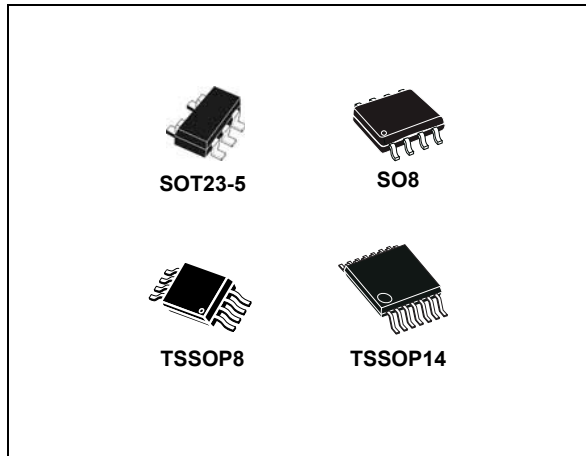


## Wide-band rail-to-rail operational amplifiers with standby function

Datasheet - production data



### Features

- Operating range from 4.5 to 12 V
- 3 dB-bandwidth: 100 MHz
- Slew rate 100 V/ $\mu$ s
- Output current up to 55 mA
- Input single supply voltage
- Output rail-to-rail
- Specified for 150  $\Omega$  loads
- Low distortion, THD 0.1%
- SOT23-5, SO8, and TSSOP packages
- Automotive qualification

### Applications

- Video buffers
- A/D converter drivers
- Hi-fi applications

### Description

The TSH8x series offers single, dual and quad operational amplifiers featuring high video performance with large bandwidth, low distortion and excellent supply voltage rejection. These amplifiers also feature large output voltage swings and a high output current capability to drive standard 150  $\Omega$  loads.

Running at single or dual supply voltages ranging from 4.5 to 12 V, these amplifiers are tested at 5 V ( $\pm 2.5$  V) and 10 V ( $\pm 5$  V) supplies.

The TSH81 device also features a standby mode, which provides the operational amplifier with a low power consumption and high output impedance. This function allows power saving or signal switching/multiplexing for high-speed and video applications.

For board space and weight saving, the TSH8x series is proposed in SOT23-5, SO8, TSSOP8, and TSSOP14 plastic micropackages.

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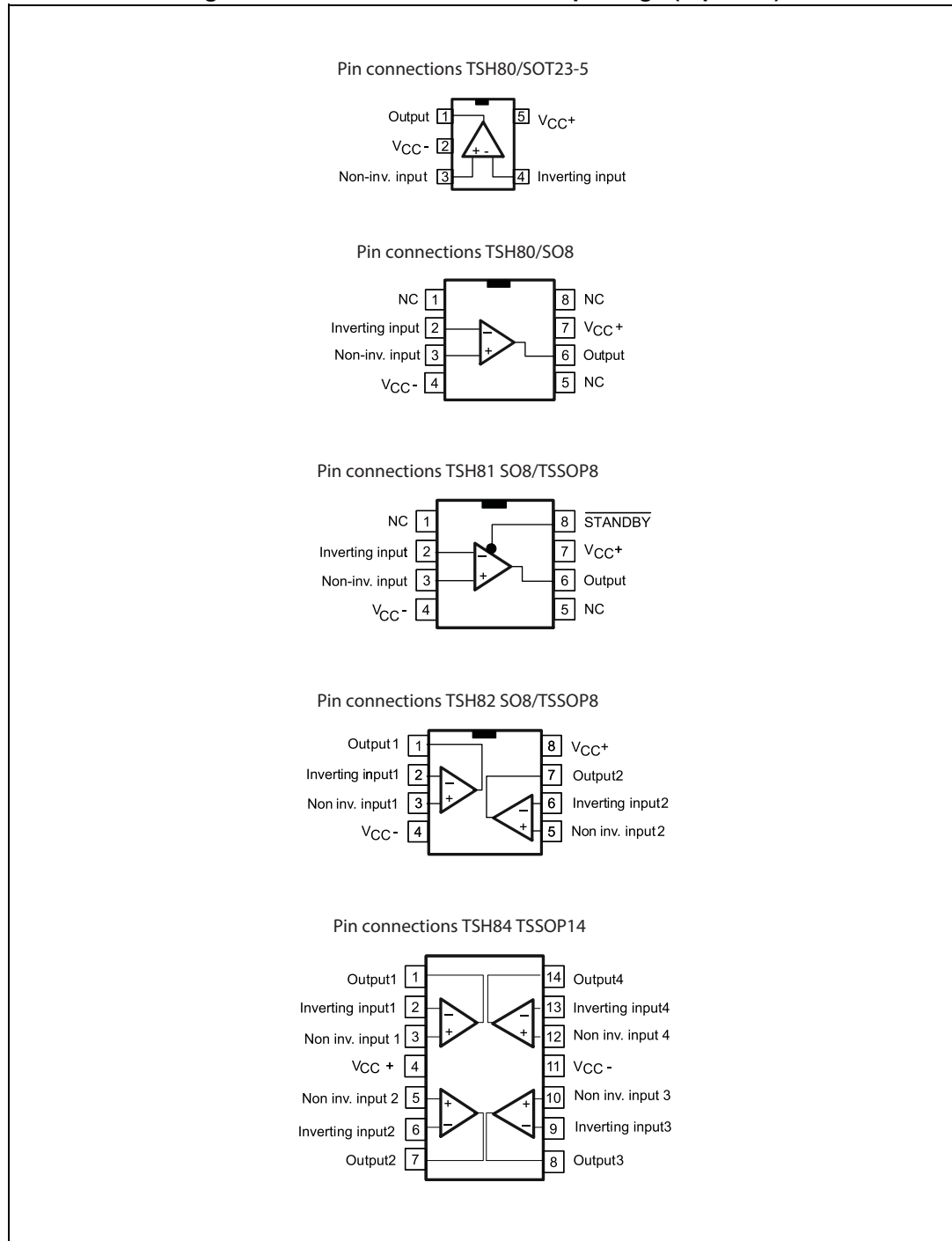
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# 1 Package pin connections

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



## 2 Absolute maximum ratings and operating conditions

Table 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>          | $\pm 2$     |      |
| $V_i$      | Input voltage <sup>(3)</sup>                       | $\pm 6$     |      |
| $T_{oper}$ | Operating free air temperature range               | -40 to +85  | °C   |
| $T_{stg}$  | Storage temperature                                | -65 to +150 |      |
| $T_j$      | Maximum junction temperature                       | 150         |      |
| $R_{thjc}$ | Thermal resistance junction-to-case <sup>(4)</sup> |             | °C/W |
|            | SOT23-5                                            | 80          |      |
|            | SO8                                                | 28          |      |
|            | TSSOP8                                             | 37          |      |
|            | TSSOP14                                            | 32          |      |
| $R_{thja}$ | Thermal resistance junction-to-ambient area        |             |      |
|            | SOT23-5                                            | 250         |      |
|            | SO8                                                | 157         |      |
|            | TSSOP8                                             | 130         |      |
| ESD        | TSSOP14                                            | 110         |      |
|            | HBM: human body model <sup>(5)</sup>               | 2           | kV   |
|            | MM: machine model <sup>(6)</sup>                   | 0.2         |      |
|            | CDM: charged device model <sup>(7)</sup>           | 1.5         |      |

1. All voltage values, except differential voltage are with respect to the network ground terminal.
2. The differential voltage is the non inverting input terminal with respect to the inverting terminal.
3. The magnitude of input and output must never exceed  $V_{CC} + 0.3$  V.
4. Short-circuits can cause excessive heating.
5. Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 k $\Omega$  resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
6. 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  $\Omega$ ). This is done for all couples of connected pin combinations while the other pins are floating.
7. Charged device model: all pins and package are charged together to the specified voltage and then discharged directly to ground through only one pin. This is done for all pins.

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 $(V_{CC}^+ - 1.1)$ |      |
| Standby (pin 8) | Threshold on pin 8 for TSH81    | $(V_{CC}^-)$ to $(V_{CC}^+)$     |      |

### 3 Electrical characteristics

**Table 3. Electrical characteristics at  $V_{CC}^+ = +5\text{ V}$ ,  $V_{CC}^- = \text{GND}$ ,  $V_{ic} = 2.5\text{ V}$ ,  $T_{amb} = 25\text{ °C}$  (unless otherwise specified)**

| Symbol                   | Parameter                                                        | Test conditions                                                                                                                                               | Min.     | Typ. | Max.         | Unit                    |
|--------------------------|------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|------|--------------|-------------------------|
| $ V_{io} $               | Input offset voltage                                             | $T_{amb} = 25\text{ °C}$<br>$T_{min} < T_{amb} < T_{max}$                                                                                                     |          | 1.1  | 10<br>12     | mV                      |
| $\Delta V_{io}/\Delta T$ | Input offset voltage drift vs. temperature                       | $T_{min} < T_{amb} < T_{max}$                                                                                                                                 |          | 3    |              | $\mu\text{V}/\text{°C}$ |
| $I_{io}$                 | Input offset current                                             | $T_{amb} = 25\text{ °C}$<br>$T_{min} < T_{amb} < T_{max}$                                                                                                     |          | 0.1  | 3.5<br>5     | $\mu\text{A}$           |
| $I_{ib}$                 | Input bias current                                               | $T_{amb} = 25\text{ °C}$<br>$T_{min} < T_{amb} < T_{max}$                                                                                                     |          | 6    | 15<br>20     |                         |
| $C_{in}$                 | Input capacitance                                                |                                                                                                                                                               |          | 0.3  |              | pF                      |
| $I_{CC}$                 | Supply current per operator                                      | $T_{amb} = 25\text{ °C}$<br>$T_{min} < T_{amb} < T_{max}$                                                                                                     |          | 8.2  | 10.5<br>11.5 | mA                      |
| CMR                      | Common mode rejection ratio ( $\Delta V_{ic}/\Delta V_{io}$ )    | $+0.1 < V_{ic} < 3.9\text{ V}$ and $V_{out} = 2.5\text{ V}$<br>$T_{amb} = 25\text{ °C}$<br>$T_{min} < T_{amb} < T_{max}$                                      | 72<br>70 | 97   |              | dB                      |
| SVR                      | Supply voltage rejection ratio ( $\Delta V_{CC}/\Delta V_{io}$ ) | $T_{amb} = 25\text{ °C}$<br>$T_{min} < T_{amb} < T_{max}$                                                                                                     | 68<br>65 | 75   |              |                         |
| PSR                      | Power supply rejection ratio ( $\Delta V_{CC}/\Delta V_{out}$ )  | Positive and negative rail                                                                                                                                    |          | 75   |              |                         |
| $A_{vd}$                 | Large signal voltage gain                                        | $R_L = 150\text{ }\Omega$ connected to $1.5\text{ V}$ and $V_{out} = 1\text{ V}$ to $4\text{ V}$<br>$T_{amb} = 25\text{ °C}$<br>$T_{min} < T_{amb} < T_{max}$ | 75<br>70 | 84   |              |                         |
| $I_o$                    | Source                                                           | $V_{id} = +1$ , $V_{out}$ connected to $1.5\text{ V}$<br>$T_{amb} = 25\text{ °C}$<br>$T_{min} < T_{amb} < T_{max}$                                            | 35<br>28 | 55   |              | mA                      |
|                          | Sink                                                             | $V_{id} = -1$ , $V_{out}$ connected to $1.5\text{ V}$<br>$T_{amb} = 25\text{ °C}$<br>$T_{min} < T_{amb} < T_{max}$                                            | 33<br>28 | 55   |              |                         |

