



# TSV321-TSV358-TSV324

General purpose input/output rail-to-rail  
low power operational amplifiers

## Features

- Operating range  $V_{CC} = 2.5\text{ V to }6\text{ V}$
- Rail-to-rail input and output
- Extended  $V_{icm}$  ( $V_{DD} - 0.2\text{ V to }V_{CC} + 0.2\text{ V}$ )
- Capable of driving a  $32\ \Omega$  load resistor
- High stability:  $500\text{ pF}$
- Available in SOT23-5 micropackage
- Operating temperature range:  $-40^\circ\text{ C, }+125^\circ\text{ C}$

## Applications

- Battery-powered applications
- Audio driver (headphone driver)
- Sensor signal conditioning
- Laptop/notebook computers

## Description

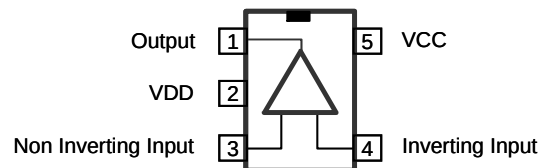
The TSV358 and TSV324 (dual and quad) are low voltage versions of the LM358 and LM324 commodity operational amplifiers. The TSV321 is the single version. The TSV321/358/324 are able to operate with voltages as low as  $2.5\text{ V}$  and feature both I/O rail-to-rail.

The common mode input voltage extends  $200\text{ mV}$  beyond the supply voltages at  $25^\circ\text{ C}$  while the output voltage swing is within  $100\text{ mV}$  of each rail with a  $600\ \Omega$  load resistor. At  $V_{CC} = 3\text{ V}$ , these devices offer  $1.3\text{ MHz}$  of gain-bandwidth product and provide high output current capability with a typical value of  $80\text{ mA}$ .

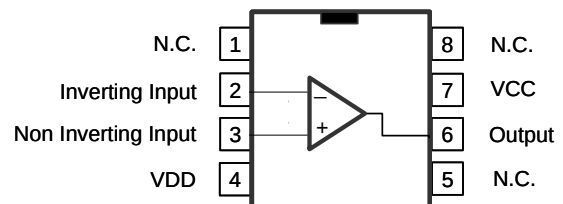
These features make the TSV3xx family ideal for active filters, general purpose low-voltage applications, and general purpose portable devices.

### Pin connections (top view)

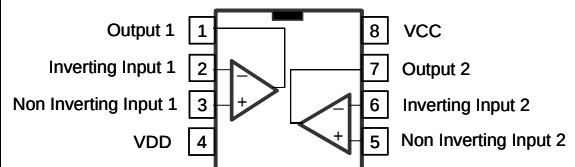
#### TSV321RILT (SOT23-5)



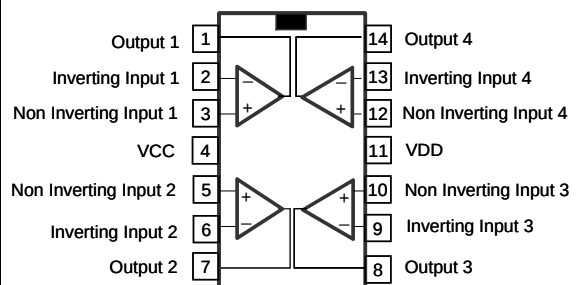
#### TSV321ID-TSV321IDT (SO-8)



#### TSV358IST-TSV358ID-TSV358IDT-TSV358IPT (SO-8, miniSO-8, TSSOP8)



#### TSV324ID-TSV324IDT-TSV324IPT (SO-14, TSSOP14)



# 1 Absolute maximum ratings and operating conditions

**Table 1. 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    |
| $V_{in}$   | Input voltage                                         | $V_{DD}-0.3$ to $V_{CC}+0.3$ | V    |
| $T_{stg}$  | 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                          |      |
|            | SO-8                                                  | 125                          |      |
|            | SO-14                                                 | 105                          |      |
|            | TSSOP8                                                | 120                          |      |
|            | TSSOP14                                               | 100                          |      |
|            | MiniSO-8                                              | 190                          |      |
| $R_{thjc}$ | Thermal resistance junction to case <sup>(3)</sup>    |                              | °C/W |
|            | SOT23-5                                               | 81                           |      |
|            | SO-8                                                  | 40                           |      |
|            | SO-14                                                 | 31                           |      |
|            | TSSOP8                                                | 37                           |      |
|            | TSSOP14                                               | 32                           |      |
|            | MiniSO-8                                              | 39                           |      |
| 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   |
|            | Latch-up immunity                                     | 200                          | mA   |
|            | Lead temperature (soldering, 10s)                     | 250                          | °C   |
|            | Output short-circuit duration                         | See note <sup>(7)</sup>      |      |

