

## Precision low noise dual operational amplifier

Datasheet – production data

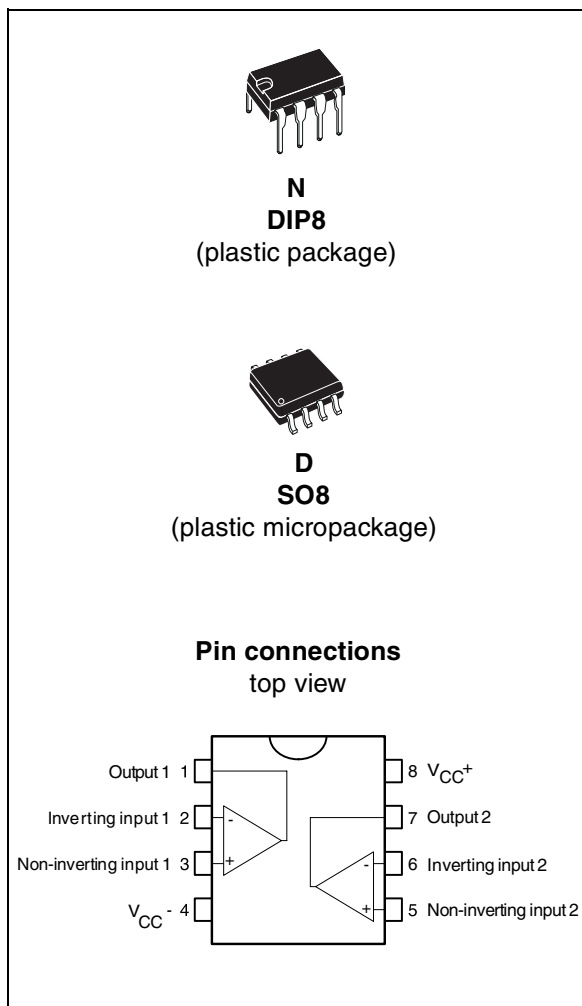
### Features

- Large output voltage swing: +14.3 V/-14.6 V
- Low input offset voltage 850  $\mu$ V max.
- Low voltage noise: 4.5 nV/ $\sqrt{\text{Hz}}$
- High gain bandwidth product: 15 MHz
- High slew rate: 7 V/ $\mu$ s
- Low distortion: 0.002%
- ESD internal protection 2 kV
- Excellent frequency stability

### Description

The TS522 device is a monolithic dual operational amplifier mainly dedicated to audio applications. The TS522 device offers a very low input offset voltage as well as low voltage noise (4.5 nV/ $\sqrt{\text{Hz}}$ ) and high dynamic performances (15 MHz gain bandwidth product, 7 V/ $\mu$ s slew rate).

The output stage allows a large output voltage swing and symmetrical source and sink currents.



# 1 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings**

| Symbol     | Parameter  | Value          | Unit |
|------------|--|----------------|------|
| $V_{CC}$   | Supply voltage   | $\pm 18$ to 36 | V    |
| $V_{id}$   | Differential input voltage <sup>(1)</sup>                  | $\pm 30$       | V    |
| $V_i$      | Input voltage <sup>(1)</sup>                               | $\pm 15$       | V    |
|            | Output short-circuit duration <sup>(2)</sup>               | Infinite       |      |
| $T_j$      | Maximum junction temperature                               | + 150          | °C   |
| $T_{stg}$  | Storage temperature range                                  | -65 to +150    | °C   |
| $R_{thja}$ | Thermal resistance junction-to-ambient <sup>(3), (4)</sup> |                | °C/W |
|            | SO-8   | 125            |      |
|            | DIP8   | 85             |      |
| $R_{thjc}$ | Thermal resistance junction-to-case <sup>(3), (4)</sup>    |                | °C/W |
|            | SO-8   | 40             |      |
|            | DIP8   | 41             |      |
| ESD        | HBM: human body model <sup>(5)</sup>                       | 2              | kV   |
|            | MM: machine model <sup>(6)</sup>                           | 200            | V    |
|            | CDM: charged device model <sup>(7)</sup>                   | 1.5            | kV   |