**Table 3. Electrical characteristics at  $V_{CC}^+ = +5\text{ V}$ ,  $V_{CC}^- = \text{GND}$ ,  $V_{ic} = 2.5\text{ V}$ ,  $T_{amb} = 25\text{ }^\circ\text{C}$   
(unless otherwise specified) (continued)**

| Symbol   | Parameter                            | Test conditions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Min.                                            | Typ.                                                         | Max.                     | Unit                   |
|----------|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|--------------------------------------------------------------|--------------------------|------------------------|
| $V_{oh}$ | High-level output voltage            | $T_{amb} = 25\text{ }^\circ\text{C}$<br>$R_L = 150\text{ }\Omega$ connected to GND<br>$R_L = 600\text{ }\Omega$ connected to GND<br>$R_L = 2\text{ k}\Omega$ connected to GND<br>$R_L = 10\text{ k}\Omega$ connected to GND<br>$R_L = 150\text{ }\Omega$ connected to 2.5 V<br>$R_L = 600\text{ }\Omega$ connected to 2.5 V<br>$R_L = 2\text{ k}\Omega$ connected to 2.5 V<br>$R_L = 10\text{ k}\Omega$ connected to 2.5 V<br>$T_{min} < T_{amb} < T_{max}$<br>$R_L = 150\text{ }\Omega$ connected to GND<br>$R_L = 150\text{ }\Omega$ connected to 2.5 V | 4.2<br>4.60 <sup>(1)</sup><br>4.5<br>4.1<br>4.4 | 4.36<br>4.85<br>4.90<br>4.93<br>4.66<br>4.90<br>4.92<br>4.93 |                          | V                      |
| $V_{ol}$ | Low-level output voltage             | $T_{amb} = 25\text{ }^\circ\text{C}$<br>$R_L = 150\text{ }\Omega$ connected to GND<br>$R_L = 600\text{ }\Omega$ connected to GND<br>$R_L = 2\text{ k}\Omega$ connected to GND<br>$R_L = 10\text{ k}\Omega$ connected to GND<br>$R_L = 150\text{ }\Omega$ connected to 2.5 V<br>$R_L = 600\text{ }\Omega$ connected to 2.5 V<br>$R_L = 2\text{ k}\Omega$ connected to 2.5 V<br>$R_L = 10\text{ k}\Omega$ connected to 2.5 V<br>$T_{min} < T_{amb} < T_{max}$<br>$R_L = 150\text{ }\Omega$ connected to GND<br>$R_L = 150\text{ }\Omega$ connected to 2.5 V |                                                 | 48<br>54<br>55<br>56<br>220<br>105<br>76<br>61               | 150<br>400<br>200<br>450 | mV                     |
| GBP      | Gain bandwidth product               | $F = 10\text{ MHz}$<br>$A_{VCL} = +11$<br>$A_{VCL} = -10$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                 | 65<br>55                                                     |                          | MHz                    |
| Bw       | Bandwidth at -3 dB                   | $A_{VCL} = +1$<br>$R_L = 150\text{ }\Omega$ connected to 2.5 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                 | 87                                                           |                          |                        |
| SR       | Slew rate                            | $A_{VCL} = +2$<br>$R_L = 150\text{ }\Omega // C_L$ to 2.5 V<br>$C_L = 5\text{ pF}$<br>$C_L = 30\text{ pF}$                                                                                                                                                                                                                                                                                                                                                                                                                                                | 60                                              | 104<br>105                                                   |                          | V/ms                   |
| $\phi_m$ | Phase margin                         | $R_L = 150\text{ }\Omega // 30\text{ pF}$ to 2.5 V                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                 | 40                                                           |                          | Degree                 |
| $e_n$    | Equivalent input noise voltage       | $F = 100\text{ kHz}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                 | 11                                                           |                          | nV/ $\sqrt{\text{Hz}}$ |
| THD      | Total harmonic distortion            | $A_{VCL} = +2$ , $F = 4\text{ MHz}$<br>$R_L = 150\text{ }\Omega // 30\text{ pF}$ to 2.5 V<br>$V_{out} = 1V_{pp}$<br>$V_{out} = 2V_{pp}$                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                 | -61<br>-54                                                   |                          | dB                     |
| IM2      | Second order intermodulation product | $A_{VCL} = +2$ , $V_{out} = 2V_{pp}$<br>$R_L = 150\text{ }\Omega$ connected to 2.5 V<br>$F_{in1} = 180\text{ kHz}$ , $F_{in2} = 280\text{ kHz}$<br>spurious measurement at 100 kHz                                                                                                                                                                                                                                                                                                                                                                        |                                                 | -76                                                          |                          | dBc                    |

**Table 3. Electrical characteristics at  $V_{CC}^+ = +5\text{ V}$ ,  $V_{CC}^- = \text{GND}$ ,  $V_{ic} = 2.5\text{ V}$ ,  $T_{amb} = 25\text{ °C}$   
(unless otherwise specified) (continued)**

| Symbol     | Parameter                           | Test conditions                                                                                                                                                                              | Min. | Typ. | Max. | Unit   |
|------------|-------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|--------|
| IM3        | Third order intermodulation product | $A_{VCL} = +2$ , $V_{out} = 2\text{ V}_{pp}$<br>$R_L = 150\ \Omega$ to $2.5\text{ V}$<br>$F_{in1} = 180\text{ kHz}$ , $F_{in2} = 280\text{ kHz}$<br>spurious measurement at $400\text{ kHz}$ |      | -68  |      | dBc    |
| $\Delta G$ | Differential gain                   | $A_{VCL} = +2$ , $R_L = 150\ \Omega$ to $2.5\text{ V}$<br>$F = 4.5\text{ MHz}$ , $V_{out} = 2\text{ V}_{pp}$                                                                                 |      | 0.5  |      | %      |
| Df         | Differential phase                  | $A_{VCL} = +2$ , $R_L = 150\ \Omega$ to $2.5\text{ V}$<br>$F = 4.5\text{ MHz}$ , $V_{out} = 2\text{ V}_{pp}$                                                                                 |      | 0.5  |      | Degree |
| Gf         | Gain flatness                       | $F = \text{DC to } 6\text{ MHz}$ , $A_{VCL} = +2$                                                                                                                                            |      | 0.2  |      | dB     |
| Vo1/Vo2    | Channel separation                  | $F = 1\text{ MHz to } 10\text{ MHz}$                                                                                                                                                         |      | 65   |      |        |

1. Tested on the TSH80ILT device only.

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

| Symbol                   | Parameter                                                        | Test conditions                                                                                                                                                                                                                                                                                            | Min.                   | Typ.                            | Max.         | Unit                         |
|--------------------------|------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|---------------------------------|--------------|------------------------------|
| $ V_{io} $               | Input offset voltage                                             | $T_{amb} = 25\text{ }^\circ\text{C}$<br>$T_{min} < T_{amb} < T_{max}$                                                                                                                                                                                                                                      |                        | 0.8                             | 10<br>12     | mV                           |
| $\Delta V_{io}/\Delta T$ | Input offset voltage drift vs. temperature                       | $T_{min} < T_{amb} < T_{max}$                                                                                                                                                                                                                                                                              |                        | 2                               |              | $\mu\text{V}/^\circ\text{C}$ |
| $I_{io}$                 | Input offset current                                             | $T_{amb} = 25\text{ }^\circ\text{C}$<br>$T_{min} < T_{amb} < T_{max}$                                                                                                                                                                                                                                      |                        | 0.1                             | 3.5<br>5     | $\mu\text{A}$                |
| $I_{ib}$                 | Input bias current                                               | $T_{amb} = 25\text{ }^\circ\text{C}$<br>$T_{min} < T_{amb} < T_{max}$                                                                                                                                                                                                                                      |                        | 6                               | 15<br>20     |                              |
| $C_{in}$                 | Input capacitance                                                |                                                                                                                                                                                                                                                                                                            |                        | 0.7                             |              | pF                           |
| $I_{CC}$                 | Supply current per operator                                      | $T_{amb} = 25\text{ }^\circ\text{C}$<br>$T_{min} < T_{amb} < T_{max}$                                                                                                                                                                                                                                      |                        | 9.8                             | 12.3<br>13.4 | mA                           |
| CMR                      | Common mode rejection ratio ( $\Delta V_{ic}/\Delta V_{io}$ )    | $-4.9 < V_{ic} < 3.9\text{ V}$ and $V_{out} = \text{GND}$<br>$T_{amb} = 25\text{ }^\circ\text{C}$<br>$T_{min} < T_{amb} < T_{max}$                                                                                                                                                                         | 81<br>72               | 106                             |              | dB                           |
| SVR                      | Supply voltage rejection ratio ( $\Delta V_{CC}/\Delta V_{io}$ ) | $T_{amb} = 25\text{ }^\circ\text{C}$<br>$T_{min} < T_{amb} < T_{max}$                                                                                                                                                                                                                                      | 71<br>65               | 77                              |              |                              |
| PSR                      | Power supply rejection ratio ( $\Delta V_{CC}/\Delta V_{out}$ )  | Positive and negative rail                                                                                                                                                                                                                                                                                 |                        | 75                              |              |                              |
| $A_{vd}$                 | Large signal voltage gain                                        | $R_L = 150\text{ }\Omega$ connected to GND and $V_{out} = -4$ to $+4$<br>$T_{amb} = 25\text{ }^\circ\text{C}$<br>$T_{min} < T_{amb} < T_{max}$                                                                                                                                                             | 75<br>70               | 86                              |              |                              |
| $I_o$                    | Source                                                           | $V_{id} = +1$ , $V_{out}$ connected to $1.5\text{ V}$<br>$T_{amb} = 25\text{ }^\circ\text{C}$<br>$T_{min} < T_{amb} < T_{max}$                                                                                                                                                                             | 35<br>28               | 55                              |              | mA                           |
|                          | Sink                                                             | $V_{id} = -1$ , $V_{out}$ connected to $1.5\text{ V}$<br>$T_{amb} = 25\text{ }^\circ\text{C}$<br>$T_{min} < T_{amb} < T_{max}$                                                                                                                                                                             | 30<br>28               | 55                              |              |                              |
| $V_{oh}$                 | High-level output voltage                                        | $T_{amb} = 25\text{ }^\circ\text{C}$<br>$R_L = 150\text{ }\Omega$ connected to GND<br>$R_L = 600\text{ }\Omega$ connected to GND<br>$R_L = 2\text{ k}\Omega$ connected to GND<br>$R_L = 10\text{ k}\Omega$ connected to GND<br>$T_{min} < T_{amb} < T_{max}$<br>$R_L = 150\text{ }\Omega$ connected to GND | 4.2<br><br><br><br>4.1 | 4.36<br>4.85<br>4.9<br>4.93     |              | V                            |
| $V_{ol}$                 | Low-level output voltage                                         | $T_{amb} = 25\text{ }^\circ\text{C}$<br>$R_L = 150\text{ }\Omega$ connected to GND<br>$R_L = 600\text{ }\Omega$ connected to GND<br>$R_L = 2\text{ k}\Omega$ connected to GND<br>$R_L = 10\text{ k}\Omega$ connected to GND<br>$T_{min} < T_{amb} < T_{max}$<br>$R_L = 150\text{ }\Omega$ connected to GND |                        | -4.63<br>-4.86<br>-4.9<br>-4.93 | -4.4         | mV                           |
|                          |                                                                  |                                                                                                                                                                                                                                                                                                            |                        |                                 | -4.3         |                              |

