

## 1.8 V input/output, rail-to-rail, low power operational amplifiers

### Features

- Operating range from  $V_{CC} = 1.8$  to 6 V
- Rail-to-rail input and output
- Extended  $V_{icm}$  ( $V_{CC-} - 0.2$  V to  $V_{CC+} + 0.2$  V)
- Low supply current (120  $\mu$ A)
- Good accuracy (1 mV max for A version)
- Gain bandwidth product (530 kHz)
- High unity gain stability (able to drive 500 pF)
- ESD tolerance (2 kV)
- Latch-up immunity
- Available in SOT23-5 micropackage

### Applications

- Two-cell battery-powered systems
- Battery-powered electronic equipment
- Cordless phones
- Cellular phones
- Laptops
- PDAs

### Description

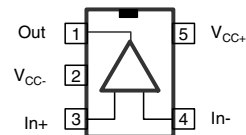
The TS185x (single, dual and quad) can operate with voltages as low as 1.8 V. They feature both input and output rail-to-rail (1.71 at  $V_{CC} = 1.8$  V,  $R_L = 2$  k $\Omega$ ), 120  $\mu$ A current consumption and 530 kHz gain bandwidth product.

With this low consumption and a sufficient GBP for many applications, these operational amplifiers are well-suited to all kinds of battery supplied and portable applications.

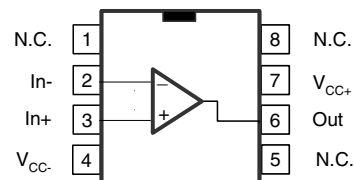
The TS1851 is housed in the space-saving 5-pin SOT23-5 package, which simplifies board design (outside dimensions are 2.8 mm x 2.9 mm).

#### Pin connections (top view)

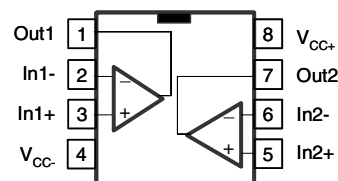
TS1851ILT



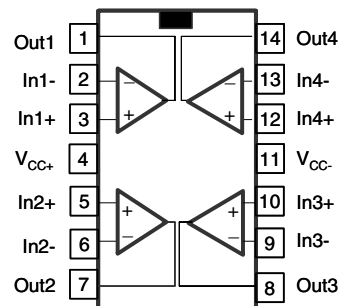
TS1851ID/IDT



TS1852ID/IDT-TS1852IST-TS1852IPT



TS1854ID/IDT-TS1854IPT



**Table 1. Device summary**

| Reference | Single version | Dual version | Quad version |
|-----------|----------------|--------------|--------------|
| TS185x    | TS1851         | TS1852       | TS1854       |
| TS185xA   | TS1851A        | TS1852A      | TS1854A      |

# Contents

|          |                                                          |           |
|----------|----------------------------------------------------------|-----------|
| <b>1</b> | <b>Absolute maximum ratings and operating conditions</b> | <b>3</b>  |
| <b>2</b> | <b>Electrical characteristics</b>                        | <b>5</b>  |
| <b>3</b> | <b>Package information</b>                               | <b>15</b> |
| 3.1      | SO-8 package information                                 | 16        |
| 3.2      | TSSOP8 package information                               | 17        |
| 3.3      | MiniSO-8 package information                             | 18        |
| 3.4      | SO-14 package information                                | 19        |
| 3.5      | TSSOP14 package information                              | 20        |
| 3.6      | SOT23-5 package information                              | 21        |
| <b>4</b> | <b>Ordering information</b>                              | <b>22</b> |
| <b>5</b> | <b>Revision history</b>                                  | <b>23</b> |

# 1 Absolute maximum ratings and operating conditions

**Table 2. Absolute maximum ratings**

| Symbol     | Parameter                                             | Value                              | Unit |
|------------|-------------------------------------------------------|------------------------------------|------|
| $V_{CC}$   | Supply voltage <sup>(1)</sup>                         | 7                                  | V    |
| $V_{id}$   | Differential input voltage <sup>(2)</sup>             | $\pm 1$                            | V    |
| $V_i$      | Input voltage                                         | $V_{CC-} - 0.3$ to $V_{CC+} + 0.3$ | V    |
| $T_{oper}$ | Operating free-air temperature range                  | -40 to + 125                       | °C   |
| $T_{stg}$  | Storage temperature                                   | -65 to +150                        | °C   |
| $T_j$      | Maximum junction temperature                          | 150                                | °C   |
| $R_{thja}$ | Thermal resistance junction to ambient <sup>(3)</sup> |                                    | °C/W |
|            | SOT23-5                                               | 250                                |      |
|            | miniSO-8                                              | 190                                |      |
|            | SO-8                                                  | 125                                |      |
|            | SO-14                                                 | 103                                |      |
|            | TSSOP8                                                | 120                                |      |
|            | TSSOP14                                               | 100                                |      |
| $R_{thjc}$ | Thermal resistance junction to case                   |                                    | °C/W |
|            | SOT23-5                                               | 81                                 |      |
|            | miniSO-8                                              | 39                                 |      |
|            | SO-8                                                  | 40                                 |      |
|            | SO-14                                                 | 31                                 |      |
|            | TSSOP8                                                | 37                                 |      |
|            | TSSOP14                                               | 32                                 |      |
| ESD        | HBM: human body model <sup>(4)</sup>                  | 2                                  | kV   |
|            | MM: machine model <sup>(5)</sup>                      | 200                                | V    |
|            | CDM: charged device model <sup>(6)</sup>              | 1.5                                | kV   |
|            | Lead temperature (soldering, 10sec)                   | 250                                | °C   |
|            | Output short-circuit duration                         | See note <sup>(7)</sup>            |      |

1. All voltage values, except differential voltages, are with respect to network terminal.
2. Differential voltages are the non-inverting input terminal with respect to the inverting input terminal. If  $V_{id} > \pm 1$  V, the maximum input current must not exceed  $\pm 1$  mA. When  $V_{id} > \pm 1$  V, add an input series resistor to limit the input current.
3. Short-circuits can cause excessive heating. Destructive dissipation can result from simultaneous short-circuits on all amplifiers.
4. 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.
5. 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.
6. 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.
7. Short-circuits from the output to  $V_{CC}$  can cause excessive heating. The maximum output current is approximately 48 mA, independent of the magnitude of  $V_{CC}$ . Destructive dissipation can result from simultaneous short-circuits on all amplifiers.

**Table 3. Operating conditions**

| Symbol     | Parameter                                                                                                                                                                  | Value                                                        | Unit               |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|--------------------|
| $V_{CC}$   | Supply voltage                                                                                                                                                             | 1.8 to 6                                                     | V                  |
| $V_{icm}$  | Common-mode input voltage range<br>$T_{op} = 25^{\circ}\text{C}$ , $1.8 \leq V_{CC} \leq 6\text{ V}$<br>$T_{min} < T_{op} < T_{max}$ , $1.8 \leq V_{CC} \leq 5.5\text{ V}$ | $V_{CC-} - 0.2$ to $V_{CC+} + 0.2$<br>$V_{CC-}$ to $V_{CC+}$ | V                  |
| $T_{oper}$ | Operating free-air temperature range                                                                                                                                       | -40 to + 125                                                 | $^{\circ}\text{C}$ |

## 2 Electrical characteristics

**Table 4. Electrical characteristics measured at  $V_{CC+} = +1.8\text{ V}$ ,  $V_{CC-} = 0\text{ V}$ , with  $C_L$  and  $R_L$  connected to  $V_{CC}/2$ ,  $T_{\text{amb}} = 25^\circ\text{C}$  (unless otherwise specified) <sup>(1)</sup>**

| Symbol          | Parameter                                                              | Conditions                                                                                                                                                                                                                                | Min.                       | Typ.        | Max.                   | Unit                         |
|-----------------|------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|-------------|------------------------|------------------------------|
| $V_{io}$        | Input offset voltage                                                   | TS1851/2/4<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$<br>TS1851A/2A/4A<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                                                               |                            | 0.1         | 3<br>6<br>1<br>1.5     | mV                           |
| $\Delta V_{io}$ | Input offset voltage drift                                             |                                                                                                                                                                                                                                           |                            | 2           |                        | $\mu\text{V}/^\circ\text{C}$ |
| $I_{io}$        | Input offset current                                                   | $V_{\text{icm}} = V_{\text{out}} = V_{CC}/2$ <sup>(2)</sup><br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                                                                               |                            | 1           | 9<br>25                | nA                           |
| $I_{ib}$        | Input bias current                                                     | $V_{\text{icm}} = V_{\text{out}} = V_{CC}/2$ <sup>(2)</sup><br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                                                                               |                            | 10          | 50<br>80               | nA                           |
| CMR             | Common mode rejection ratio<br>$20 \log (\Delta V_{ic}/\Delta V_{io})$ | $0 \leq V_{\text{icm}} \leq V_{CC}$<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                                                                                                       | 55<br>52                   | 85          |                        | dB                           |
| $A_{vd}$        | Large signal voltage gain                                              | $V_{\text{out}} = 0.5$ to $1.3\text{ V}$<br>$R_L = 10\text{ k}\Omega$<br>$R_L = 2\text{ k}\Omega$                                                                                                                                         | 80<br>70                   | 100<br>100  |                        | dB                           |
| $V_{OH}$        | High level output voltage                                              | $V_{id} = 100\text{ mV}$<br>$R_L = 10\text{ k}\Omega$<br>$R_L = 2\text{ k}\Omega$<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$ , $R_L = 10\text{ k}\Omega$<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$ , $R_L = 2\text{ k}\Omega$  | 1.7<br>1.65<br>1.7<br>1.65 | 1.77<br>1.7 |                        | V                            |
| $V_{OL}$        | Low level output voltage                                               | $V_{id} = -100\text{ mV}$<br>$R_L = 10\text{ k}\Omega$<br>$R_L = 2\text{ k}\Omega$<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$ , $R_L = 10\text{ k}\Omega$<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$ , $R_L = 2\text{ k}\Omega$ |                            | 40<br>62    | 70<br>90<br>100<br>120 | mV                           |
| $I_o$           | Output source current                                                  | $V_{id} = 100\text{ mV}$ , $V_O = V_{CC-}$ at $T_{\text{amb}}$                                                                                                                                                                            | 15                         | 29          |                        | mA                           |
|                 |                                                                        | at $T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                                                                                                                                           | 5                          | 5           |                        |                              |
|                 | Output sink current                                                    | $V_{id} = -100\text{ mV}$ , $V_O = V_{CC+}$ at $T_{\text{amb}}$                                                                                                                                                                           | 15                         | 46          |                        | mA                           |
|                 |                                                                        | at $T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                                                                                                                                           | 5                          |             |                        |                              |
| $I_{CC}$        | Supply current (per amplifier)                                         | $V_{\text{out}} = V_{CC}/2$<br>$A_{VCL} = 1$ , no load<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                                                                                    |                            | 120         | 170<br>200             | $\mu\text{A}$                |
| GBP             | Gain bandwidth product                                                 | $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , $f = 100\text{ kHz}$                                                                                                                                                                  | 300                        | 530         |                        | kHz                          |
| SR              | Slew rate                                                              | $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , $A_V = 1$                                                                                                                                                                             | 0.1                        | 0.18        |                        | V/ $\mu\text{s}$             |
| $\phi_m$        | Phase margin                                                           | $C_L = 100\text{ pF}$                                                                                                                                                                                                                     |                            | 60          |                        | Degrees                      |
| $e_n$           | Input voltage noise                                                    | $f = 1\text{ kHz}$                                                                                                                                                                                                                        |                            | 40          |                        | nV/ $\sqrt{\text{Hz}}$       |
| THD             | Total harmonic distortion                                              |                                                                                                                                                                                                                                           |                            | 0.01        |                        | %                            |