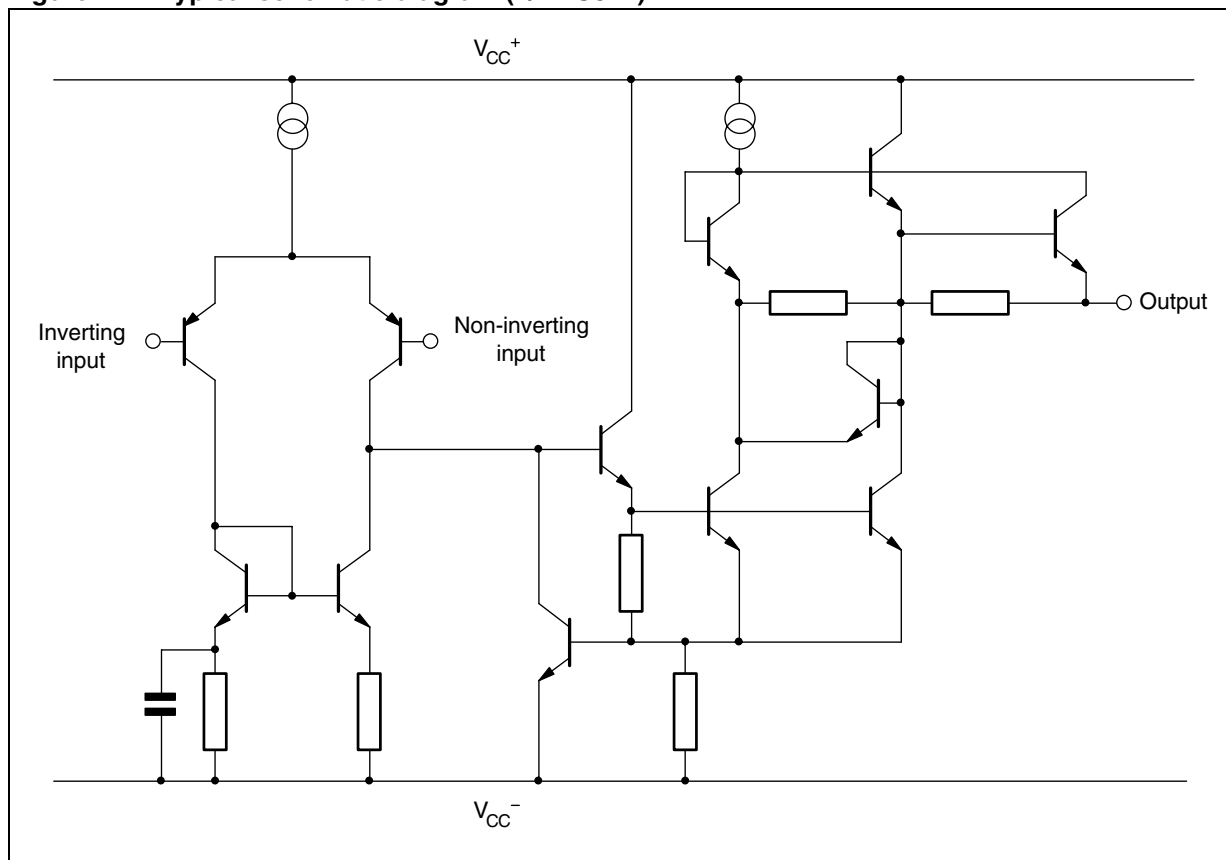
1. Either or both input voltages must not exceed the magnitude of  $V_{CC}^+$  or  $V_{CC}^-$ .
2. Power dissipation must be considered to ensure maximum junction temperature ( $T_j$ ) is not exceeded.
3. Short-circuits can cause excessive heating and destructive dissipation.
4.  $R_{th}$  are typical values.
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 the 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                       | $\pm 2.5$ to $\pm 15$ | V    |
| $T_{oper}$ | Operating free air temperature range | -40 to 125            | °C   |