**Table 4. Electrical characteristics at  $V_{CC}^+ = +5\text{ V}$ ,  $V_{CC}^- = -5\text{ V}$ ,  $V_{IC} = \text{GND}$ ,  $T_{\text{amb}} = 25\text{ }^{\circ}\text{C}$   
(unless otherwise specified) (continued)**

| Symbol     | Parameter                            | Test conditions                                                                                                                                                                                                    | Min. | Typ.       | Max. | Unit                   |
|------------|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------------|------|------------------------|
| GBP        | Gain bandwidth product               | $F = 10\text{ MHz}$<br>$A_{VCL} = +11$<br>$A_{VCL} = -10$                                                                                                                                                          |      | 65<br>55   |      | MHz                    |
| Bw         | Bandwidth at -3 dB                   | $A_{VCL} = +1$<br>$R_L = 150\text{ }\Omega // 30\text{ pF to GND}$                                                                                                                                                 |      | 100        |      |                        |
| SR         | Slew rate                            | $A_{VCL} = +2$<br>$R_L = 150\text{ }\Omega // C_L \text{ to GND}$<br>$C_L = 5\text{ pF}$<br>$C_L = 30\text{ pF}$                                                                                                   | 68   | 117<br>118 |      | V/ $\mu\text{s}$       |
| fm         | Phase margin                         | $R_L = 150\text{ }\Omega \text{ connected to GND}$                                                                                                                                                                 |      | 40         |      | Degree                 |
| en         | Equivalent input noise voltage       | $F = 100\text{ kHz}$                                                                                                                                                                                               |      | 11         |      | nV/ $\sqrt{\text{Hz}}$ |
| THD        | Total harmonic distortion            | $A_{VCL} = +2$ , $F = 4\text{ MHz}$<br>$R_L = 150\text{ }\Omega // 30\text{ pF to GND}$<br>$V_{\text{out}} = 1\text{ V}_{\text{pp}}$<br>$V_{\text{out}} = 2\text{ V}_{\text{pp}}$                                  |      | -61<br>-54 |      | dB                     |
| IM2        | Second order intermodulation product | $A_{VCL} = +2$ , $V_{\text{out}} = 2\text{ V}_{\text{pp}}$<br>$R_L = 150\text{ }\Omega \text{ to GND}$<br>$F_{\text{in1}} = 180\text{ kHz}$ , $F_{\text{in2}} = 280\text{ kHz}$<br>spurious measurement at 100 kHz |      | -76        |      |                        |
| IM3        | Third order intermodulation product  | $A_{VCL} = +2$ , $V_{\text{out}} = 2\text{ V}_{\text{pp}}$<br>$R_L = 150\text{ }\Omega \text{ to GND}$<br>$F_{\text{in1}} = 180\text{ kHz}$ , $F_{\text{in2}} = 280\text{ kHz}$<br>spurious measurement at 400 kHz |      | -68        |      |                        |
| $\Delta G$ | Differential gain                    | $A_{VCL} = +2$ , $R_L = 150\text{ }\Omega \text{ to GND}$<br>$F = 4.5\text{ MHz}$ , $V_{\text{out}} = 2\text{ V}_{\text{pp}}$                                                                                      |      | 0.5        |      | %                      |
| Df         | Differential phase                   | $A_{VCL} = +2$ , $R_L = 150\text{ }\Omega \text{ to GND}$<br>$F = 4.5\text{ MHz}$ , $V_{\text{out}} = 2\text{ V}_{\text{pp}}$                                                                                      |      | 0.5        |      | Degree                 |
| Gf         | Gain flatness                        | $F = \text{DC to } 6\text{ MHz}$ , $A_{VCL} = +2$                                                                                                                                                                  |      | 0.2        |      | dB                     |
| Vo1/Vo2    | Channel separation                   | $F = 1\text{ MHz to } 10\text{ MHz}$                                                                                                                                                                               |      | 65         |      |                        |

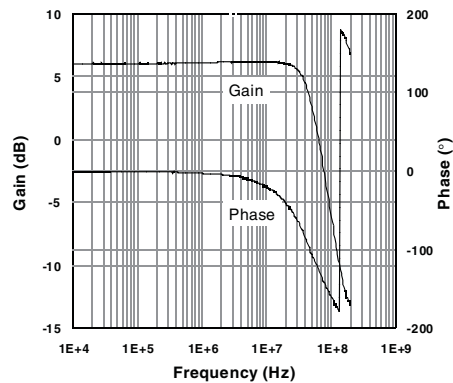
Table 5. Standby mode -  $V_{CC}^+$ ,  $V_{CC}^-$ ,  $T_{amb} = 25\text{ °C}$  (unless otherwise specified)

| 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                                      |                                         | $(V_{CC}^- + 2)$ |          | $(V_{CC}^+)$       |                  |
| $I_{CC-STBY}$ | Current consumption per operator when standby is active | Pin 8 (TSH81) to $V_{CC}^-$             |                  | 20       | 55                 | $\mu A$          |
| $Z_{out}$     | Output impedance ( $R_{out}/C_{out}$ )                  | $R_{out}$<br>$C_{out}$                  |                  | 10<br>17 |                    | M $\Omega$<br>pF |
| $T_{on}$      | Time from standby mode to active mode                   |                                         |                  | 2        |                    | $\mu s$          |
| $T_{off}$     | Time from active mode to standby mode                   | Down to $I_{CC-STBY} = 10\text{ }\mu A$ |                  | 10       |                    |                  |

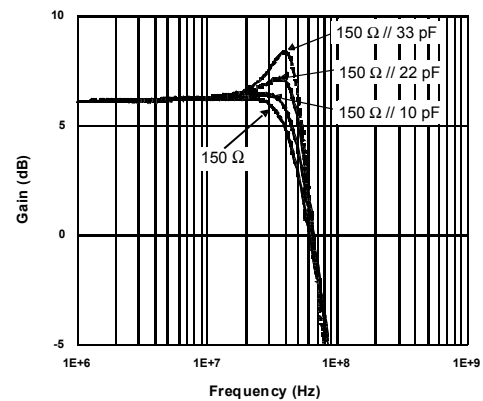
Table 6. TSH81 standby control pin status

| TSH81 standby control pin 8 ( $\overline{STANDBY}$ ) | Operator status |
|------------------------------------------------------|-----------------|
| $V_{low}$                                            | Standby         |
| $V_{high}$                                           | Active          |

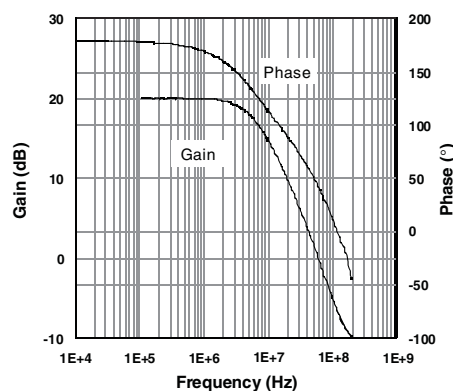
**Figure 2. Closed loop gain and phase vs. frequency (gain = +2,  $V_{CC} = \pm 2.5$  V)**  
 $R_L = 150\ \Omega$ ,  $T_{amb} = 25\ ^\circ\text{C}$



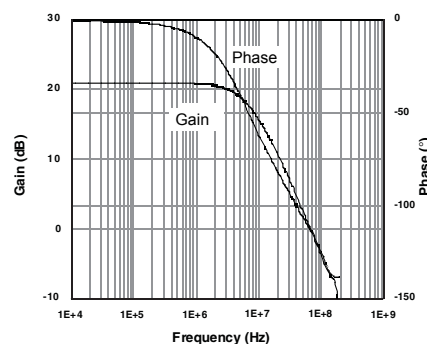
**Figure 3. Overshoot vs. output capacitance ( $V_{CC} = \pm 2.5$  V)**  
Gain = +2,  $T_{amb} = 25\ ^\circ\text{C}$



**Figure 4. Closed loop gain and phase vs. frequency (gain = -10,  $V_{CC} = \pm 2.5$  V)**  
 $R_L = 150\ \Omega$ ,  $T_{amb} = 25\ ^\circ\text{C}$

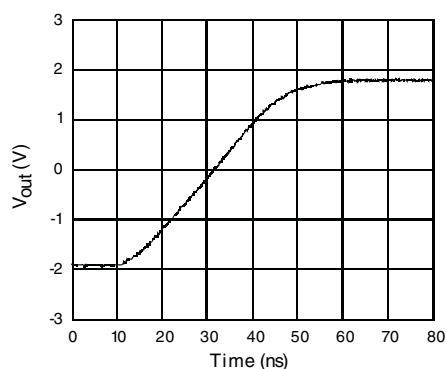


**Figure 5. Closed loop gain and phase vs. frequency (gain = +11,  $V_{CC} = \pm 2.5$  V)**  
 $R_L = 150\ \Omega$ ,  $T_{amb} = 25\ ^\circ\text{C}$



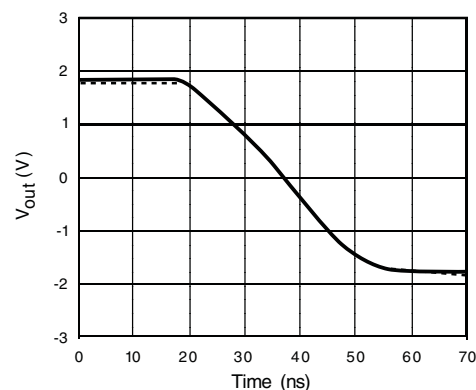
**Figure 6. Large signal measurement – positive slew rate ( $V_{CC} = \pm 2.5$  V)**