1. All parameter limits at temperatures other than  $25^\circ\text{C}$  are guaranteed by correlation.

2. Maximum values include unavoidable inaccuracies of the industrial tests.

**Table 5. Electrical characteristics measured at  $V_{CC+} = +3\text{ V}$ ,  $V_{CC-} = 0\text{ V}$ , with  $C_L$  and  $R_L$  connected to  $V_{CC}/2$ ,  $T_{\text{amb}} = 25^\circ\text{C}$  (unless otherwise specified) <sup>(1)</sup>**

| Symbol          | Parameter                                                              | Conditions                                                                                                                                                                                                                                | Min.                       | Typ.         | Max.                    | Unit                         |
|-----------------|------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|--------------|-------------------------|------------------------------|
| $V_{io}$        | Input offset voltage                                                   | $V_{icm} = V_{out} = V_{CC}/2$<br>TS1851/2/4<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$<br>TS1851A/2A/4A<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                             |                            | 0.1          | 3<br>6<br>1<br>1.5      | mV                           |
| $\Delta V_{io}$ | Input offset voltage drift                                             |                                                                                                                                                                                                                                           |                            | 2            |                         | $\mu\text{V}/^\circ\text{C}$ |
| $I_{io}$        | Input offset current                                                   | $V_{icm} = V_{out} = V_{CC}/2^{(2)}$<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                                                                                                      |                            | 1            | 9<br>25                 | nA                           |
| $I_{ib}$        | Input bias current                                                     | $V_{icm} = V_{out} = V_{CC}/2^{(2)}$<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                                                                                                      |                            | 10           | 55<br>85                | nA                           |
| CMR             | Common mode rejection ratio<br>$20 \log (\Delta V_{ic}/\Delta V_{io})$ | $0 \leq V_{icm} \leq V_{CC}$<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                                                                                                              | 60<br>57                   | 90           |                         | dB                           |
| $A_{vd}$        | Large signal voltage gain                                              | $V_{out} = 0.5 \text{ to } 2.5\text{ V}$<br>$R_L = 10\text{ k}\Omega$<br>$R_L = 2\text{ k}\Omega$                                                                                                                                         | 83<br>74                   | 102<br>102   |                         | dB                           |
| $V_{OH}$        | High level output voltage                                              | $V_{id} = 100\text{ mV}$<br>$R_L = 10\text{ k}\Omega$<br>$R_L = 2\text{ k}\Omega$<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$ , $R_L = 10\text{ k}\Omega$<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$ , $R_L = 2\text{ k}\Omega$  | 2.9<br>2.85<br>2.9<br>2.85 | 2.96<br>2.94 |                         | V                            |
| $V_{OL}$        | Low level output voltage                                               | $V_{id} = -100\text{ mV}$<br>$R_L = 10\text{ k}\Omega$<br>$R_L = 2\text{ k}\Omega$<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$ , $R_L = 10\text{ k}\Omega$<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$ , $R_L = 2\text{ k}\Omega$ |                            | 10<br>46     | 90<br>100<br>120<br>130 | mV                           |
| $I_o$           | Output source current                                                  | $V_{id} = 100\text{ mV}$ , $V_O = V_{CC-}$ , at $T_{\text{amb}}$                                                                                                                                                                          | 15                         | 47           |                         | mA                           |
|                 |                                                                        | At $T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                                                                                                                                           | 5                          |              |                         |                              |
|                 | Output sink current                                                    | $V_{id} = -100\text{ mV}$ , $V_O = V_{CC+}$ , at $T_{\text{amb}}$                                                                                                                                                                         | 15                         | 47           |                         | mA                           |
|                 |                                                                        | At $T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                                                                                                                                           | 5                          |              |                         |                              |
| $I_{CC}$        | Supply current (per amplifier)                                         | $V_{out} = V_{CC}/2$<br>$A_{VCL} = 1$ , no load<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                                                                                           |                            | 150          | 200<br>230              | $\mu\text{A}$                |
| GBP             | Gain bandwidth product                                                 | $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , $f = 100\text{ kHz}$                                                                                                                                                                  | 370                        | 600          |                         | kHz                          |
| SR              | Slew rate                                                              | $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , $A_V = 1$                                                                                                                                                                             | 0.12                       | 0.2          |                         | V/ $\mu\text{s}$             |
| $\phi_m$        | Phase margin                                                           | $C_L = 100\text{ pF}$                                                                                                                                                                                                                     |                            | 60           |                         | Degrees                      |
| $e_n$           | Input voltage noise                                                    | $f = 1\text{ kHz}$                                                                                                                                                                                                                        |                            | 40           |                         | nV/ $\sqrt{\text{Hz}}$       |
| THD             | Total harmonic distortion                                              | $V_{out} = 2\text{ V}_{pk-pk}$ , $A_V = -1$ , $f = 1\text{ kHz}$                                                                                                                                                                          |                            | 0.005        |                         | %                            |

1. All parameter limits at temperatures other than  $25^\circ\text{C}$  are guaranteed by correlation.

2. Maximum values include unavoidable inaccuracies of the industrial tests.

**Table 6. Electrical characteristics measured at  $V_{CC+} = +5\text{ V}$ ,  $V_{CC-} = 0\text{ V}$ , with  $C_L$  and  $R_L$  connected to  $V_{CC}/2$ ,  $T_{\text{amb}} = 25^\circ\text{C}$  (unless otherwise specified) <sup>(1)</sup>**

| Symbol          | Parameter                                                                 | Conditions                                                                                                                                                                                                                                | Min.                       | Typ.         | Max.                     | Unit                         |
|-----------------|---------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|--------------|--------------------------|------------------------------|
| $V_{io}$        | Input offset voltage                                                      | $V_{icm} = V_{out} = V_{CC}/2$<br>TS1851/2/4<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$<br>TS1851A/2A/4A<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                             |                            | 0.1          | 3<br>6<br>1<br>1.5       | mV                           |
| $\Delta V_{io}$ | Input offset voltage drift                                                |                                                                                                                                                                                                                                           |                            | 2            |                          | $\mu\text{V}/^\circ\text{C}$ |
| $I_{io}$        | Input offset current                                                      | $V_{icm} = V_{out} = V_{CC}/2^{(2)}$<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                                                                                                      |                            | 1            | 9<br>25                  | nA                           |
| $I_{ib}$        | Input bias current                                                        | $V_{icm} = V_{out} = V_{CC}/2^{(2)}$<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                                                                                                      |                            | 16           | 63<br>93                 | nA                           |
| CMR             | Common mode rejection ratio<br>$20 \log (\Delta V_{ic}/\Delta V_{io})$    | $0 \leq V_{icm} \leq V_{CC}$<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                                                                                                              | 65<br>62                   | 95           |                          | dB                           |
| SVR             | Supply voltage rejection ratio<br>$20 \log (\Delta V_{CC}/\Delta V_{io})$ | $V_{CC} = 1.8 \text{ to } 5\text{ V}$                                                                                                                                                                                                     | 70                         | 90           |                          | dB                           |
| $A_{vd}$        | Large signal voltage gain                                                 | $V_{out} = 0.5 \text{ to } 4\text{ V}$<br>$R_L = 10\text{ k}\Omega$<br>$R_L = 2\text{ k}\Omega$                                                                                                                                           | 85<br>77                   | 104<br>104   |                          | dB                           |
| $V_{OH}$        | High level output voltage                                                 | $V_{id} = 100\text{ mV}$<br>$R_L = 10\text{ k}\Omega$<br>$R_L = 2\text{ k}\Omega$<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$ , $R_L = 10\text{ k}\Omega$<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$ , $R_L = 2\text{ k}\Omega$  | 4.85<br>4.8<br>4.85<br>4.8 | 4.95<br>4.91 |                          | V                            |
| $V_{OL}$        | Low level output voltage                                                  | $V_{id} = -100\text{ mV}$<br>$R_L = 10\text{ k}\Omega$<br>$R_L = 2\text{ k}\Omega$<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$ , $R_L = 10\text{ k}\Omega$<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$ , $R_L = 2\text{ k}\Omega$ |                            | 40<br>80     | 180<br>200<br>180<br>200 | mV                           |
| $I_o$           | Output source current                                                     | $V_{id} = 100\text{ mV}$ , $V_O = V_{CC-}$ , at $T_{\text{amb}}$                                                                                                                                                                          | 15                         | 48           |                          | mA                           |
|                 |                                                                           | at $T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                                                                                                                                           | 5                          |              |                          |                              |
|                 | Output sink current                                                       | $V_{id} = -100\text{ mV}$ , $V_O = V_{CC+}$ , at $T_{\text{amb}}$                                                                                                                                                                         | 15                         | 48           |                          | mA                           |
|                 |                                                                           | at $T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                                                                                                                                           | 5                          |              |                          |                              |
| $I_{CC}$        | Supply current (per amplifier)                                            | $V_{out} = V_{CC}/2$<br>$A_{VCL} = 1$ , no load<br>$T_{\min} \leq T_{\text{amb}} \leq T_{\max}$                                                                                                                                           |                            | 162          | 220<br>250               | $\mu\text{A}$                |
| GBP             | Gain bandwidth product                                                    | $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , $f = 100\text{ kHz}$                                                                                                                                                                  | 380                        | 656          |                          | kHz                          |
| SR              | Slew rate                                                                 | $R_L = 10\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , $A_V = 1$                                                                                                                                                                             | 0.13                       | 0.25         |                          | V/ $\mu\text{s}$             |
| $\phi_m$        | Phase margin                                                              | $C_L = 100\text{ pF}$                                                                                                                                                                                                                     |                            | 60           |                          | Degrees                      |
| $e_n$           | Input voltage noise                                                       | $f = 1\text{ kHz}$                                                                                                                                                                                                                        |                            | 40           |                          | nV/ $\sqrt{\text{Hz}}$       |
| THD             | Total harmonic distortion                                                 | $V_{out} = 2\text{ V}_{pk-pk}$ , $A_V = -1$ , $f = 1\text{ kHz}$                                                                                                                                                                          |                            | 0.01         |                          | %                            |