1. All voltages values, except differential voltage 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, an input series resistor must be added to limit input current.
3. Short-circuits can cause excessive heating and destructive dissipation.  $R_{th}$  are typical values.
4. Human body model: 100 pF discharged through a 1.5 k $\Omega$  resistor between two pins of the device, done for all couples of pin combinations with other pins 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  $< 5 \Omega$ ), done for all couples of pin combinations with other pins floating.
6. Charged device model: all pins plus package are charged together to the specified voltage and then discharged directly to the ground.
7. Short-circuits from the output to  $V_{CC}$  can cause excessive heating. The maximum output current is approximately 80 mA, independent of the magnitude of  $V_{CC}$ . Destructive dissipation can result from simultaneous short-circuits on all amplifiers.

**Table 2. Operating conditions**

| Symbol     | Parameter                                                                                                                                                                  | Value                                                    | Unit               |
|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|--------------------|
| $V_{CC}$   | Supply voltage                                                                                                                                                             | 2.5 to 6                                                 | V                  |
| $V_{icm}$  | Common mode input voltage range<br>$T_{amb} = 25^{\circ}\text{C}$ , $2.5 \leq V_{CC} \leq 6\text{V}$<br>$T_{min} < T_{amb} < T_{max}$ , $2.5 \leq V_{CC} \leq 5.5\text{V}$ | $V_{DD} - 0.2$ to $V_{CC} + 0.2$<br>$V_{DD}$ to $V_{CC}$ | V                  |
| $T_{oper}$ | Operating free air temperature range                                                                                                                                       | -40 to + 125                                             | $^{\circ}\text{C}$ |

## 2 Electrical characteristics

**Table 3. Electrical characteristics at  $V_{CC} = +3V$ ,  $V_{DD} = 0V$ ,  $R_L$ ,  $C_L$  connected to  $V_{CC}/2$ , and  $T_{amb} = 25^\circ C$  (unless otherwise specified)**

| Symbol          | Parameter                                                              | Test conditions                                                                                                                                                                 | Min.                         | Typ.         | Max.                     | Unit             |
|-----------------|------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|--------------|--------------------------|------------------|
| $V_{io}$        | Input offset voltage                                                   | $V_{icm} = V_{out} = V_{CC}/2$<br>TSV321/358/324<br>$T_{min} \leq T_{amb} \leq T_{max}$<br>TSV321A/358A/324A<br>$T_{min} \leq T_{amb} \leq T_{max}$                             |                              | 0.2<br>0.1   | 3<br>6<br>1<br>3         | mV               |
| $\Delta V_{io}$ | Input offset voltage drift                                             |                                                                                                                                                                                 |                              | 2            |                          | $\mu V/^\circ C$ |
| $I_{io}$        | Input offset current                                                   | $V_{icm} = V_{out} = V_{CC}/2$ <sup>(1)</sup><br>$T_{min} \leq T_{amb} \leq T_{max}$                                                                                            |                              | 3            | 30<br>60                 | nA               |
| $I_{ib}$        | Input bias current                                                     | $V_{icm} = V_{out} = V_{CC}/2$ <sup>(1)</sup><br>$T_{min} \leq T_{amb} \leq T_{max}$                                                                                            |                              | 40           | 125<br>150               | nA               |
| CMR             | Common mode rejection ratio<br>$20 \log (\Delta V_{ic}/\Delta V_{io})$ | $0 \leq V_{icm} \leq V_{CC}$ , $V_{out} = V_{CC}/2$                                                                                                                             | 60                           | 80           |                          | dB               |
| $A_{vd}$        | Large signal voltage gain                                              | $V_{out} = 0.5V$ to $2.5V$<br>$R_L = 2k\Omega$<br>$R_L = 600\Omega$                                                                                                             | 80<br>74                     | 92<br>95     |                          | dB               |
| $V_{OH}$        | High level output voltage                                              | $V_{id} = 100mV$<br>$R_L = 2k\Omega$<br>$R_L = 600\Omega$<br>$T_{min} \leq T_{amb} \leq T_{max}$ , $R_L = 2k\Omega$<br>$T_{min} \leq T_{amb} \leq T_{max}$ , $R_L = 600\Omega$  | 2.82<br>2.80<br>2.82<br>2.80 | 2.95<br>2.95 |                          | V                |
| $V_{OL}$        | Low level output voltage                                               | $V_{id} = -100mV$<br>$R_L = 2k\Omega$<br>$R_L = 600\Omega$<br>$T_{min} \leq T_{amb} \leq T_{max}$ , $R_L = 2k\Omega$<br>$T_{min} \leq T_{amb} \leq T_{max}$ , $R_L = 600\Omega$ |                              | 88<br>115    | 120<br>160<br>120<br>160 | mV               |
| $I_o$           | Output source current                                                  | $V_{id} = 100mV$ , $V_O = V_{DD}$                                                                                                                                               | 20                           | 80           |                          | mA               |
|                 | Output sink current                                                    | $V_{id} = -100mV$ , $V_O = V_{CC}$                                                                                                                                              | 20                           | 80           |                          |                  |
| $I_{CC}$        | Supply current (per amplifier)                                         | $A_{VCL} = 1$ , no load<br>$T_{min} \leq T_{amb} \leq T_{max}$                                                                                                                  |                              | 420          | 650<br>690               | $\mu A$          |
| GBP             | Gain bandwidth product                                                 | $R_L = 10k\Omega$ , $C_L = 100pF$ , $f = 100kHz$                                                                                                                                | 1                            | 1.3          |                          | MHz              |
| SR              | Slew rate                                                              | $R_L = 10k\Omega$ , $C_L = 100pF$                                                                                                                                               | 0.42                         | 0.6          |                          | V/ $\mu s$       |
| $\phi_m$        | Phase margin                                                           | $C_L = 100pF$                                                                                                                                                                   |                              | 53           |                          | Degrees          |
| $e_n$           | Input voltage noise                                                    |                                                                                                                                                                                 |                              | 27           |                          | nV/ $\sqrt{Hz}$  |
| THD             | Total harmonic distortion                                              |                                                                                                                                                                                 |                              | 0.01         |                          | %                |