Gain = +2,  $Z_L = 150\ \Omega // 5.6\ \text{pF}$ ,  $V_{in} = 400\ \text{mVpk}$



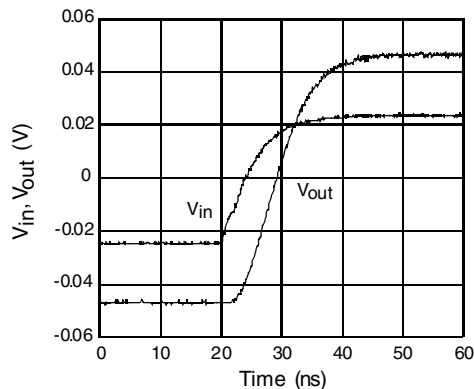
**Figure 7. Large signal measurement – negative slew rate ( $V_{CC} = \pm 2.5$  V)**

Gain = +2,  $Z_L = 150\ \Omega // 5.6\ \text{pF}$ ,  $V_{in} = 400\ \text{mVpk}$



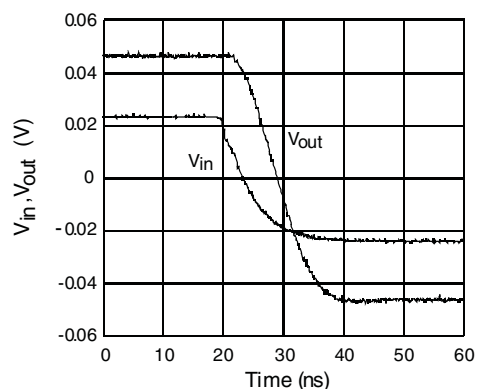
**Figure 8. Small signal measurement – rise time**  
( $V_{CC} = \pm 2.5\text{ V}$ )

Gain = +2,  $R_L = 150\ \Omega$ ,  $V_{in} = 400\text{ mVpk}$



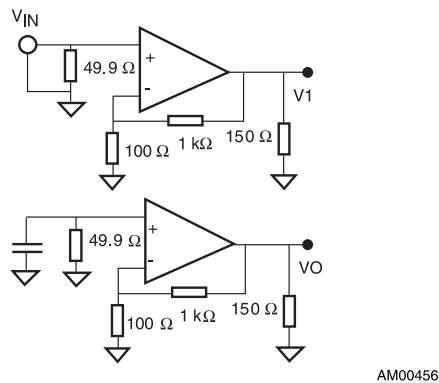
**Figure 9. Small signal measurement – fall time**  
( $V_{CC} = \pm 2.5\text{ V}$ )

Gain = +2,  $R_L = 150\ \Omega$ ,  $V_{in} = 400\text{ mVpk}$



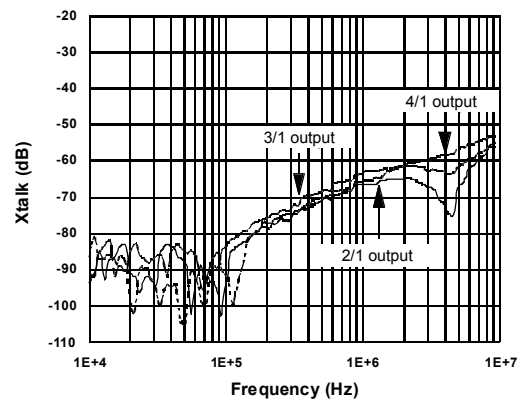
**Figure 10. Channel separation (crosstalk) vs. frequency schematic** ( $V_{CC} = \pm 2.5\text{ V}$ )

Measurement configuration: crosstalk =  $20 \log(V_0/V_1)$



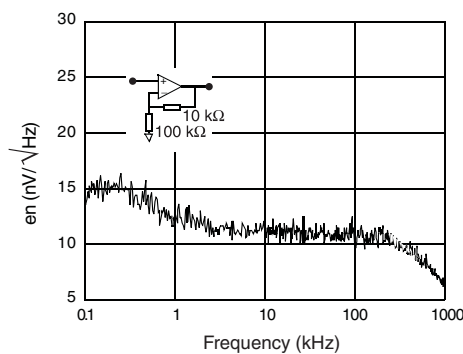
**Figure 11. Channel separation (crosstalk) vs. frequency** ( $V_{CC} = \pm 2.5\text{ V}$ )

Gain = +11,  $Z_L = 150\ \Omega // 27\text{ pF}$



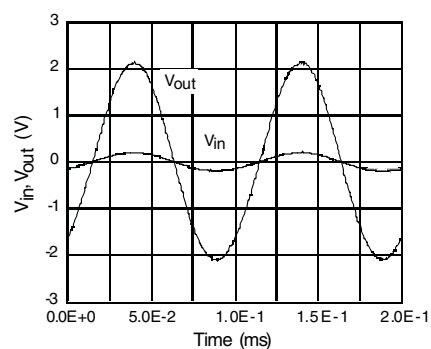
**Figure 12. Equivalent input noise voltage**  
( $V_{CC} = \pm 2.5\text{ V}$ )

Gain = +100, no load

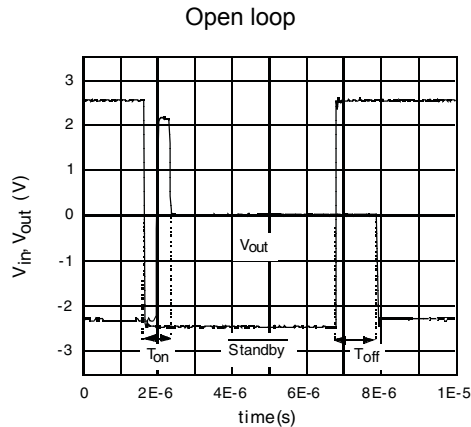


**Figure 13. Maximum output swing**  
( $V_{CC} = \pm 2.5\text{ V}$ )

Gain = +11,  $R_L = 150\ \Omega$

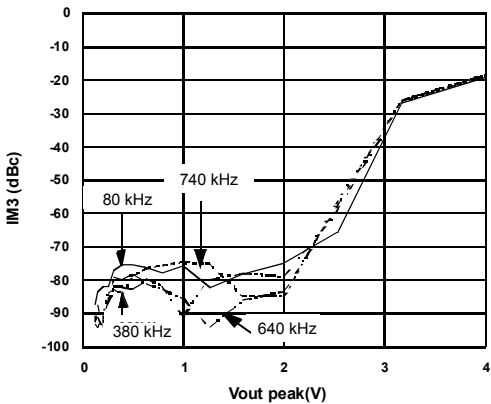


**Figure 14. Standby mode -  $T_{on}$ ,  $T_{off}$**   
( $V_{CC} = \pm 2.5$  V)



**Figure 15. Third order intermodulation**  
( $V_{CC} = \pm 2.5$  V)<sup>(1)</sup>

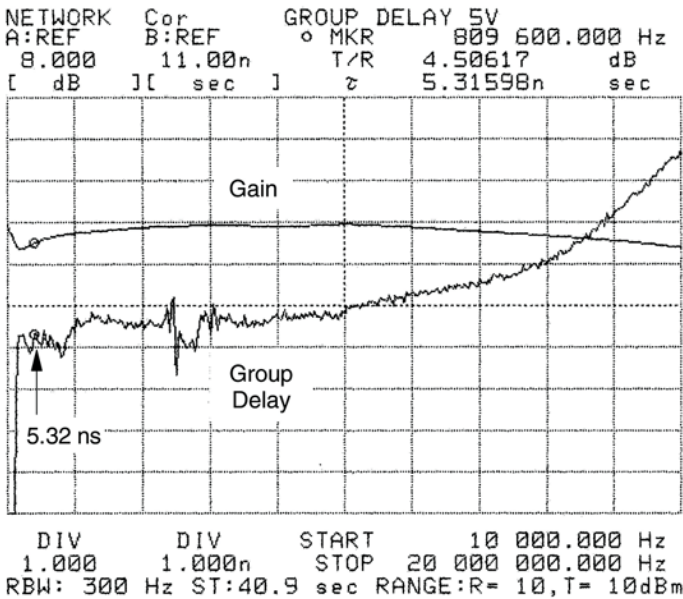
Gain = +2,  $Z_L = 150 \Omega // 27$  pF,  $T_{amb} = 25^\circ\text{C}$



1. The IFR2026 synthesizer generates a two-tone signal ( $F_1 = 180$  kHz,  $F_2 = 280$  kHz), each tone having the same amplitude. The HP3585 spectrum analyzer measures the intermodulation products as a function of the output voltage. The generator and the spectrum analyzer are phase locked for better accuracy.

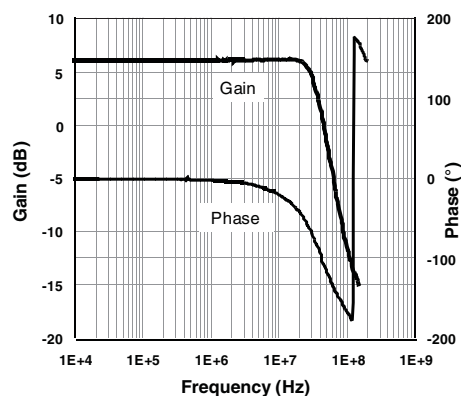
**Figure 16. Group delay ( $V_{CC} = \pm 2.5$  V)**

Gain = +2,  $Z_L = 150 \Omega // 27$  pF,  $T_{amb} = 25^\circ\text{C}$



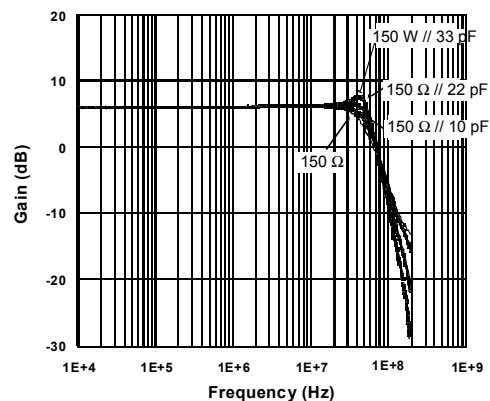
**Figure 17. Closed loop gain and phase vs. frequency (gain = +2,  $V_{CC} = \pm 5$  V)**