1. All parameter limits at temperatures other than  $25^\circ\text{C}$  are guaranteed by correlation.

2. Maximum values include unavoidable inaccuracies of the industrial tests.

Figure 1. Input offset voltage distribution

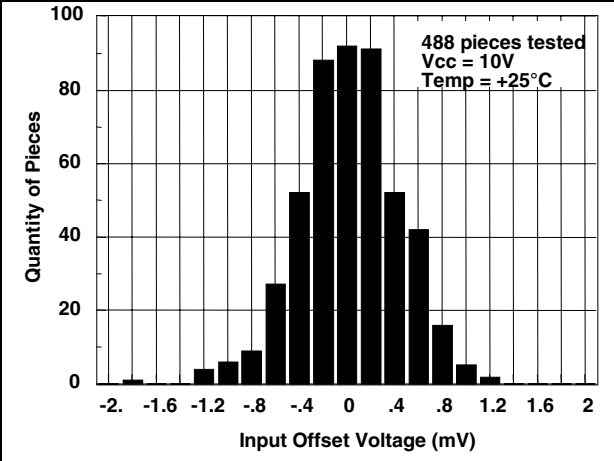


Figure 2. Input offset voltage vs. temperature

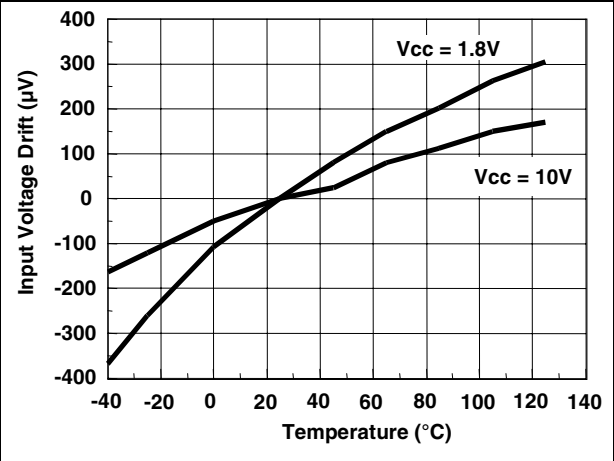


Figure 3. Input bias current vs. temperature at  $V_{CC} = 1.8V$

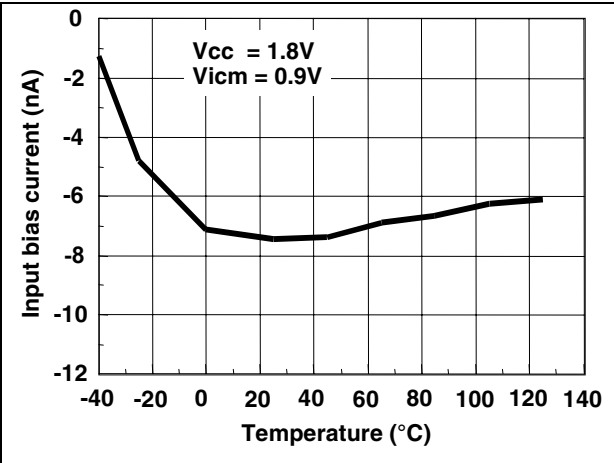


Figure 4. Input bias current vs. temperature at  $V_{CC} = 3V$

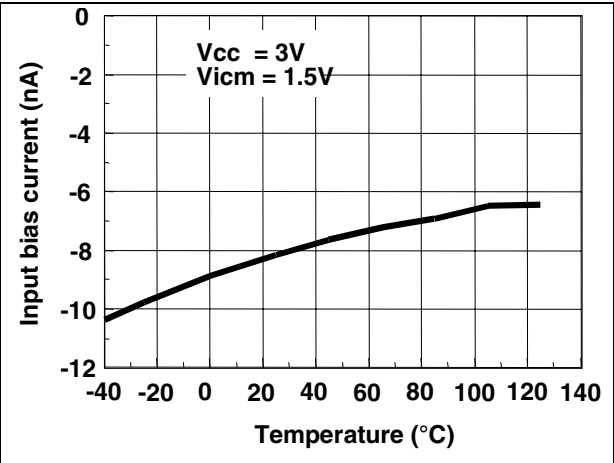


Figure 5. Input bias current vs. temperature at  $V_{CC} = 5V$

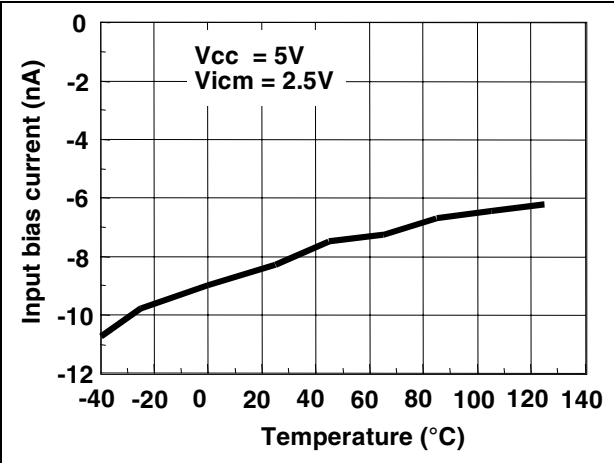


Figure 6. Supply current/amplifier vs. supply voltage

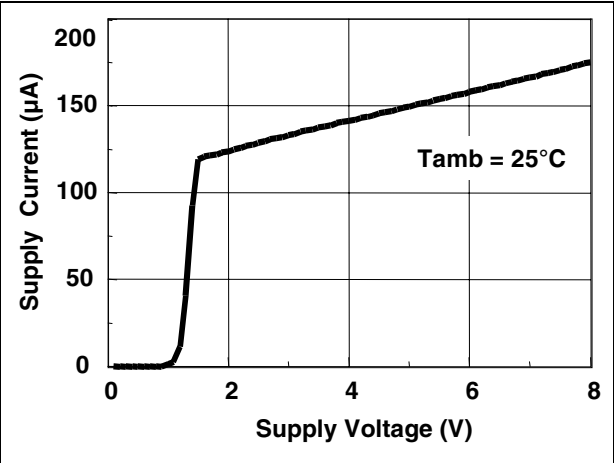


Figure 7. Supply current/amplifier vs. temperature

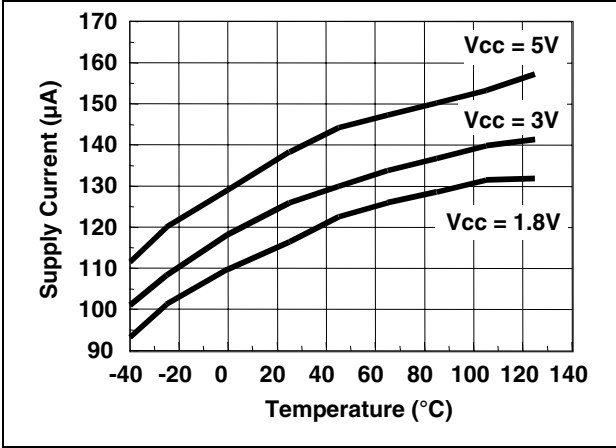


Figure 8. Common mode rejection vs. temperature at Vcc = 1.8 V

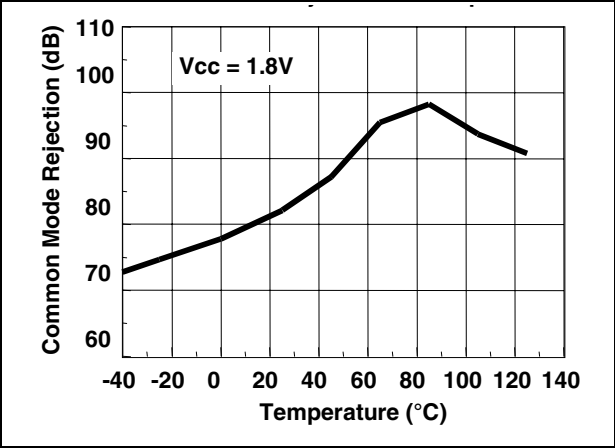


Figure 9. Common mode rejection vs. temperature at Vcc = 3 V

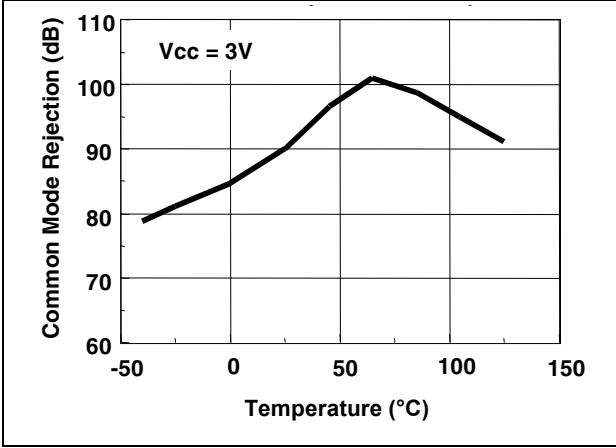


Figure 10. Common mode rejection vs. temperature at Vcc = 5 V

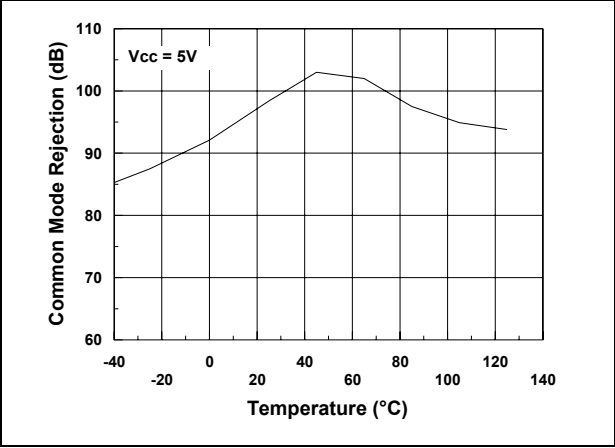