## 2 Schematic diagram

Figure 1. Typical schematic diagram (1/2 TS522)



### 3 Electrical characteristics

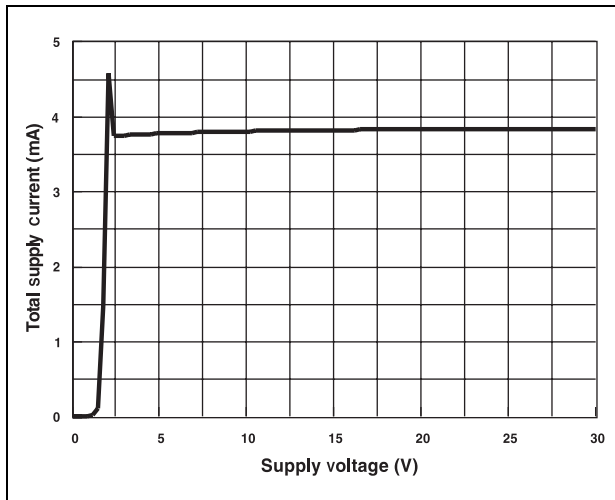
**Table 3. Electrical characteristics at  $V_{CC+} = 15\text{ V}$ ,  $V_{CC-} = -15\text{ V}$ ,  $T_{amb} = 25\text{ °C}$  (unless otherwise specified)**

| Symbol          | Parameter  | Min.     | Typ.  | Max.        | Unit                    |   |
|-----------------|--|----------|---|-------------|-------------------------|---|
| $V_{io}$        | Input offset voltage ( $V_o = 0\text{ V}$ , $V_{ic} = 0\text{ V}$ )<br>$T_{amb} = +25\text{ °C}$<br>$T_{min} \leq T_{amb} \leq T_{max}$  |          |   | 0.85<br>1.7 | mV                      |   |
| $\Delta V_{io}$ | Input offset voltage drift<br>$V_{ic} = 0\text{ V}$ , $V_o = 0\text{ V}$ , $T_{min} \leq T_{amb} \leq T_{max}$   |          | 2   |             | $\mu\text{V}/\text{°C}$ |   |
| $I_{io}$        | Input offset current ( $V_{ic} = 0\text{ V}$ , $V_o = 0\text{ V}$ )<br>$T_{amb} = +25\text{ °C}$<br>$T_{min} \leq T_{amb} \leq T_{max}$  |          | 10  | 150<br>175  | nA                      |   |
| $I_{ib}$        | Input bias current ( $V_{ic} = 0\text{ V}$ , $V_o = 0\text{ V}$ )<br>$T_{amb} = +25\text{ °C}$<br>$T_{min} \leq T_{amb} \leq T_{max}$  |          | 250   | 750<br>800  | nA                      |   |
| $V_{icm}$       | Common mode input voltage range<br>( $\Delta V_{io} = 5\text{ mV}$ , $V_o = 0\text{ V}$ )  | $\pm 13$ | $\pm 14$  |             | V                       |   |
| $A_{vd}$        | Large signal voltage gain ( $R_L = 2\text{ k}\Omega$ , $V_o = \pm 10\text{ V}$ )<br>$T_{amb} = +25\text{ °C}$<br>$T_{min} \leq T_{amb} \leq T_{max}$   | 90<br>85 | 100   |             | dB                      |   |
| $\pm V_{opp}$   | Output voltage swing ( $V_{id} = \pm 1\text{ V}$ )<br>$R_L = 600\text{ }\Omega$<br>$R_L = 600\text{ }\Omega$<br><br>$R_L = 2.0\text{ k}\Omega$<br>$R_L = 2.0\text{ k}\Omega$<br><br>$R_L = 10\text{ k}\Omega$<br>$R_L = 10\text{ k}\Omega$ |          | 12.2<br>-12.7<br><br>14<br>-14.2<br><br>14.3<br>-14.6 |             | -13.2<br>-14            | V |
| CMR             | Common mode rejection ratio ( $V_{ic} = \pm 13\text{ V}$ )   | 80       | 100   |             | dB                      |   |
| SVR             | Supply voltage rejection ratio<br>$V_{CC+}/V_{CC-} = +15\text{ V}/-15\text{ V}$ to $+5\text{ V}/-5\text{ V}$   | 80       | 105   |             | dB                      |   |
| $I_o$           | Output short-circuit current<br>( $V_{id} = \pm 1\text{ V}$ , output to ground)<br>Source<br>Sink  | 15<br>20 | 29<br>37  |             | mA                      |   |
| $I_{CC}$        | Supply current ( $V_o = 0\text{ V}$ , all amplifiers)<br>$T_{amb} = +25\text{ °C}$<br>$T_{min} \leq T_{amb} \leq T_{max}$  |          | 4   | 5<br>5.5    | mA                      |   |
| SR              | Slew rate<br>( $V_i = -10\text{ V}$ to $+10\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , $A_V = +1$ )  | 5        | 7   |             | $\text{V}/\mu\text{s}$  |   |
| GBP             | Gain bandwidth product<br>( $f = 100\text{ kHz}$ , $R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$ )  | 10       | 15  |             | MHz                     |   |
| B               | Unity gain bandwidth (open loop)   |          | 9   |             | MHz                     |   |