$R_L = 150\ \Omega$ ,  $T_{amb} = 25\ ^\circ\text{C}$



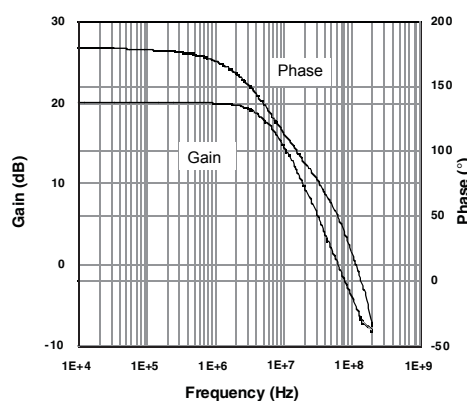
**Figure 18. Overshoot vs. output capacitance ( $V_{CC} = \pm 5$  V)**

Gain = +2,  $T_{amb} = 25\ ^\circ\text{C}$



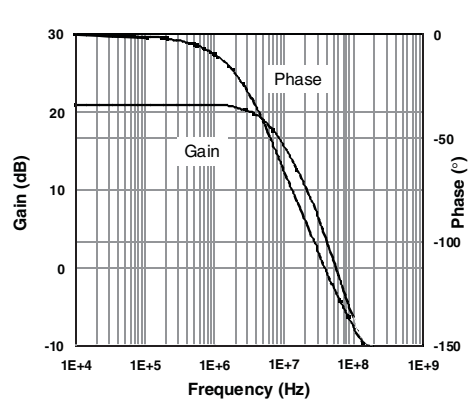
**Figure 19. Closed loop gain and phase vs. frequency (gain = -10,  $V_{CC} = \pm 5$  V)**

$R_L = 150\ \Omega$ ,  $T_{amb} = 25\ ^\circ\text{C}$



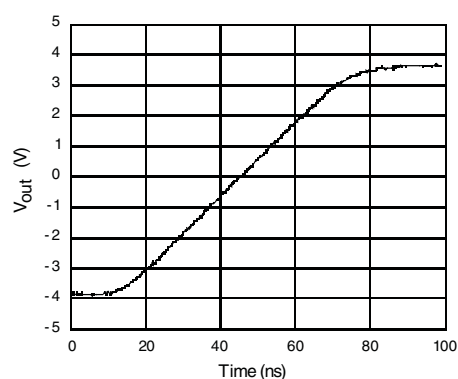
**Figure 20. Closed loop gain and phase vs. frequency (gain = +11,  $V_{CC} = \pm 5$  V)**

$R_L = 150\ \Omega$ ,  $T_{amb} = 25\ ^\circ\text{C}$



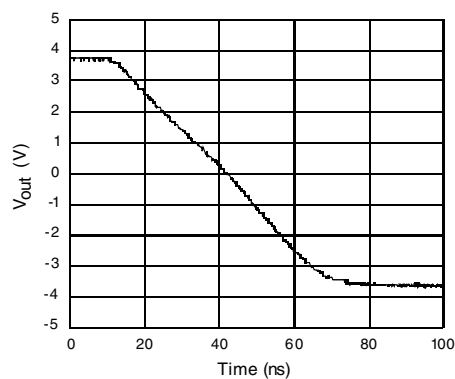
**Figure 21. Large signal measurement - positive slew rate ( $V_{CC} = \pm 5$  V)**

Gain = +2,  $Z_L = 150\ \Omega // 5.6\ \text{pF}$ ,  $V_{in} = 400\ \text{mVpk}$



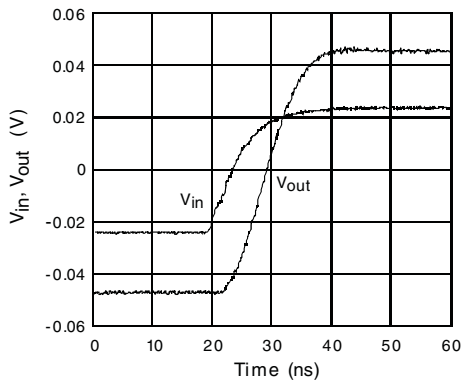
**Figure 22. Large signal measurement - negative slew rate ( $V_{CC} = \pm 5$  V)**

Gain = +2,  $Z_L = 150\ \Omega // 5.6\ \text{pF}$ ,  $V_{in} = 400\ \text{mVpk}$



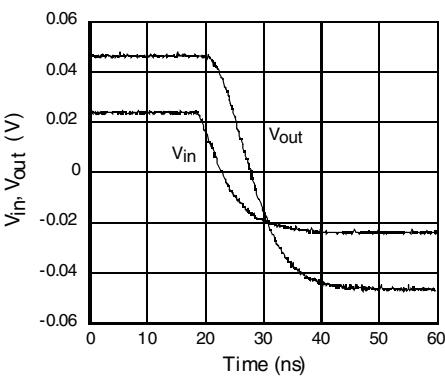
**Figure 23. Small signal measurement - rise time**  
( $V_{CC} = \pm 5\text{ V}$ )

Gain = +2,  $R_L = 150\ \Omega$ ,  $V_{in} = 400\text{ mVpk}$



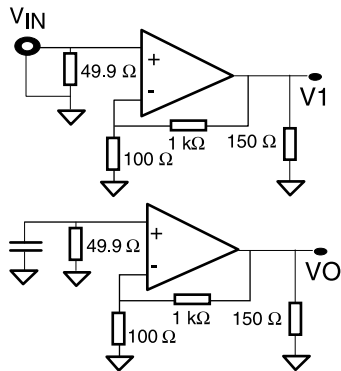
**Figure 24. Small signal measurement - fall time**  
( $V_{CC} = \pm 5\text{ V}$ )

Gain = +2,  $R_L = 150\ \Omega$ ,  $V_{in} = 400\text{ mVpk}$



**Figure 25. Channel separation (crosstalk) vs. frequency schematic ( $V_{CC} = \pm 5\text{ V}$ )**

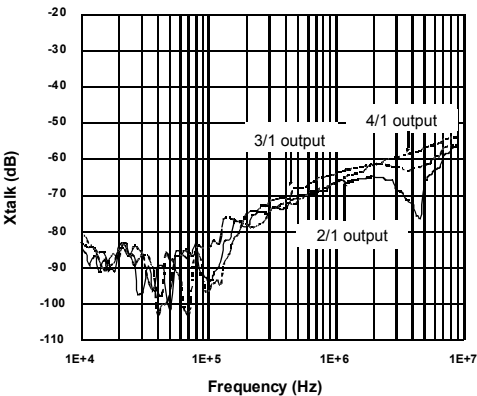
Measurement configuration: crosstalk =  $20 \log (V_0/V_1)$



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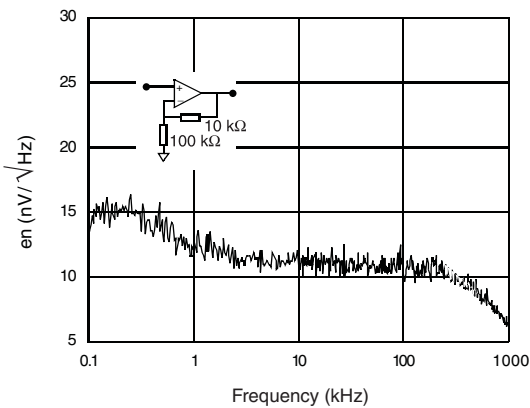
**Figure 26. Channel separation (crosstalk) vs. frequency ( $V_{CC} = \pm 5\text{ V}$ )**

Gain = +11,  $Z_L = 150\ \Omega // 27\text{ pF}$



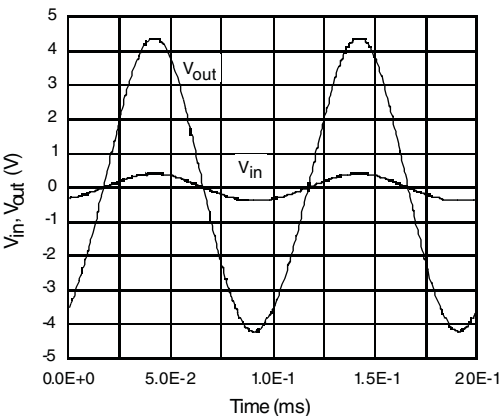
**Figure 27. Equivalent input noise voltage**  
( $V_{CC} = \pm 5\text{ V}$ )