Figure 11. Supply voltage rejection vs. temperature at Vcc = 2 V

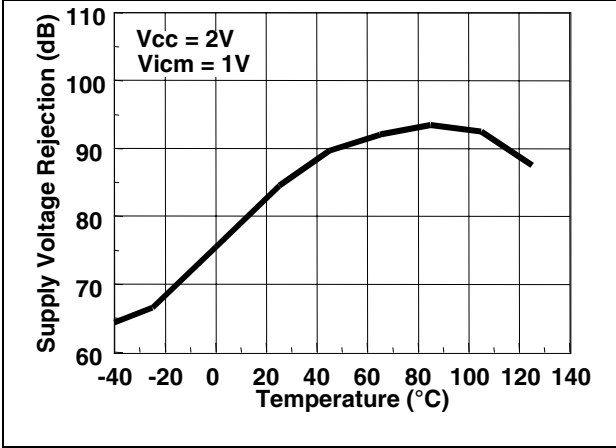


Figure 12. Supply voltage rejection vs. temperature at Vcc = 3 V

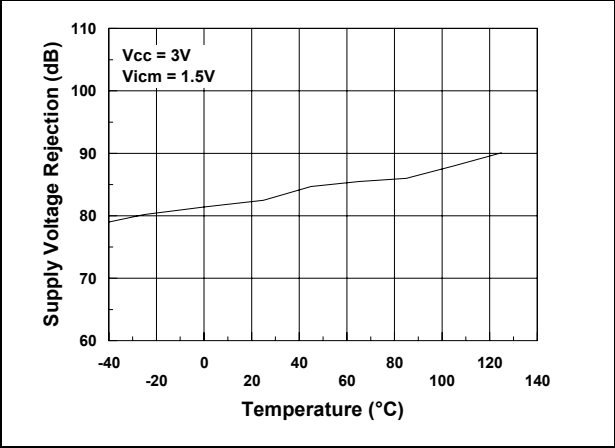


Figure 13. Supply voltage rejection vs. temperature at  $V_{CC} = 5\text{ V}$

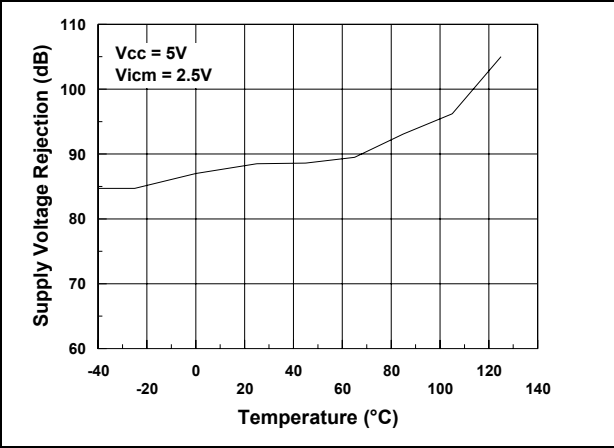


Figure 14. Open loop gain vs. temperature at  $V_{CC} = 1.8\text{ V}$

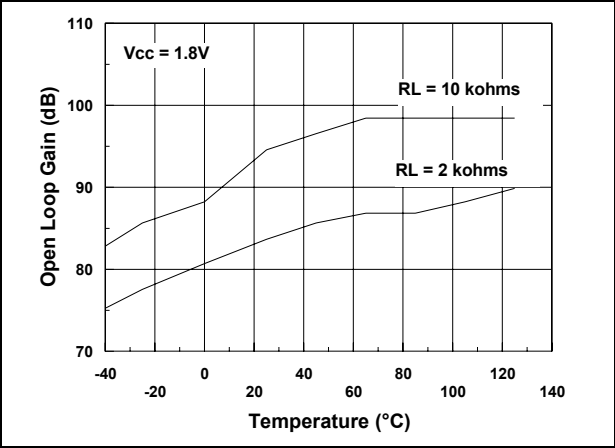


Figure 15. Open loop gain vs. temperature at  $V_{CC} = 3\text{ V}$

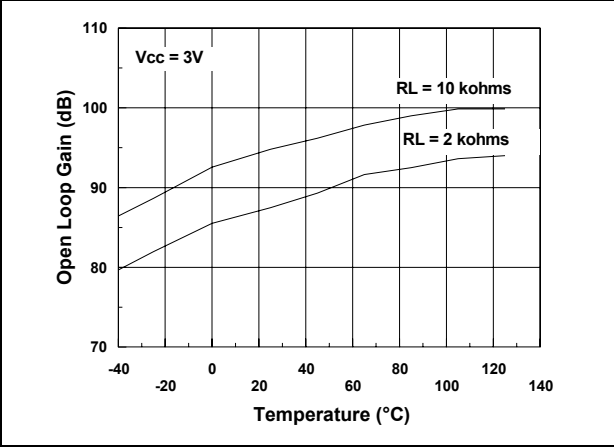


Figure 16. Open loop gain vs. temperature at  $V_{CC} = 5\text{ V}$

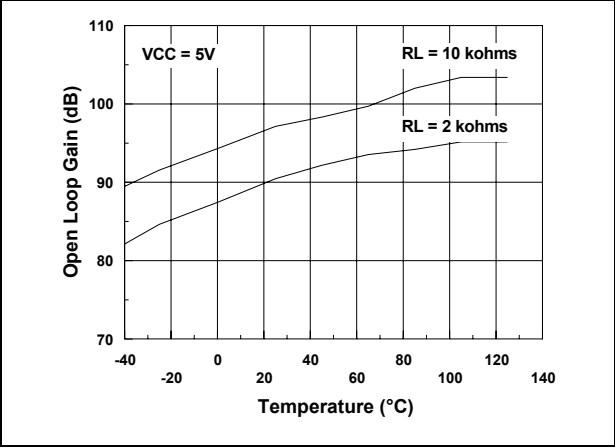


Figure 17. High level output voltage vs. temperature,  $R_L = 10\text{ k}\Omega$

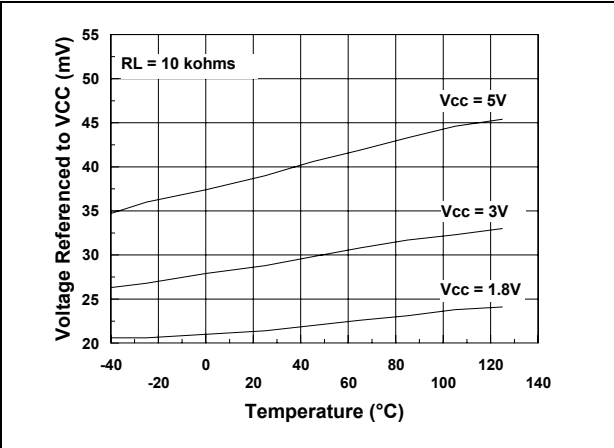


Figure 18. Low level output voltage vs. temperature,  $R_L = 10\text{ k}\Omega$

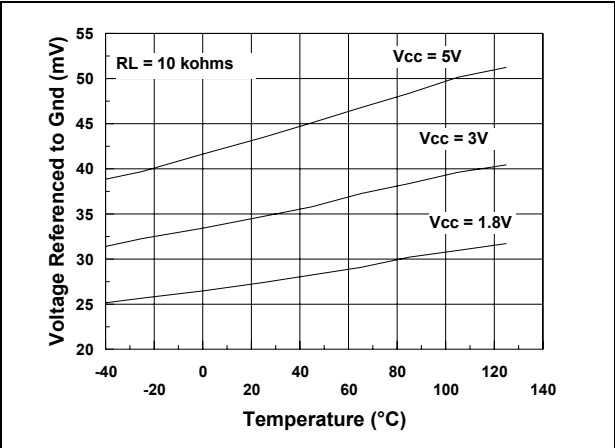


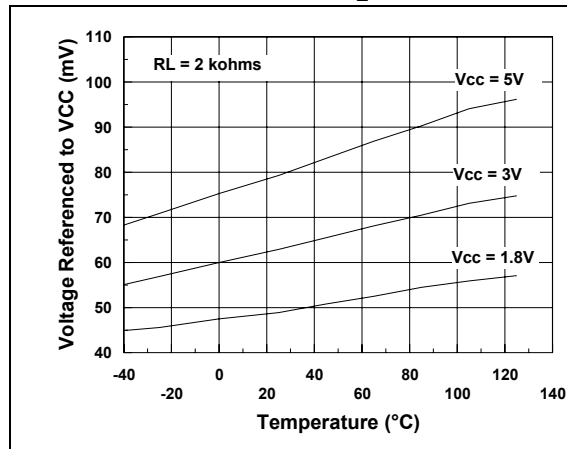
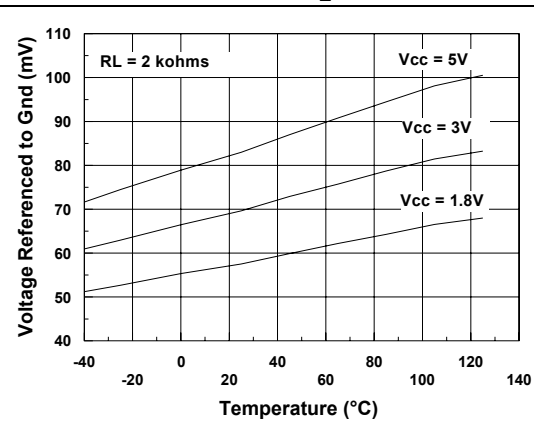
Figure 19. High level output voltage vs. temperature,  $R_L = 2\text{ k}\Omega$ Figure 20. Low level output voltage vs. temperature,  $R_L = 2\text{ k}\Omega$ 