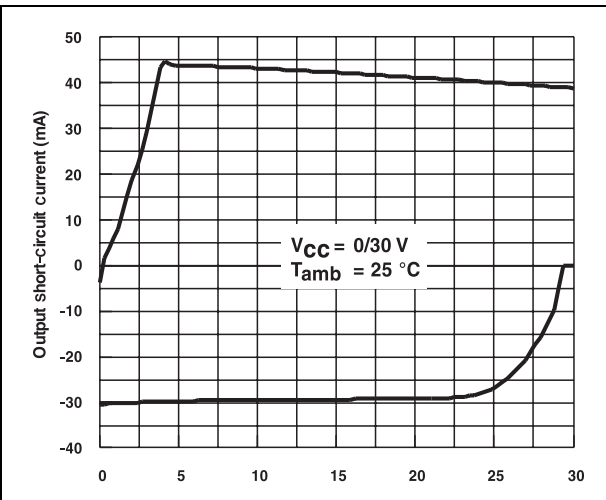
**Table 3. Electrical characteristics at  $V_{CC+} = 15\text{ V}$ ,  $V_{CC-} = -15\text{ V}$ ,  $T_{amb} = 25\text{ °C}$   
(unless otherwise specified) (continued)**

| Symbol          | Parameter  | Min. | Typ.      | Max. | Unit                      |
|-----------------|--|------|-----------|------|---------------------------|
| $A_m$           | Gain margin ( $R_L = 2\text{ k}\Omega$ )<br>$C_L = 0\text{ pF}$<br>$C_L = 100\text{ pF}$   |      | -11<br>-6 |      | dB                        |
| $\phi_m$        | Phase margin<br>$C_L = 0\text{ pF}$<br>$C_L = 100\text{ pF}$   |      | 55<br>30  |      | Degrees                   |
| $e_n$           | Equivalent input noise voltage<br>( $R_s = 100\ \Omega$ , $f = 1\text{ kHz}$ )   |      | 4.5       |      | $\frac{nV}{\sqrt{Hz}}$    |
| $i_n$           | Equivalent input noise current<br>( $f = 1\text{ kHz}$ )   |      | 0.5       |      | $\frac{\mu A}{\sqrt{Hz}}$ |
| THD             | Total harmonic distortion<br>$R_L = 2\text{ k}\Omega$ , $f = 20\text{ Hz to } 20\text{ kHz}$ , $V_o = 3\text{ V}_{rms}$ , $A_v = +1$ |      | 0.002     |      | %                         |