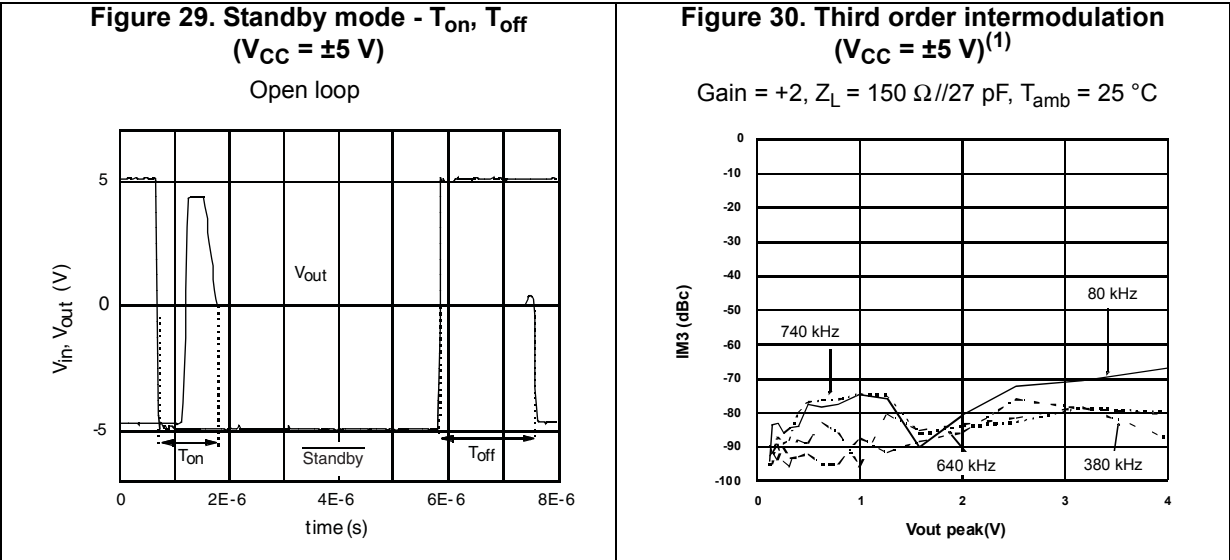
Gain = +100, no load



**Figure 28. Maximum output swing**  
( $V_{CC} = \pm 5\text{ V}$ )

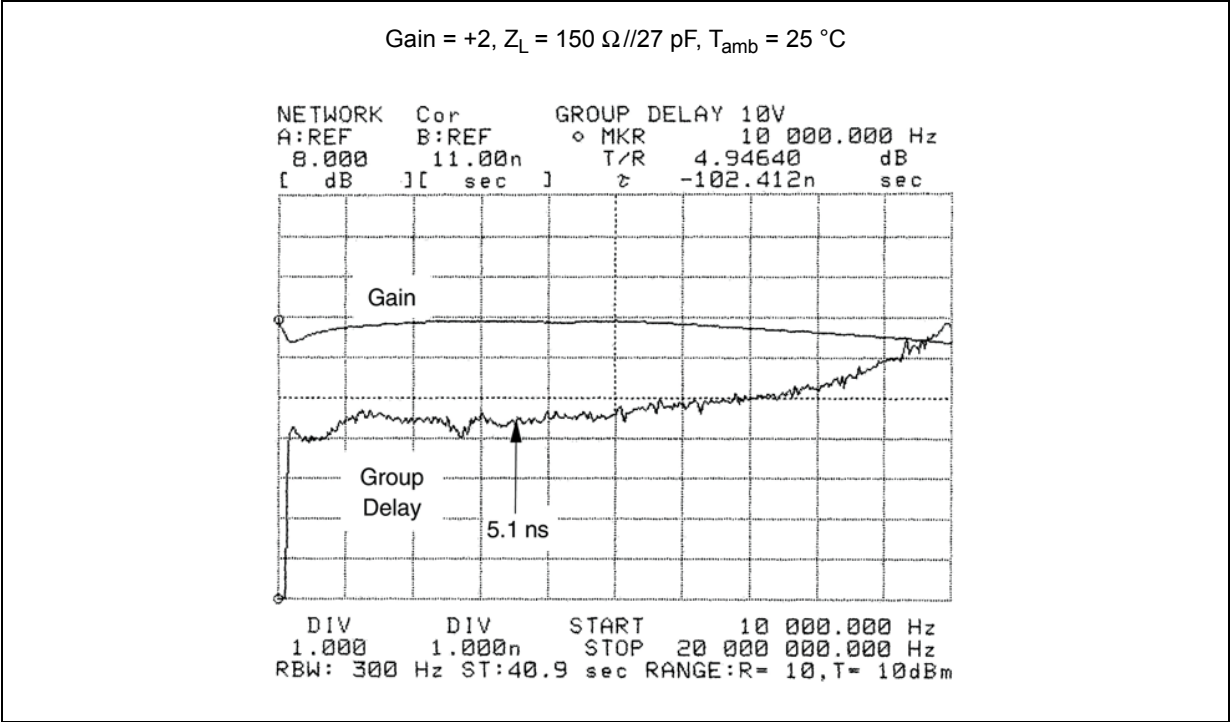
Gain = +11,  $R_L = 150\ \Omega$





1. The IFR2026 synthesizer generates a two-tone signal ( $F_1 = 180\text{ kHz}$ ,  $F_2 = 280\text{ kHz}$ ), each tone having the same amplitude. The HP3585 spectrum analyzer measures the intermodulation products as a function of the output voltage. The generator and the spectrum analyzer are phase locked for better accuracy.

**Figure 31. Group delay ( $V_{CC} = \pm 5\text{ V}$ )**



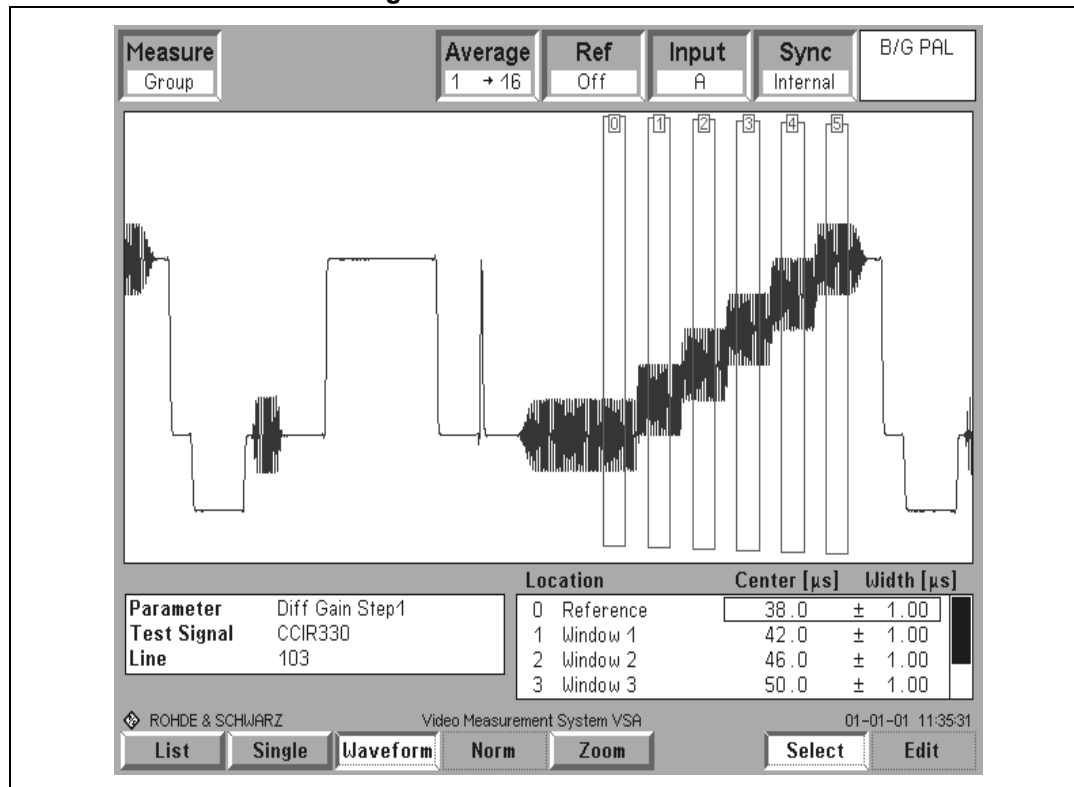
## 4 Test conditions

### 4.1 Layout precautions

To make the best use of the TSH8x circuits at high frequencies, some precautions have to be taken with regard to the power supplies.

- In high-speed circuit applications, the implementation of a proper ground plane on both sides of the PCB is mandatory to ensure low inductance and low resistance common return.
- Power supply bypass capacitors (4.7  $\mu$ F and ceramic 100 pF) should be placed as close as possible to the IC pins in order to improve high frequency bypassing and reduce harmonic distortion. The power supply capacitors must be incorporated for both the negative and positive pins.
- All inputs and outputs must be properly terminated with output resistors. Thus, the amplifier load is resistive only and the stability of the amplifier is improved. All leads must be wide and must be as short as possible, especially for op-amp inputs and outputs, in order to decrease parasitic capacitance and inductance.
- Time constants result from parasitic capacitance. To reduce time constants in lower-gain applications, use a low feedback resistance (under 1 k $\Omega$ ).
- Choose the smallest component size possible (SMD).
- On the output, the load capacitance must be negligible to maintain good stability. Place a serial resistance as close as possible to the output pin to minimize the effect of the load capacitance.

Figure 32. CCIR330 video line



## 4.2 Video capabilities

To characterize the differential phase and differential gain, a CCIR330 video line is used.

The video line contains of five (flat) levels of luminance onto which the chrominance signal is superimposed. The luminance gives various amplitudes which define the saturation of the signal. The chrominance gives various phases which define the color of the signal.

Differential phase (or differential gain) distortion is present if a signal chrominance phase (gain) is affected by the luminance level. The differential phase and gain represent the ability to uniformly process the high frequency information at all luminance levels.

When a differential gain is present, color saturation is not correctly reproduced.

The input generator is the Rohde & Schwarz CCVS. The output measurement is made by the Rohde and Schwarz VSA.