Figure 21. Output current vs. temperature

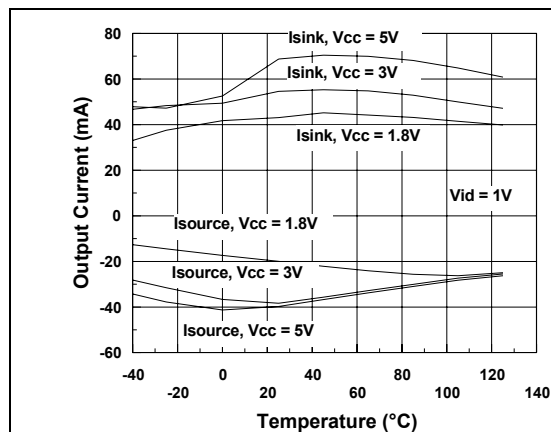
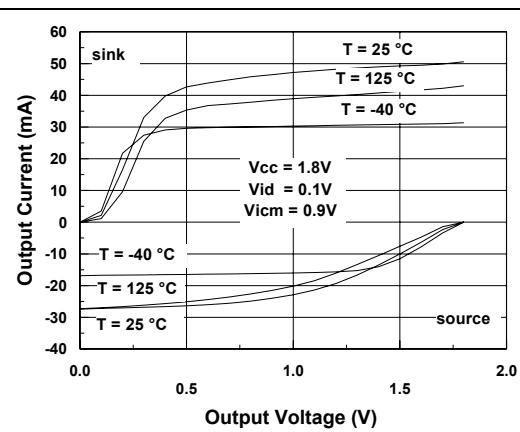
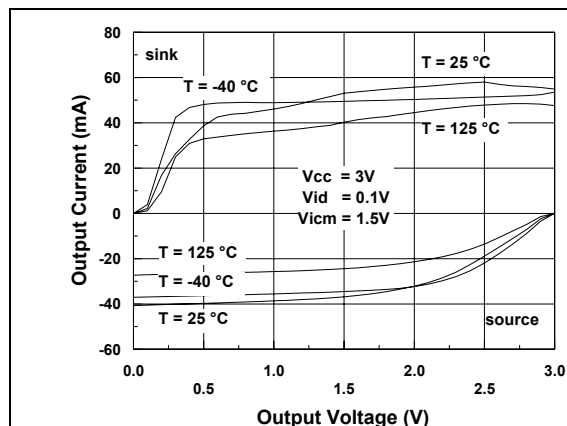
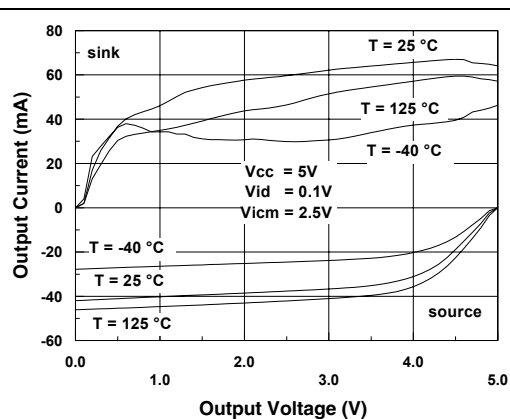
Figure 22. Output current vs. output voltage at  $V_{CC} = 1.8\text{ V}$ Figure 23. Output current vs. output voltage at  $V_{CC} = 3\text{ V}$ Figure 24. Output current vs. output voltage at  $V_{CC} = 5\text{ V}$ 