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

**Table 4. Electrical characteristics at  $V_{CC} = +5V$ ,  $V_{DD} = 0V$ ,  $R_L$ ,  $C_L$  connected to  $V_{CC}/2$ , and  $T_{amb} = 25^\circ C$  (unless otherwise specified)**

| Symbol          | Parameter                                                                 | Conditions                                                                                                                                                                      | Min.                         | Typ.         | Max.                     | Unit             |
|-----------------|---------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|--------------|--------------------------|------------------|
| $V_{io}$        | Input offset voltage                                                      | $V_{icm} = V_{out} = V_{CC}/2$<br>TSV321/358/324<br>$T_{min} \leq T_{amb} \leq T_{max}$<br>TSV321A/358A/324A<br>$T_{min} \leq T_{amb} \leq T_{max}$                             |                              | 0.2<br>0.1   | 3<br>6<br>1<br>3         | mV               |
| $\Delta V_{io}$ | Input offset voltage drift                                                |                                                                                                                                                                                 |                              | 2            |                          | $\mu V/^\circ C$ |
| $I_{io}$        | Input offset current                                                      | $V_{icm} = V_{out} = V_{CC}/2$ <sup>(1)</sup><br>$T_{min} \leq T_{amb} \leq T_{max}$                                                                                            |                              | 3            | 30<br>60                 | nA               |
| $I_{ib}$        | Input bias current                                                        | $V_{icm} = V_{out} = V_{CC}/2$ <sup>(1)</sup><br>$T_{min} \leq T_{amb} \leq T_{max}$                                                                                            |                              | 70           | 130<br>150               | nA               |
| CMR             | Common mode rejection ratio<br>$20 \log (\Delta V_{ic}/\Delta V_{io})$    | $0 \leq V_{icm} \leq V_{CC}$ , $V_{out} = V_{CC}/2$                                                                                                                             | 65                           | 85           |                          | dB               |
| SVR             | Supply voltage rejection ratio<br>$20 \log (\Delta V_{CC}/\Delta V_{io})$ | $V_{CC} = 2.5$ to $5V$                                                                                                                                                          | 70                           | 90           |                          | dB               |
| $A_{vd}$        | Large signal voltage gain                                                 | $V_{out} = 0.5V$ to $4.5V$<br>$R_L = 2k\Omega$<br>$R_L = 600\Omega$                                                                                                             | 83<br>77                     | 92<br>85     |                          | dB               |
| $V_{OH}$        | High level output voltage                                                 | $V_{id} = 100mV$<br>$R_L = 2k\Omega$<br>$R_L = 600\Omega$<br>$T_{min} \leq T_{amb} \leq T_{max}$ , $R_L = 2k\Omega$<br>$T_{min} \leq T_{amb} \leq T_{max}$ , $R_L = 600\Omega$  | 4.80<br>4.75<br>4.80<br>4.75 | 4.95<br>4.90 |                          | V                |