**Figure 33. Measurement on Rohde and Schwarz VSA**

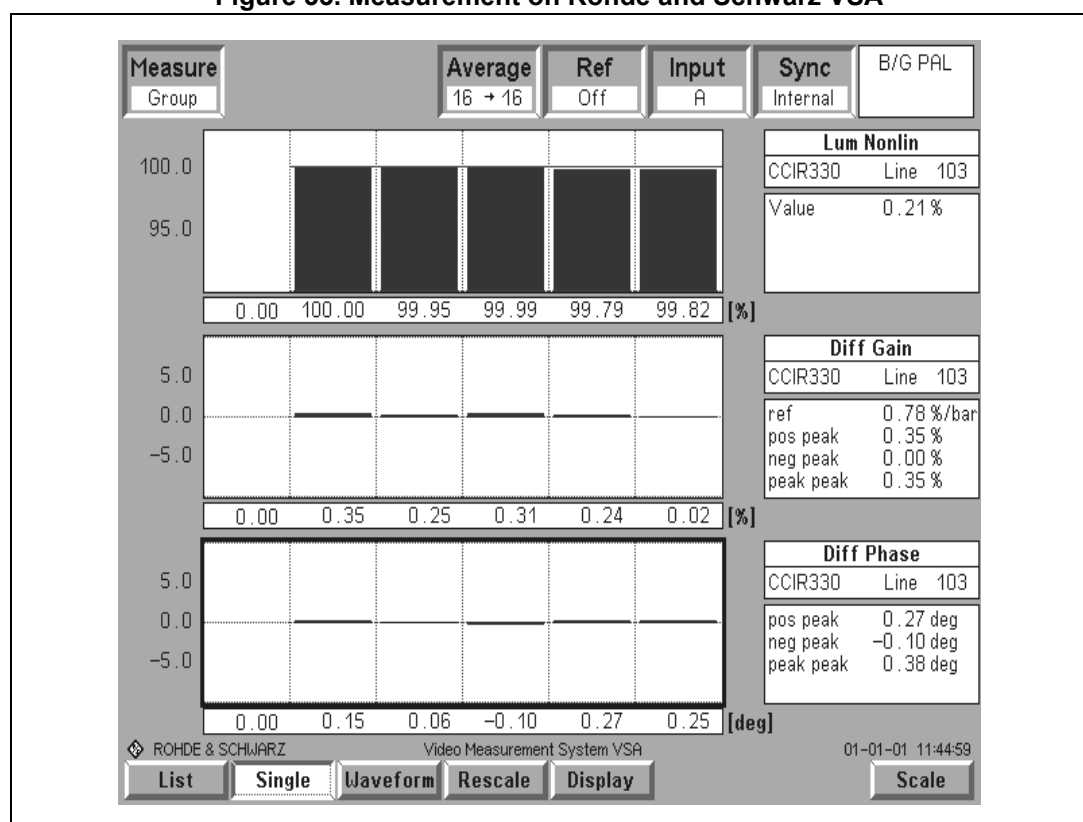


Table 7. Video results

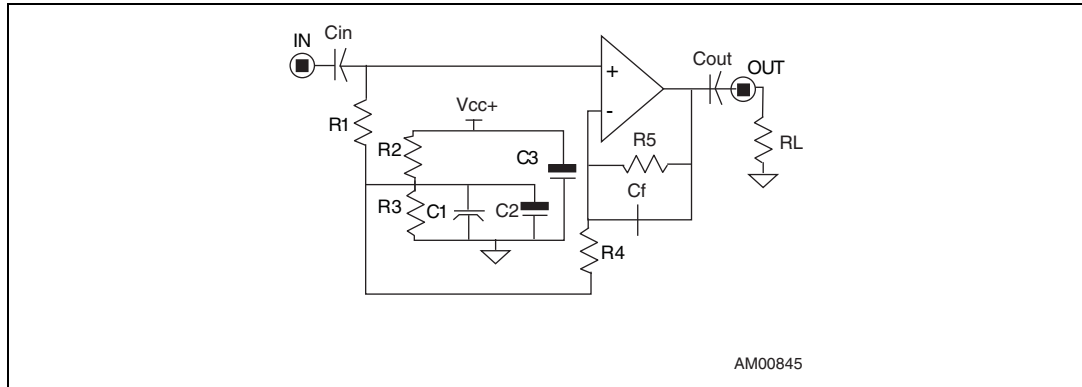
| Parameter        | Value ( $V_{CC} = \pm 2.5 \text{ V}$ ) | Value ( $V_{CC} = \pm 5 \text{ V}$ ) | Unit   |
|------------------|----------------------------------------|--------------------------------------|--------|
| Lum NL           | 0.1                                    | 0.3                                  | %      |
| Lum NL Step1     | 100                                    | 100                                  |        |
| Lum NL Step2     | 100                                    | 99.9                                 |        |
| Lum NL Step3     | 99.9                                   | 99.8                                 |        |
| Lum NL Step4     | 99.9                                   | 99.9                                 |        |
| Lum NL Step5     | 99.9                                   | 99.7                                 |        |
| Diff Gain pos    | 0                                      | 0                                    |        |
| Diff Gain neg    | -0.7                                   | -0.6                                 |        |
| Diff Gain pp     | 0.7                                    | 0.6                                  |        |
| Diff Gain Step1  | -0.5                                   | -0.3                                 |        |
| Diff Gain Step2  | -0.7                                   | -0.6                                 |        |
| Diff Gain Step3  | -0.3                                   | -0.5                                 |        |
| Diff Gain Step4  | -0.1                                   | -0.3                                 |        |
| Diff Gain Step5  | -0.4                                   | -0.5                                 |        |
| Diff Phase pos   | 0                                      | 0.1                                  | Degree |
| Diff Phase neg   | -0.2                                   | -0.4                                 |        |
| Diff Phase pp    | 0.2                                    | 0.5                                  |        |
| Diff Phase Step1 | -0.2                                   | -0.4                                 |        |
| Diff Phase Step2 | -0.1                                   | -0.4                                 |        |
| Diff Phase Step3 | -0.1                                   | -0.3                                 |        |
| Diff Phase Step4 | 0                                      | 0.1                                  |        |
| Diff Phase Step5 | -0.2                                   | -0.1                                 |        |

## 5 Precautions on asymmetrical supply operation

The TSH8x device can be used with either a dual or a single supply. If a single supply is used, the inputs are biased to the mid-supply voltage ( $+V_{CC}/2$ ). This bias network must be carefully designed so as to reject any noise present on the supply rail.

As the bias current is  $15\text{ }\mu\text{A}$ , use a high resistance  $R1$  (approximately  $10\text{ k}\Omega$ ) to avoid introducing an offset mismatch at the amplifier's inputs.

**Figure 34. Asymmetrical supply schematic diagram**



$C1$ ,  $C2$ ,  $C3$  are bypass capacitors intended to filter perturbations from  $V_{CC}$ . The following capacitor values are appropriate:

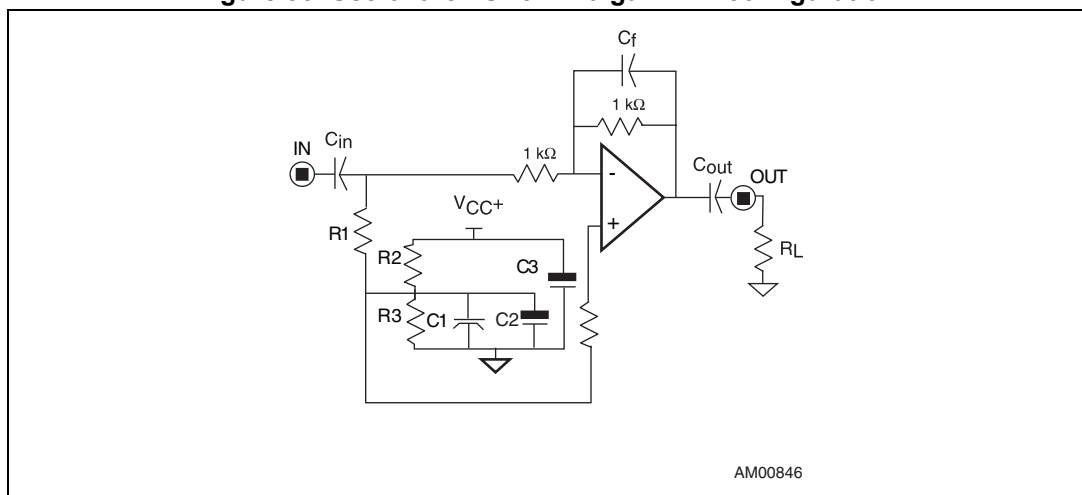
$$C1 = 100\text{ nF and } C2 = C3 = 100\text{ }\mu\text{F}$$

$R2$  and  $R3$  are such that the current running through them must be superior to 100 times the bias current. Therefore, use the following resistance values:

$$R2 = R3 = 4.7\text{ k}\Omega$$

$C_{in}$  and  $C_{out}$  are chosen to filter the DC signal by the low-pass filters ( $R1$ ,  $C_{in}$ ) and ( $R_{out}$ ,  $C_{out}$ ). With  $R1 = 10\text{ k}\Omega$ ,  $R_{out} = R_L = 150\text{ }\Omega$ , and  $C_{in} = 2\text{ }\mu\text{F}$ ,  $C_{out} = 220\text{ }\mu\text{F}$  the cutoff frequency obtained is lower than  $10\text{ Hz}$ .

**Figure 35. Use of the TSH8x in a gain = -1 configuration**



## 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](http://www.st.com). ECOPACK is an ST trademark.

## 6.1 SOT23-5 package information

Figure 36. SOT23-5 package outline

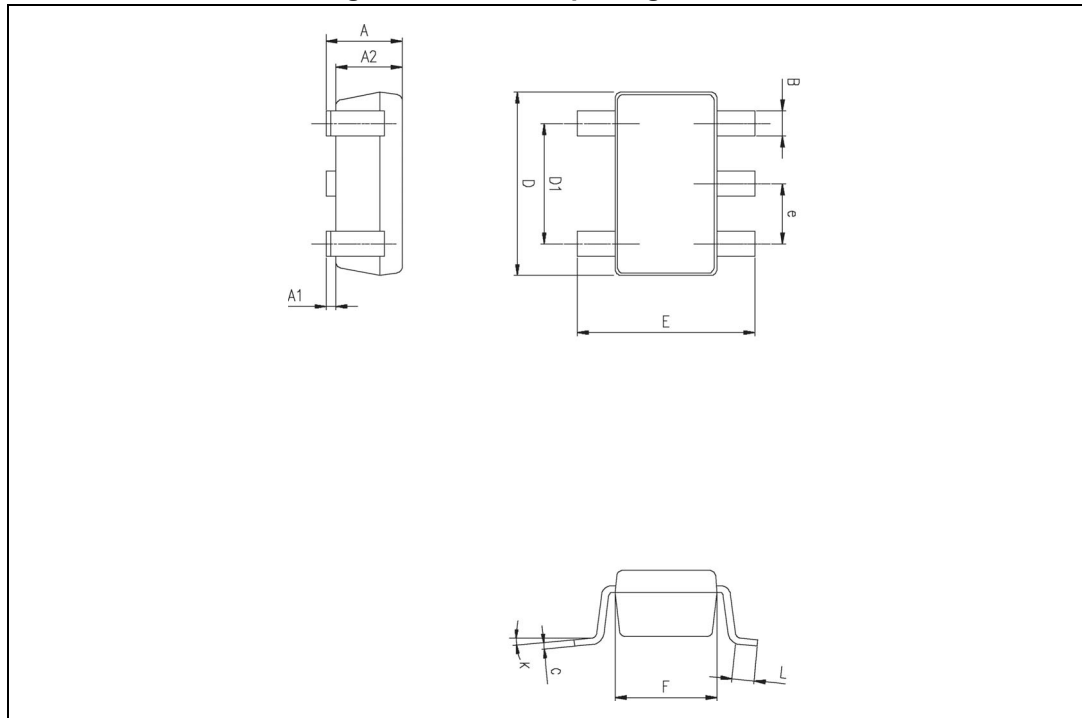


Table 8. SOT23-5 package mechanical data

| Symbol | Dimensions  |      |      |        |       |       |
|--------|-------------|------|------|--------|-------|-------|
|        | Millimeters |      |      | Inches |       |       |
|        | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A      | 0.90        | 1.20 | 1.45 | 0.035  | 0.047 | 0.057 |
| A1     |             |      | 0.15 |        |       | 0.006 |
| A2     | 0.90        | 1.05 | 1.30 | 0.035  | 0.041 | 0.051 |
| B      | 0.35        | 0.40 | 0.50 | 0.013  | 0.015 | 0.019 |
| C      | 0.09        | 0.15 | 0.20 | 0.003  | 0.006 | 0.008 |
| D      | 2.80        | 2.90 | 3.00 | 0.110  | 0.114 | 0.118 |
| D1     |             | 1.90 |      |        | 0.075 |       |
| e      |             | 0.95 |      |        | 0.037 |       |
| E      | 2.60        | 2.80 | 3.00 | 0.102  | 0.110 | 0.118 |
| F      | 1.50        | 1.60 | 1.75 | 0.059  | 0.063 | 0.069 |
| L      | 0.10        | 0.35 | 0.60 | 0.004  | 0.013 | 0.023 |
| K      | 0°          |      | 10°  |        |       |       |