Figure 25. Gain and phase vs. frequency at  $V_{CC} = 1.8\text{ V}$

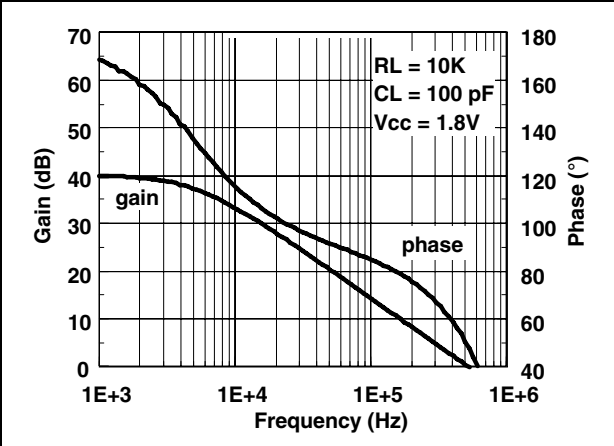


Figure 26. Gain and phase vs. frequency at  $V_{CC} = 5\text{ V}$

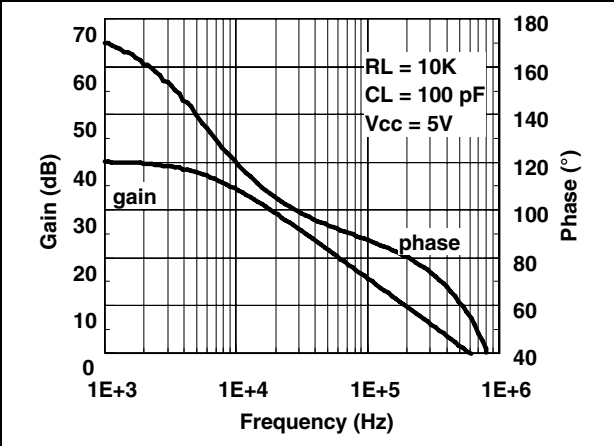


Figure 27. Gain bandwidth product vs. temperature

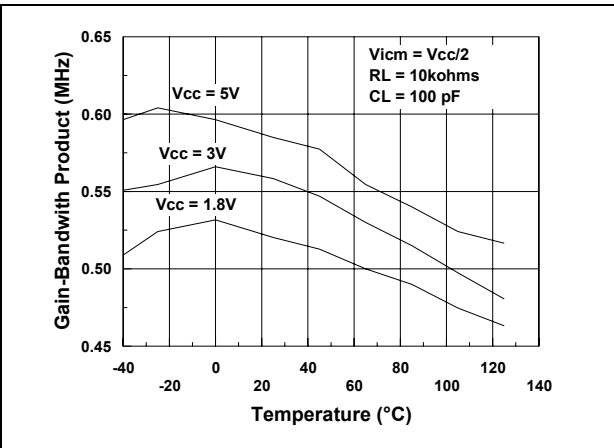


Figure 28. Gain bandwidth product vs. supply voltage

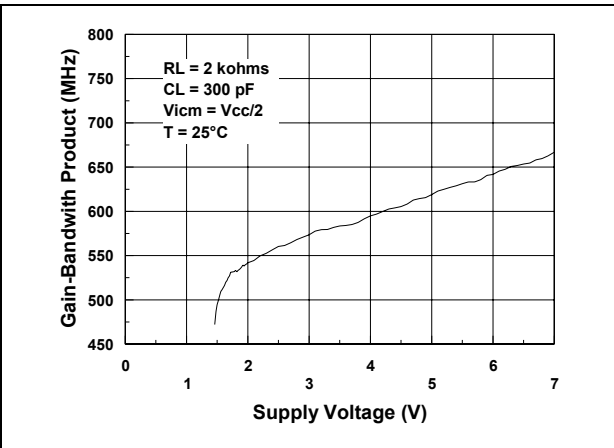


Figure 29. Slew rate vs. temperature at  $V_{CC} = 1.8\text{ V}$

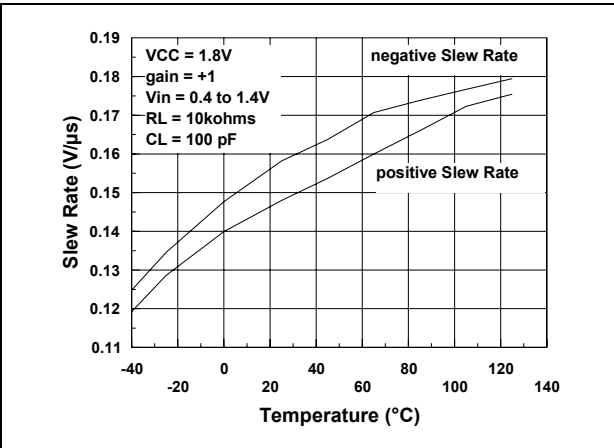


Figure 30. Slew rate vs. temperature at  $V_{CC} = 3\text{ V}$

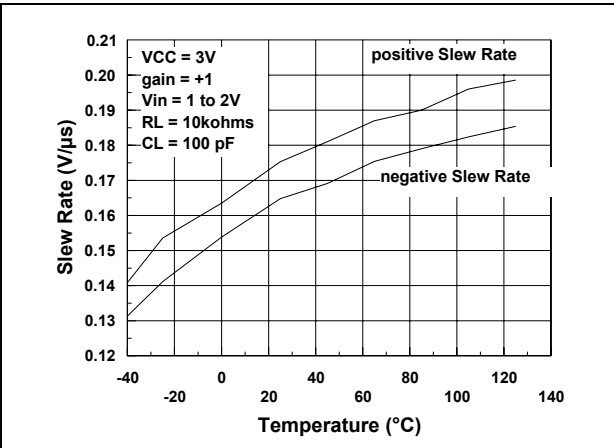


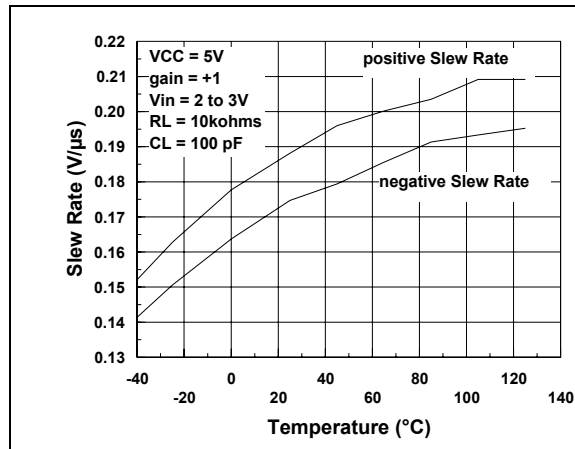
Figure 31. Slew rate vs. temperature at  $V_{CC} = 5\text{ V}$ 

Figure 32. Phase margin vs. load capacitor

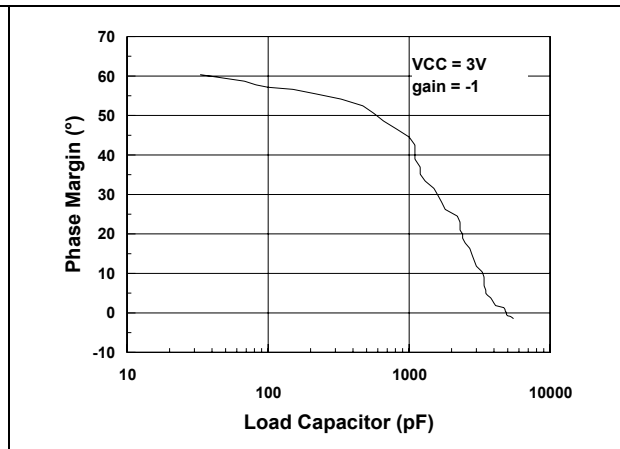


Figure 33. Phase margin vs. output current

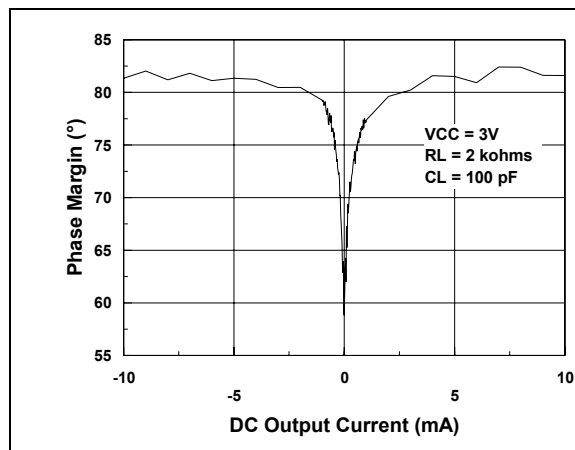


Figure 34. Equivalent input noise vs. frequency

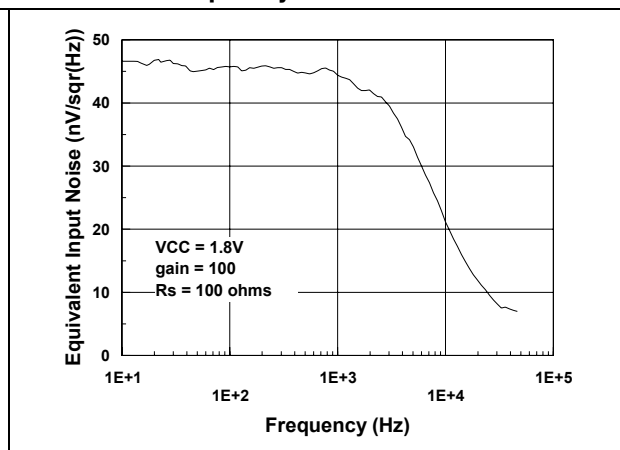
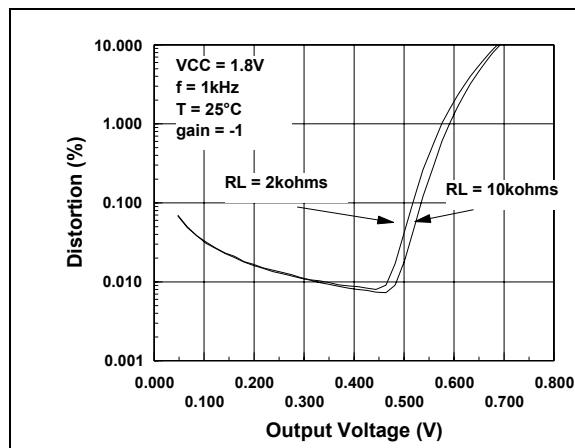
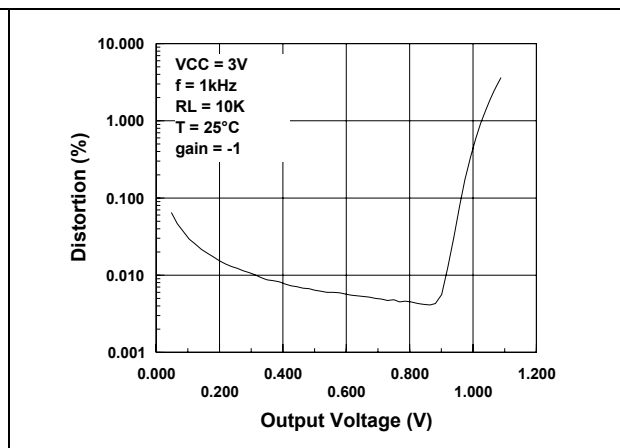
Figure 35. Distortion vs. output voltage at  $V_{CC} = 1.8\text{ V}$ Figure 36. Distortion vs. output voltage at  $V_{CC} = 3\text{ V}$ 

Figure 37. Distortion vs. output voltage at  $V_{CC} = 5\text{ V}$

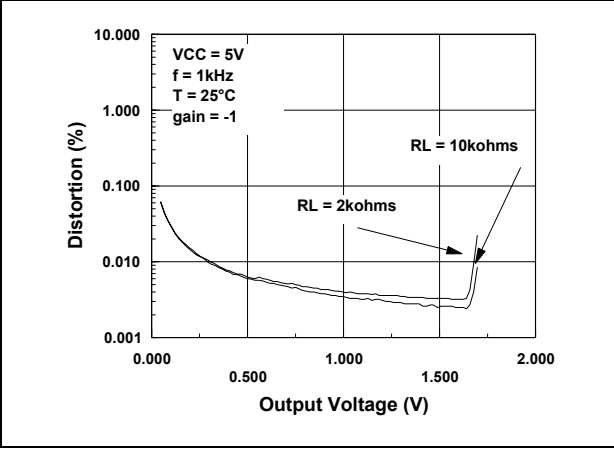
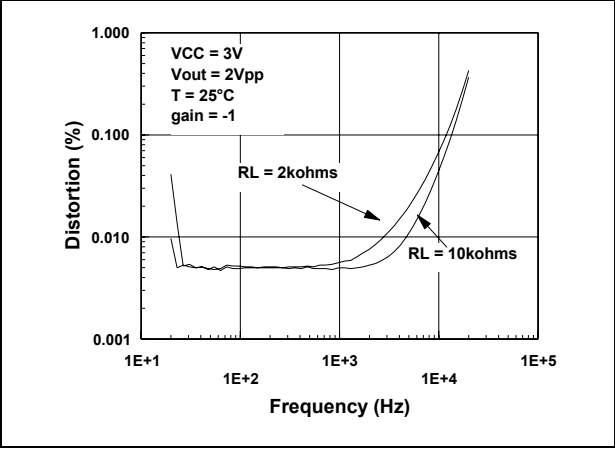