| $V_{o1}/V_{o2}$ | Channel separation ( $f = 20\text{ Hz to } 20\text{ kHz}$ )  |      | 120       |      | dB                        |
| FPB             | Full power bandwidth<br>( $V_o = 27\text{ V}_{pp}$ , $R_L = 2\text{ k}\Omega$ , $THD \leq 1\%$ )                                     |      | 120       |      | kHz                       |
| $Z_o$           | Output impedance ( $V_o = 0\text{ V}$ , $f = 9\text{ MHz}$ )   |      | 37        |      | $\Omega$                  |
| $R_i$           | Input resistance ( $V_{ic} = 0\text{ V}$ )   |      | 175       |      | k $\Omega$                |
| $C_i$           | Input capacitance ( $V_{ic} = 0\text{ V}$ )  |      | 12        |      | pF                        |

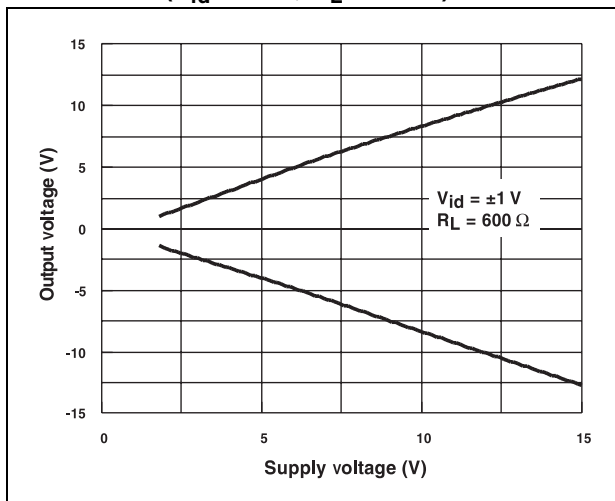
**Figure 2. Total supply current vs. supply voltage**



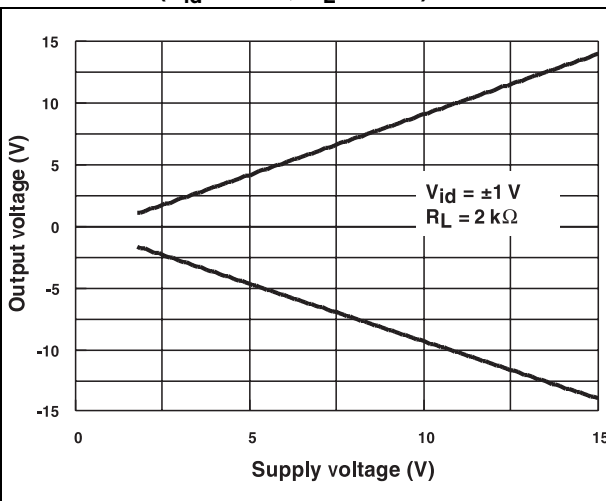
**Figure 3. Output short-circuit current vs. output voltage**



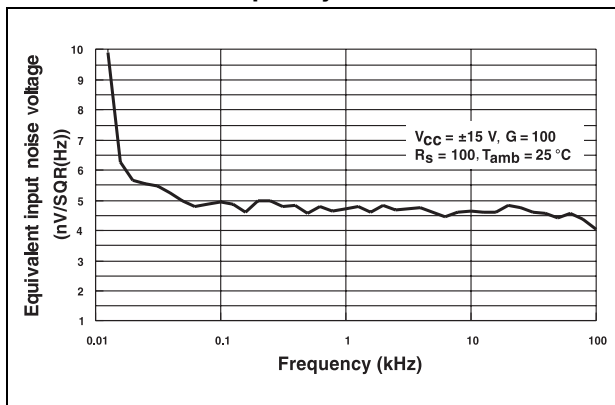
**Figure 4. Output voltage vs. supply voltage ( $V_{id} = \pm 1\text{ V}$ ,  $R_L = 600\ \Omega$ )**