## 6.2 SO8 package information

Figure 37. SO8 package outline

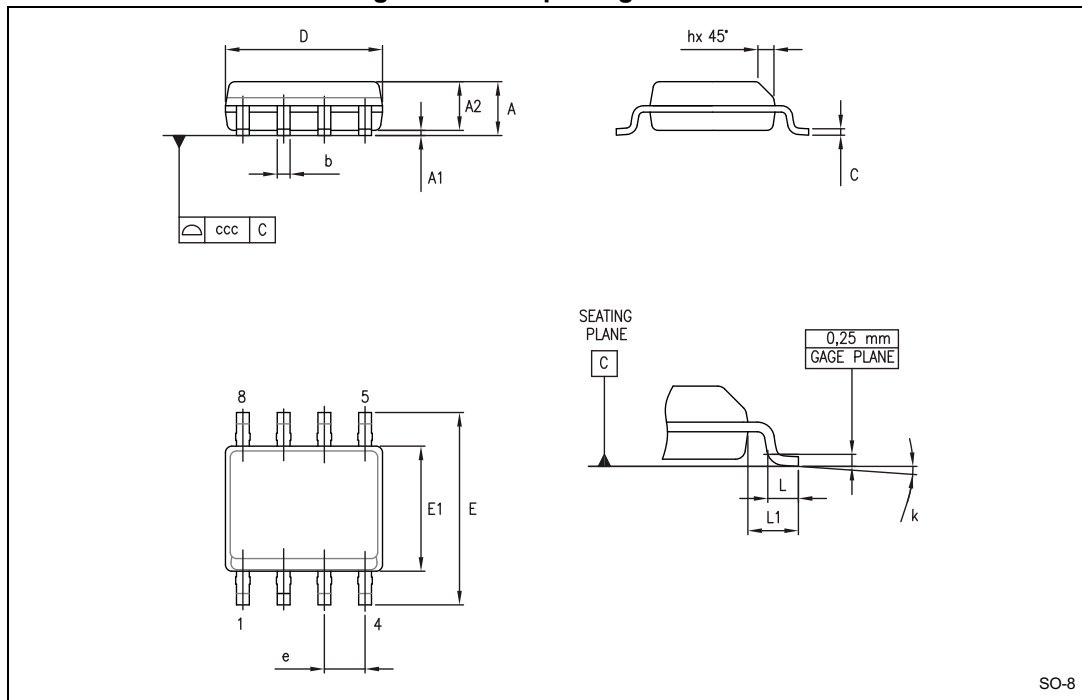


Table 9. SO8 package mechanical data

| Symbol | 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 |

### 6.3 TSSOP8 package information

Figure 38. TSSOP8 package outline

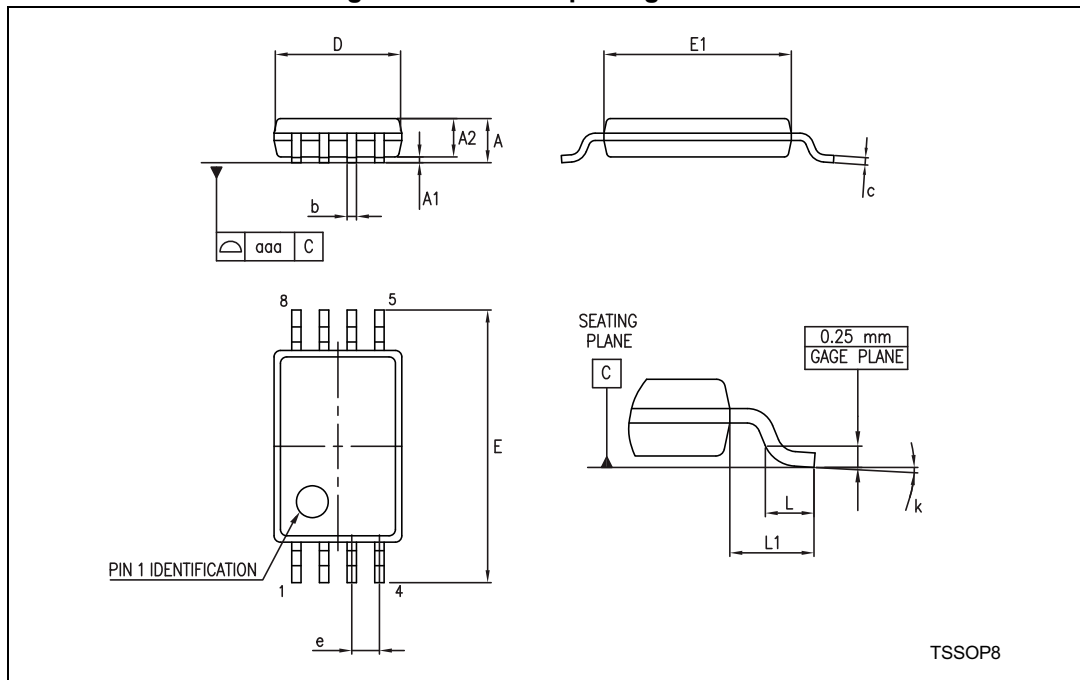


Table 10. TSSOP8 package mechanical data

| Symbol | 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      | 2.90        | 3.00 | 3.10 | 0.114  | 0.118  | 0.122 |
| 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 |      |        | 0.0256 |       |
| k      | 0°          |      | 8°   | 0°     |        | 8°    |
| L      | 0.45        | 0.60 | 0.75 | 0.018  | 0.024  | 0.030 |
| L1     |             | 1    |      |        | 0.039  |       |
| aaa    |             |      | 0.10 |        |        | 0.004 |

## 6.4 TSSOP14 package information

Figure 39. TSSOP14 package outline

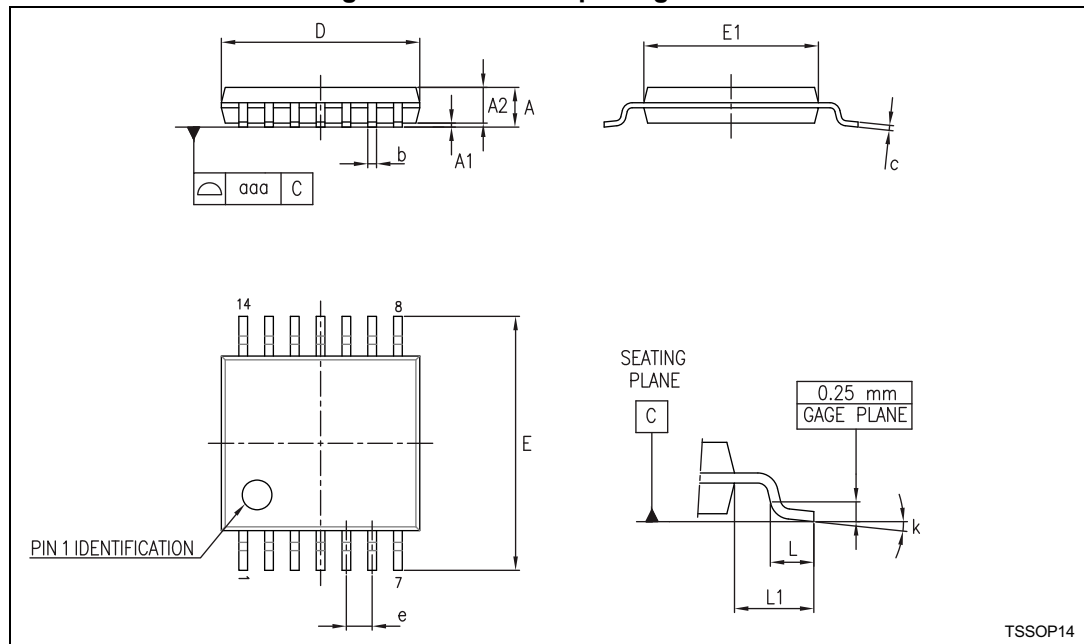


Table 11. TSSOP14 package mechanical data

| Symbol | 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  |

## 7 Ordering information

Table 12. Order codes

| Type                     | Temperature range | Package                             | Packaging     | Marking |
|--------------------------|-------------------|-------------------------------------|---------------|---------|
| TSH80ILT                 | -40 to +85 °C     | SOT23-5                             | Tape and reel | K303    |
| TSH80IYLT <sup>(1)</sup> |                   | SOT23-5<br>(automotive grade level) |               | K310    |
| TSH80IYDT <sup>(1)</sup> |                   | SO8<br>(automotive grade level)     |               | SH80IY  |
| TSH81IPT                 |                   | TSSOP8                              |               | SH81I   |
| TSH82IDT                 |                   | SO8                                 | Tape and reel | TSH82I  |
| TSH82IYDT <sup>(1)</sup> |                   | SO8<br>(automotive grade level)     | Tape and reel | TSH82IY |
| TSH82IPT                 |                   | TSSOP8                              |               | SH82I   |
| TSH84IPT                 |                   | TSSOP14                             |               | SH84I   |

1. Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 and Q002 or equivalent.

## 8 Revision history

**Table 13. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                            |
|-------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1-Feb-2003  | 1        | First release.                                                                                                                                                                                                                                                                                                                                                                                     |
| 2-Aug-2005  | 2        | PPAP references inserted in the datasheet, see <a href="#">Table 12: Order codes on page 28</a> .                                                                                                                                                                                                                                                                                                  |
| 12-Apr-2007 | 3        | Corrected temperature range for TSH80IYD/IYDT and TSH82IYD/IYDT order codes in <a href="#">Table 12: Order codes on page 28</a> .                                                                                                                                                                                                                                                                  |
| 24-Oct-2007 | 4        | TSH81IYPT PPAP references inserted in the datasheet, see <a href="#">Table 12: Order codes on page 28</a> .                                                                                                                                                                                                                                                                                        |
| 19-May-2009 | 5        | Added data relating to the quad TSH84 device.<br>Removed TSH81IYPT, TSH81IYD-IYDT, TSH82IYPT and TSH82IYD-IYDT order codes in <a href="#">Table 12: Order codes</a> .                                                                                                                                                                                                                              |
| 24-Jul-2012 | 6        | Added TSSOP14 package to figure on page 1, updated titles of <a href="#">Figure 2</a> to <a href="#">Figure 31</a> , updated <a href="#">Section 6: Package information</a> , removed TSH80ID-IDT, TSH80IYD, TSH81ID-IDT and TSH82ID order codes from <a href="#">Table 12: Order codes</a> . Modified note 1 below <a href="#">Table 12: Order codes</a> , minor corrections throughout document. |
| 13-Sep-2012 | 7        | Updated TSH80IYLT order code (status qualified) in <a href="#">Table 12</a> .<br>Removed TSH80IYD, TSH80IYDT, TSH80ID/DT, TSH81ID/DT, and TSH82ID order code from <a href="#">Table 12</a> .<br>Replaced TSH82DT by TSH82IDT order code in <a href="#">Table 12</a> .<br>Minor corrections throughout document.                                                                                    |
| 30-Apr-2013 | 8        | Updated <a href="#">Features</a> : added automotive qualification<br><a href="#">Figure 1: Pin connections for each package (top view)</a> : updated pin connections of SO8/TSSOP8 packages for TSH81 device.<br>Replaced <a href="#">Figure 36: SOT23-5 package outline</a><br><a href="#">Table 12: Order codes</a> : added automotive order code TSH82IYDT                                      |
| 03-Jul-2014 | 9        | Updated CDM to 1.5 kV in <a href="#">Table 1: Absolute maximum ratings</a><br><a href="#">Table 12: Order codes</a> : added automotive order code TSH80IYDT and removed shipping option in tubes from TSH82IDT                                                                                                                                                                                     |

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