Figure 38. Distortion vs. frequency



### 3 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK<sup>®</sup> is an ST trademark.

### 3.1 SO-8 package information

Figure 39. SO-8 package mechanical drawing

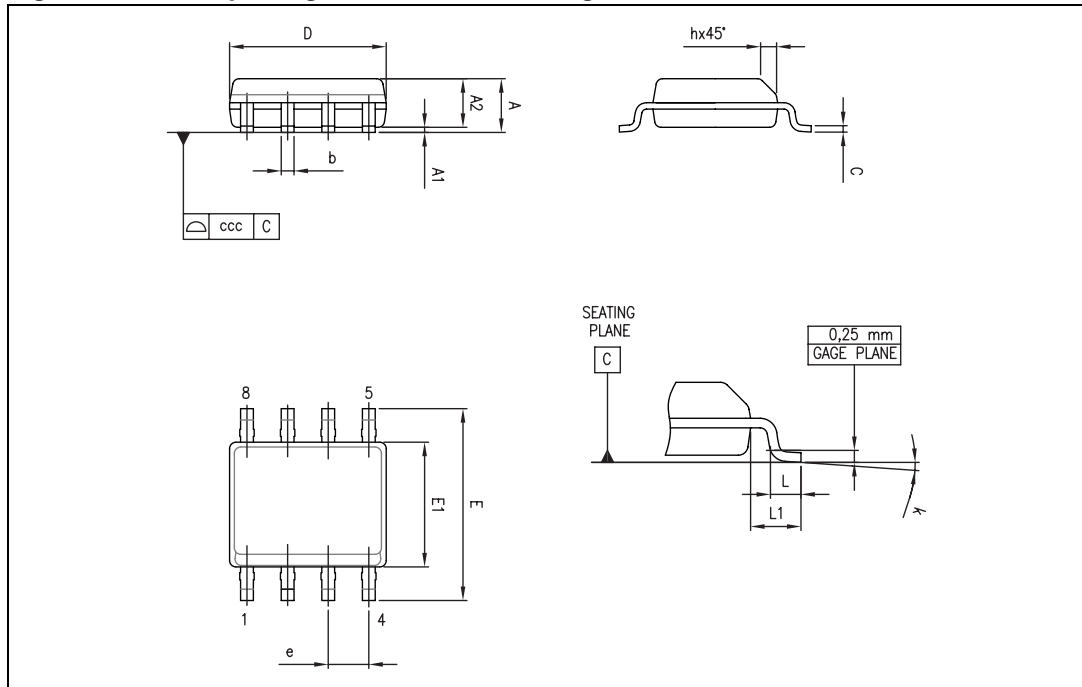


Table 7. SO-8 package mechanical data

| Ref. | 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 |

### 3.2 TSSOP8 package information

Figure 40. TSSOP8 package mechanical drawing

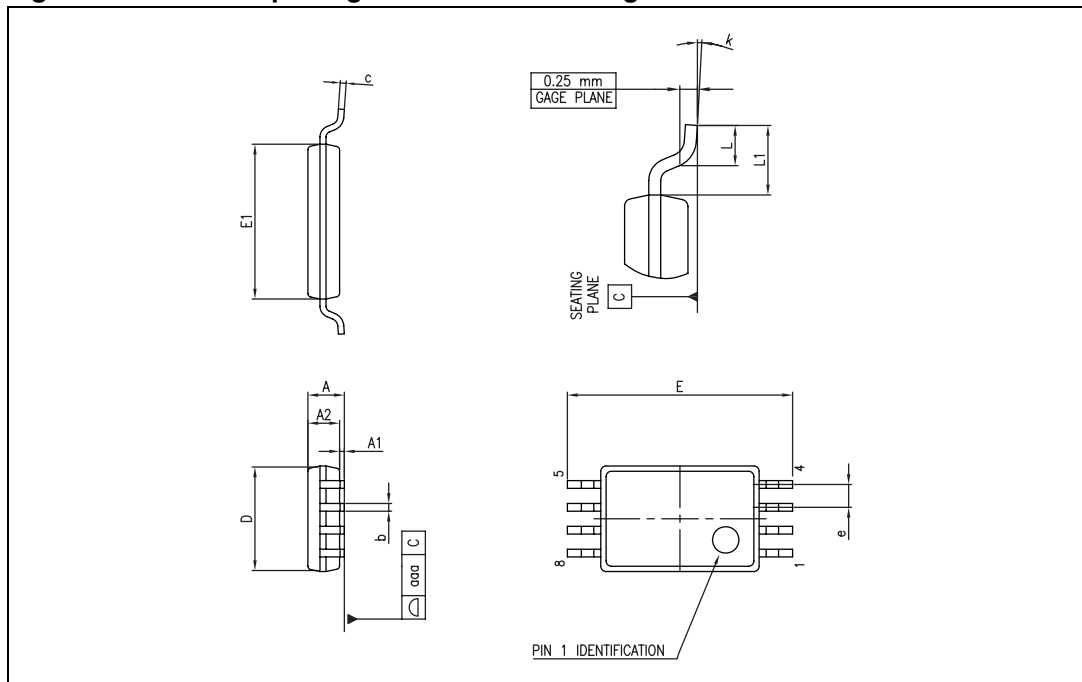


Table 8. TSSOP8 package mechanical data

| Ref. | 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 |

### 3.3 MiniSO-8 package information

Figure 41. MiniSO-8 package mechanical drawing

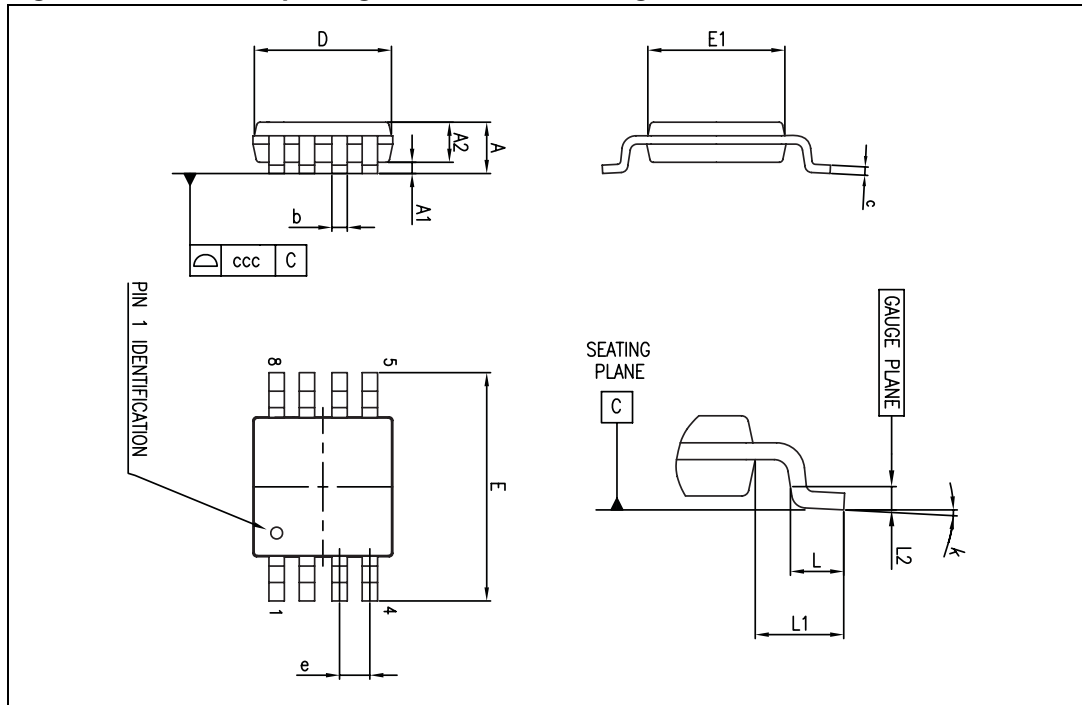


Table 9. MiniSO-8 package mechanical data

| Ref. | Dimensions  |      |      |        |       |       |
|------|-------------|------|------|--------|-------|-------|
|      | Millimeters |      |      | Inches |       |       |
|      | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A    |             |      | 1.1  |        |       | 0.043 |
| A1   | 0           |      | 0.15 | 0      |       | 0.006 |
| A2   | 0.75        | 0.85 | 0.95 | 0.030  | 0.033 | 0.037 |
| b    | 0.22        |      | 0.40 | 0.009  |       | 0.016 |
| c    | 0.08        |      | 0.23 | 0.003  |       | 0.009 |
| D    | 2.80        | 3.00 | 3.20 | 0.11   | 0.118 | 0.126 |
| E    | 4.65        | 4.90 | 5.15 | 0.183  | 0.193 | 0.203 |
| E1   | 2.80        | 3.00 | 3.10 | 0.11   | 0.118 | 0.122 |
| e    |             | 0.65 |      |        | 0.026 |       |
| L    | 0.40        | 0.60 | 0.80 | 0.016  | 0.024 | 0.031 |
| L1   |             | 0.95 |      |        | 0.037 |       |
| L2   |             | 0.25 |      |        | 0.010 |       |
| k    | 0°          |      | 8°   | 0°     |       | 8°    |
| ccc  |             |      | 0.10 |        |       | 0.004 |

### 3.4 SO-14 package information

Figure 42. SO-14 package mechanical drawing

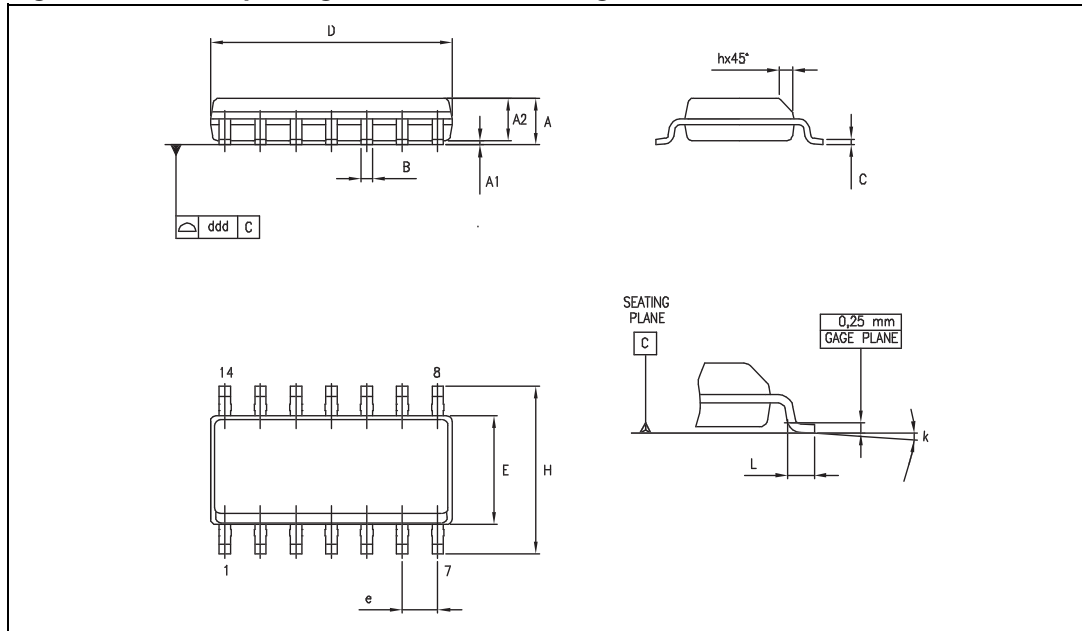


Table 10. SO-14 package mechanical data

| Dimensions |             |      |      |        |      |       |
|------------|-------------|------|------|--------|------|-------|
| Ref.       | Millimeters |      |      | Inches |      |       |
|            | Min.        | Typ. | Max. | Min.   | Typ. | Max.  |
| A          | 1.35        |      | 1.75 | 0.05   |      | 0.068 |
| A1         | 0.10        |      | 0.25 | 0.004  |      | 0.009 |
| A2         | 1.10        |      | 1.65 | 0.04   |      | 0.06  |
| B          | 0.33        |      | 0.51 | 0.01   |      | 0.02  |
| C          | 0.19        |      | 0.25 | 0.007  |      | 0.009 |
| D          | 8.55        |      | 8.75 | 0.33   |      | 0.34  |
| E          | 3.80        |      | 4.0  | 0.15   |      | 0.15  |
| e          |             | 1.27 |      |        | 0.05 |       |
| H          | 5.80        |      | 6.20 | 0.22   |      | 0.24  |
| h          | 0.25        |      | 0.50 | 0.009  |      | 0.02  |
| L          | 0.40        |      | 1.27 | 0.015  |      | 0.05  |
| k          | 8° (max.)   |      |      |        |      |       |
| ddd        |             |      | 0.10 |        |      | 0.004 |