**Figure 5. Output voltage vs. supply voltage ( $V_{id} = \pm 1\text{ V}$ ,  $R_L = 2\text{ k}\Omega$ )**



**Figure 6. Equivalent input noise voltage vs. frequency**



**Figure 7. THD + noise vs. frequency**

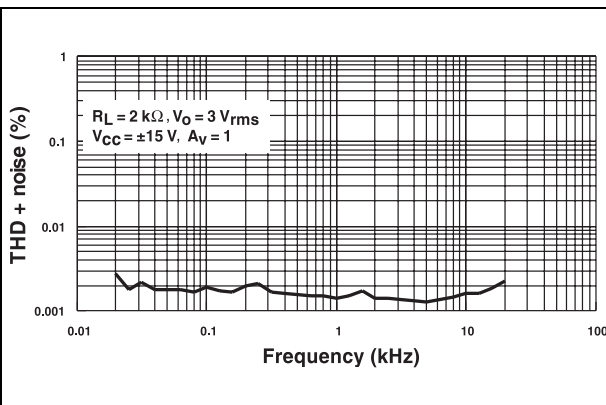


Figure 8. Voltage gain and phase vs. frequency

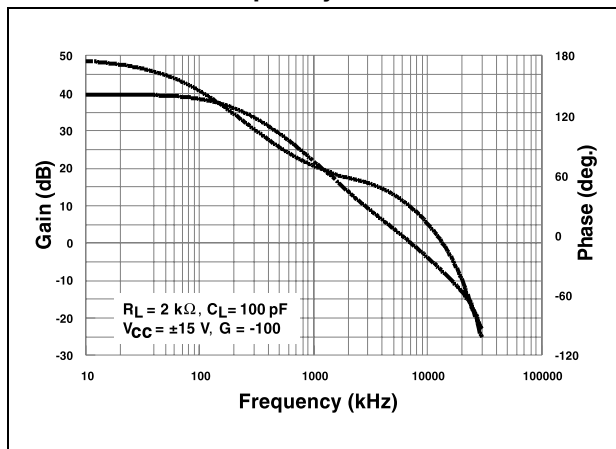
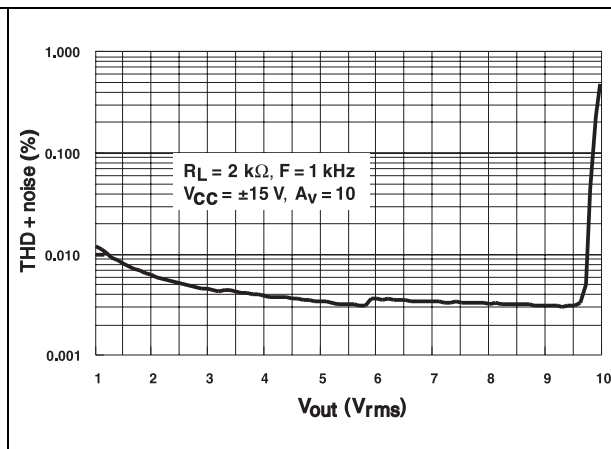


