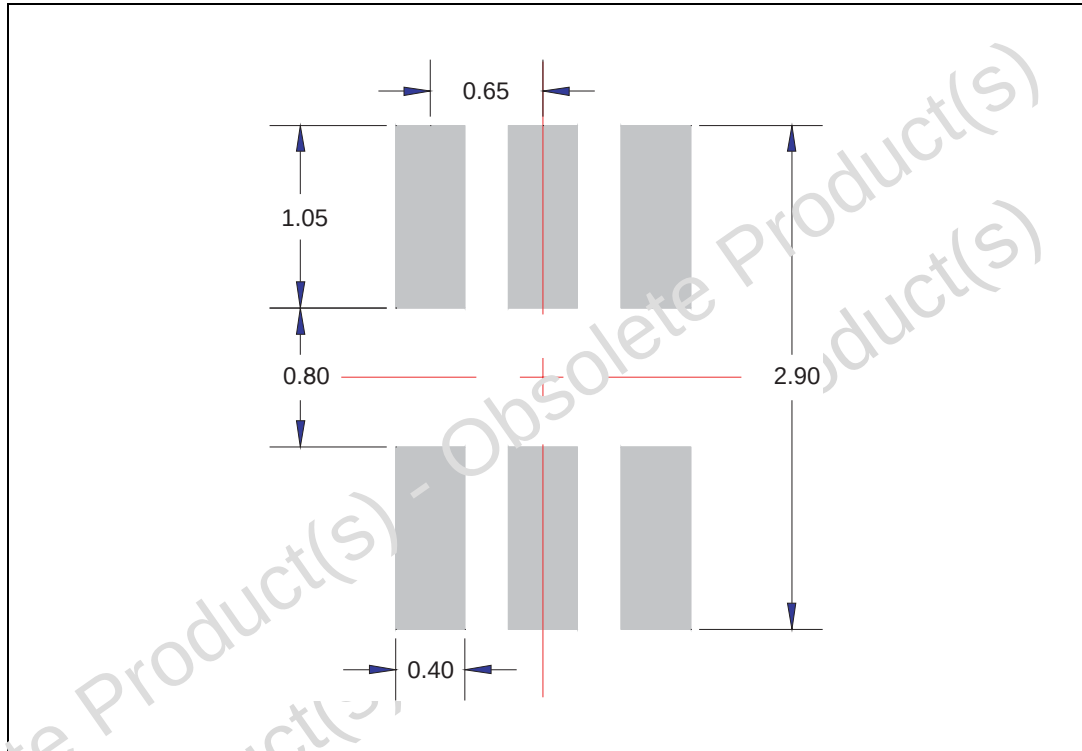
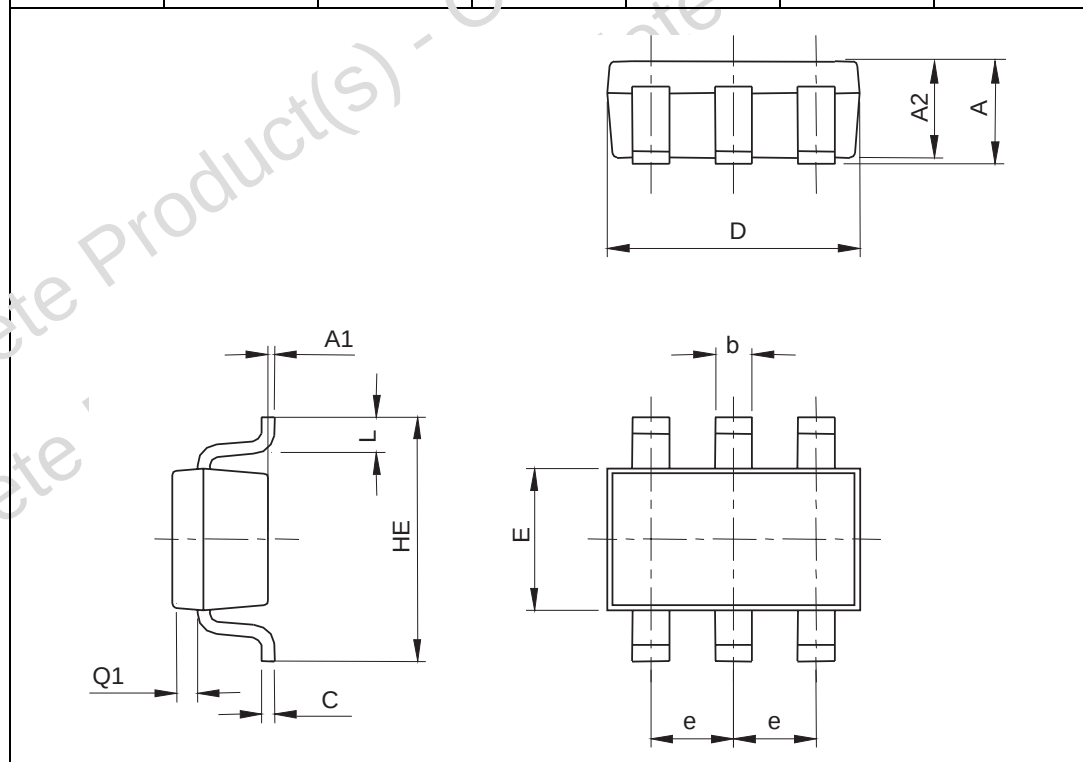


Figure 23. SC70-6 (or SOT323-6) package mechanical data

| Ref | Dimensions  |      |      |      |      |      |
|-----|-------------|------|------|------|------|------|
|     | Millimeters |      |      | Mils |      |      |
|     | Min         | Typ  | Max  | Min  | Typ  | Max  |
| A   | 0.80        |      | 1.10 | 31.5 |      | 43.3 |
| A1  | 0           |      | 0.10 | 0    |      | 3.9  |
| A2  | 0.80        |      | 1.00 | 31.5 |      | 39.3 |
| b   | 0.15        |      | 0.30 | 5.9  |      | 11.8 |
| c   | 0.10        |      | 0.18 | 3.9  |      | 7.0  |
| D   | 1.80        |      | 2.20 | 70.8 |      | 86.6 |
| E   | 1.15        |      | 1.35 | 45.2 |      | 43.1 |
| e   |             | 0.65 |      |      | 25.6 |      |
| HE  | 1.8         |      | 2.4  | 70.8 |      | 94.5 |
| L   | 0.10        |      | 0.40 | 3.9  |      | 15.7 |
| Q1  | 0.10        |      | 0.40 | 3.9  |      | 15.7 |



## 6 Ordering information

**Table 4. Order codes**

| Part number | Temperature range | Package                 | Packaging   | Marking |
|-------------|-------------------|-------------------------|-------------|---------|
| TSH120ICT   | -40°C to +85°C    | SC70-6<br>(or SOT323-6) | Tape & reel | K30     |

## 7 Revision history

**Table 5. Document revision history**

| Date        | Revision | Changes                                               |
|-------------|----------|-------------------------------------------------------|
| 29-May-2007 | 1        | Initial version, preliminary data.                    |
| 20-Jun-2007 | 2        | First complete datasheet.                             |
| 21-Aug-2007 | 3        | Corrected pinout diagram on cover page (SAG missing). |

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