### 3.5 TSSOP14 package information

Figure 43. TSSOP14 package mechanical drawing

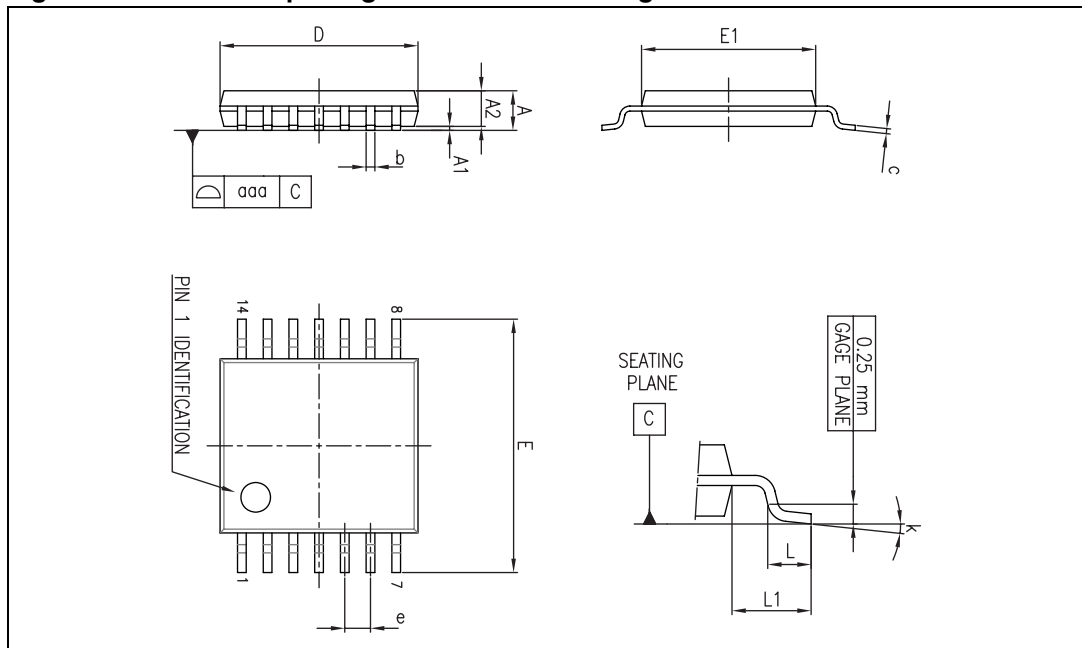


Table 11. TSSOP14 package mechanical data

| Ref. | 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  |

### 3.6 SOT23-5 package information

Figure 44. SOT23-5L package mechanical drawing

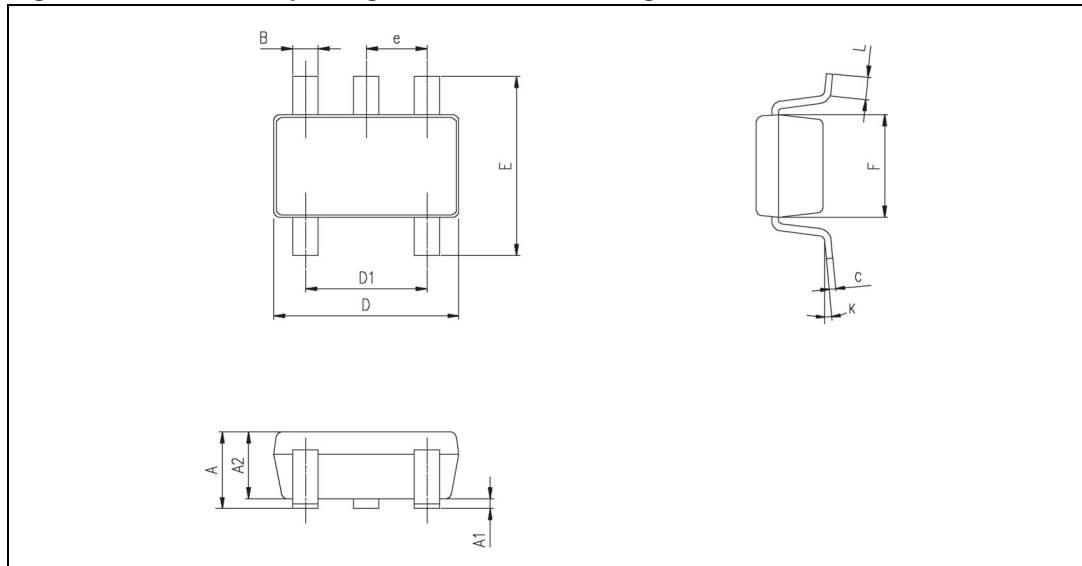


Table 12. SOT23-5L package mechanical data

| Ref. | 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°  |        |       |       |

## 4 Ordering information

Table 13. Order codes

| Order code     | Temperature range | Package                                  | Packing             | Marking |
|----------------|-------------------|------------------------------------------|---------------------|---------|
| TS1851ID/IDT   | -40°C to +125°C   | SO-8                                     | Tube or tape & reel | 1851I   |
| TS1851AID/AIDT |                   |                                          |                     | 1851AI  |
| TS1851ILT      |                   | SOT23-5L                                 | Tape & reel         | K161    |
| TS1851AILT     |                   |                                          |                     | K162    |
| TS1852ID/IDT   |                   | SO-8                                     | Tube or tape & reel | 1852I   |
| TS1852AID/AIDT |                   |                                          |                     | 1852AI  |
| TS1852IPT      |                   | TSSOP8<br>(Thin shrink outline package)  | Tape & reel         | 1852I   |
| TS1852AIPT     |                   |                                          |                     | 1852A   |
| TS1852IST      |                   | MiniSO-8                                 | Tape & reel         | K161    |
| TS1852AIST     |                   |                                          |                     | K162    |
| TS1854ID/IDT   |                   | SO-14                                    | Tube or tape & reel | 1854I   |
| TS1854AID/AIDT |                   |                                          |                     | 1854AI  |
| TS1854IPT      |                   | TSSOP14<br>(Thin shrink outline package) | Tape & reel         | 1854I   |
| TS1854AIPT     |                   |                                          |                     | 1854A   |

## 5 Revision history

**Table 14. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 01-Feb-2002 | 1        | First release.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 01-May-2005 | 2        | Modifications on AMR <a href="#">Table 2 on page 3</a> (explanation of $V_{id}$ and $V_i$ limits)                                                                                                                                                                                                                                                                                                                                                                                             |
| 22-May-2007 | 3        | Added limits in temperature in <a href="#">Table 4</a> , <a href="#">Table 5</a> , and <a href="#">Table 6</a> .<br>Added SVR in <a href="#">Table 6</a> (SVR parameter removed from <a href="#">Table 4</a> and <a href="#">Table 5</a> ).<br>Added equivalent input voltage noise in <a href="#">Table 4</a> , <a href="#">Table 5</a> , and <a href="#">Table 6</a> .<br>Added $R_{thjc}$ values in <a href="#">Table 2 on page 3</a> .<br>Updated <a href="#">Table 13: Order codes</a> . |
| 12-Mar-2010 | 4        | Updated document format.<br>Modified headings, added root part number TS185xA and added <a href="#">Table 1: Device summary</a> on cover page.<br>Modified Iout parameters in temperature, added limits at Tamb and improved typical values of $A_{vd}$ in <a href="#">Table 4</a> , <a href="#">Table 5</a> and <a href="#">Table 6</a> .<br>Updated package information in <a href="#">Chapter 3</a> .<br>Removed order codes for DIP package from <a href="#">Table 13</a> .               |

**Please Read Carefully:**

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST's terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

**UNLESS OTHERWISE SET FORTH IN ST'S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.**

**UNLESS EXPRESSLY APPROVED IN WRITING BY AN AUTHORIZED ST REPRESENTATIVE, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCTS OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS "AUTOMOTIVE GRADE" MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER'S OWN RISK.**

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

© 2010 STMicroelectronics - All rights reserved

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

[www.st.com](http://www.st.com)

# AMEYA360

## Components Supply Platform

Authorized Distribution Brand :



Website :

Welcome to visit [www.ameya360.com](http://www.ameya360.com)

Contact Us :

➤ Address :

401 Building No.5, JiuGe Business Center, Lane 2301, Yishan Rd  
Minhang District, Shanghai , China

➤ Sales :

Direct +86 (21) 6401-6692

Email [amall@ameya360.com](mailto:amall@ameya360.com)

QQ 800077892

Skype ameyasales1 ameyasales2

➤ Customer Service :

Email [service@ameya360.com](mailto:service@ameya360.com)

➤ Partnership :

Tel +86 (21) 64016692-8333

Email [mkt@ameya360.com](mailto:mkt@ameya360.com)