Figure 9. THD + noise vs.  $V_{out}$



## 4 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.



Figure 10. DIP8 package outline

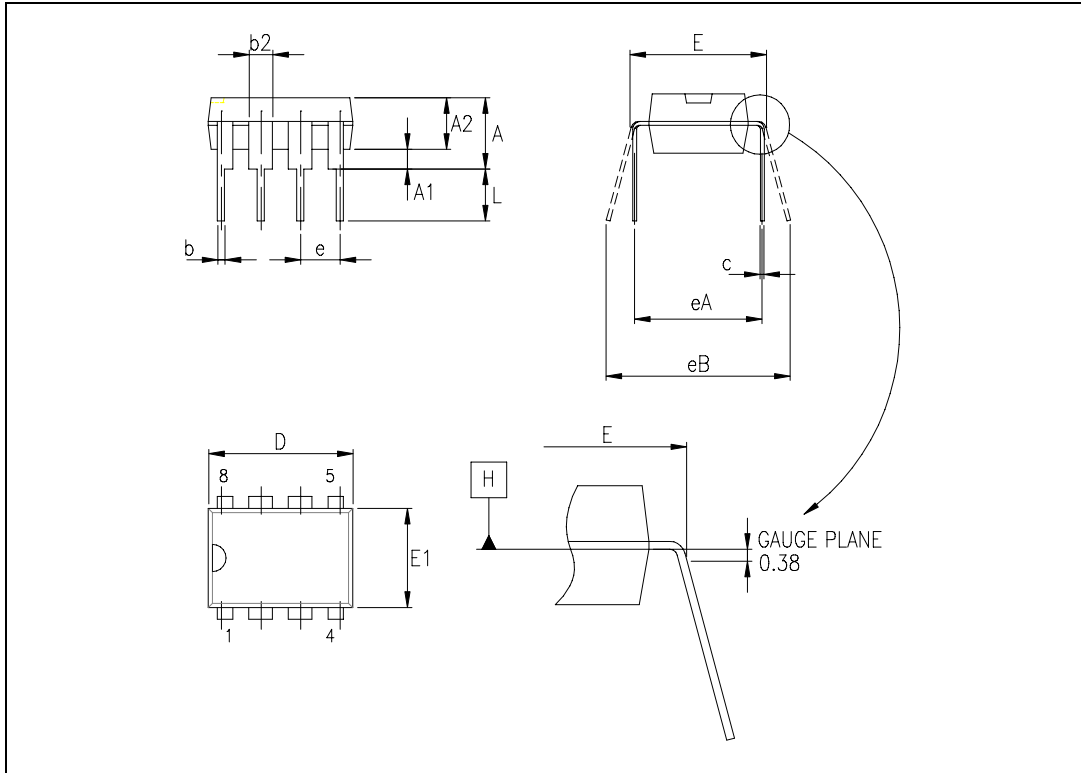


Table 4. DIP8 package mechanical data

| Symbol | Dimensions  |      |       |        |       |       |
|--------|-------------|------|-------|--------|-------|-------|
|        | Millimeters |      |       | Inches |       |       |
|        | Min.        | Typ. | Max.  | Min.   | Typ.  | Max.  |
| A      |             | 3.32 |       |        | 0.131 |       |
| a1     | 0.51        |      |       | 0.020  |       |       |
| B      | 1.15        |      | 1.65  | 0.045  |       | 0.065 |
| b      | 0.356       |      | 0.55  | 0.014  |       | 0.022 |
| b1     | 0.204       |      | 0.304 | 0.008  |       | 0.012 |
| D      |             |      | 10.92 |        |       | 0.430 |
| E      | 7.95        |      | 9.75  | 0.313  |       | 0.384 |
| e      |             | 2.54 |       |        | 0.100 |       |
| e3     |             | 7.62 |       |        | 0.300 |       |
| e4     |             | 7.62 |       |        | 0.300 |       |
| F      |             |      | 6.6   |        |       | 0.260 |
| i      |             |      | 5.08  |        |       | 0.200 |
| L      | 3.18        |      | 3.81  | 0.125  |       | 0.150 |
| Z      |             |      | 1.52  |        |       | 0.060 |

Figure 11. SO-8 package outline

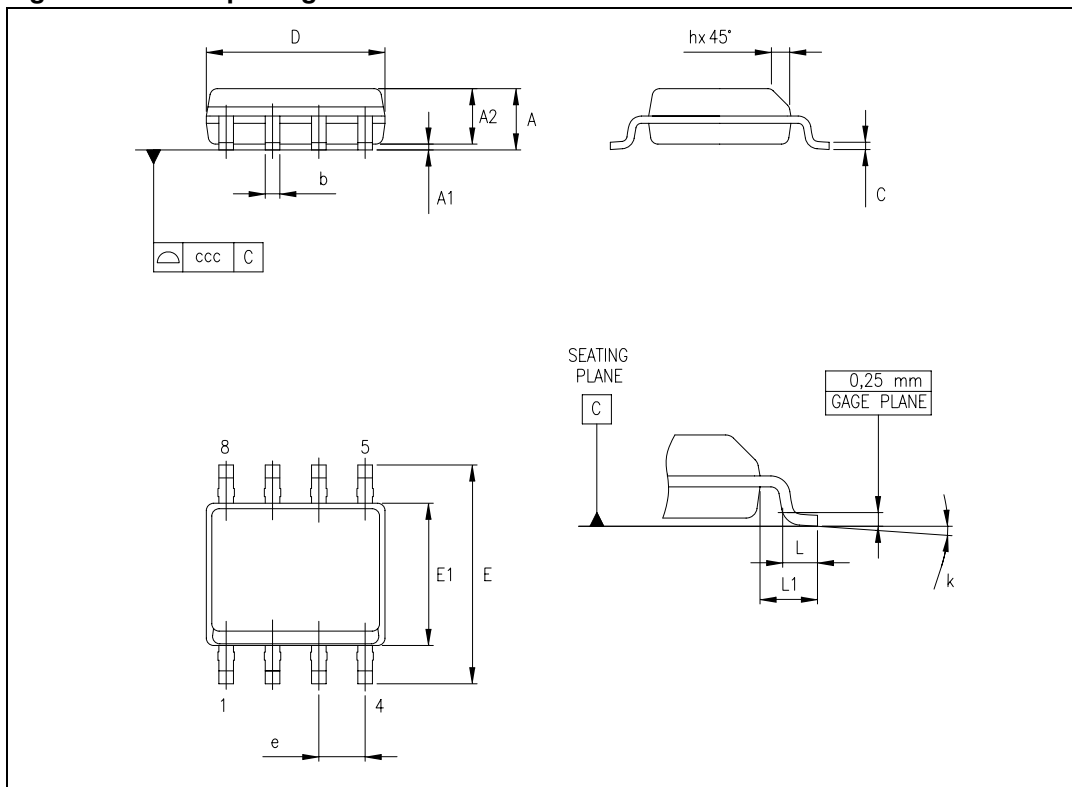


Table 5. SO-8 package mechanical data

| 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 |

## 5 Ordering information

**Table 6. Order codes**

| Order code               | Temperature range | Package                    | Packing            | Marking |
|--------------------------|-------------------|----------------------------|--------------------|---------|
| TS522ID/DT               | -40 to +125 °C    | SO-8                       | Tube/tape and reel | 522I    |
| TS522IN                  | -40 to +125 °C    | DIP8                       | Tube               | TS522IN |
| TS522IYDT <sup>(1)</sup> | -40 to +125 °C    | SO-8<br>(automotive grade) | Tube/tape and reel | 522IY   |

1. Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 and Q 002 or equivalent.

## 6 Revision history

**Table 7. Document revision history**

| Date        | Revision | Changes   |
|-------------|----------|---|
| 01-Nov-2001 | 1        | Initial release.  |
| 14-Oct-2008 | 2        | Document reformatted.<br>Added automotive grade order codes in <a href="#">Table 6: Order codes</a> .<br>Removed macromodel.  |
| 12-Sep-2012 | 3        | Updated <a href="#">Features</a> (removed "Macromodel").<br>Removed TS522IYD order code from <a href="#">Table 6</a> .<br>Updated ECOPACK text in <a href="#">Section 4</a> .<br>Minor corrections throughout document. |

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