| $V_{OL}$        | Low level output voltage                                                  | $V_{id} = -100mV$<br>$R_L = 2k\Omega$<br>$R_L = 600\Omega$<br>$T_{min} \leq T_{amb} \leq T_{max}$ , $R_L = 2k\Omega$<br>$T_{min} \leq T_{amb} \leq T_{max}$ , $R_L = 600\Omega$ |                              | 88<br>115    | 130<br>188<br>130<br>188 | mV               |
| $I_o$           | Output source current                                                     | $V_{id} = 100mV$ , $V_O = V_{DD}$                                                                                                                                               | 20                           | 80           |                          | mA               |
|                 | Output sink current                                                       | $V_{id} = -100mV$ , $V_O = V_{CC}$                                                                                                                                              | 20                           | 80           |                          |                  |
| $I_{CC}$        | Supply current (per amplifier)                                            | $A_{VCL} = 1$ , no load<br>$T_{min} \leq T_{amb} \leq T_{max}$                                                                                                                  |                              | 500          | 835<br>875               | $\mu A$          |
| GBP             | Gain bandwidth product                                                    | $R_L = 10k\Omega$ , $C_L = 100pF$ , $f = 100kHz$                                                                                                                                | 1                            | 1.4          |                          | MHz              |
| SR              | Slew rate                                                                 | $R_L = 10k\Omega$ , $C_L = 100pF$                                                                                                                                               | 0.42                         | 0.6          |                          | V/ $\mu s$       |
| $\phi_m$        | Phase margin                                                              | $C_L = 100pF$                                                                                                                                                                   |                              | 55           |                          | Degrees          |
| $e_n$           | Input voltage noise                                                       |                                                                                                                                                                                 |                              | 27           |                          | nV/ $\sqrt{Hz}$  |
| THD             | Total harmonic distortion                                                 |                                                                                                                                                                                 |                              | 0.01         |                          | %                |

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

Figure 1. Supply current/amplifier vs. supply voltage

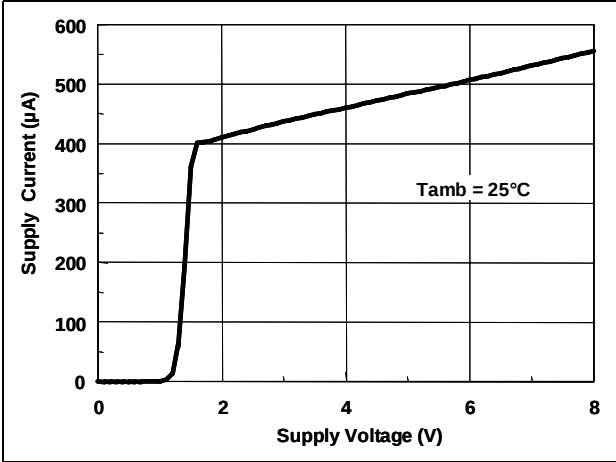


Figure 2. Supply current/amplifier vs. temperature

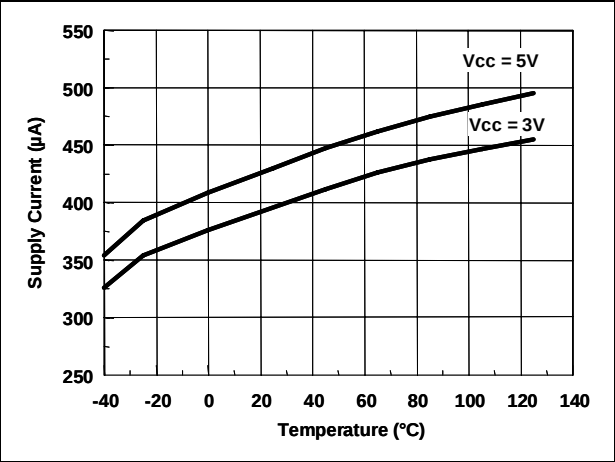


Figure 3. Output power vs. supply voltage

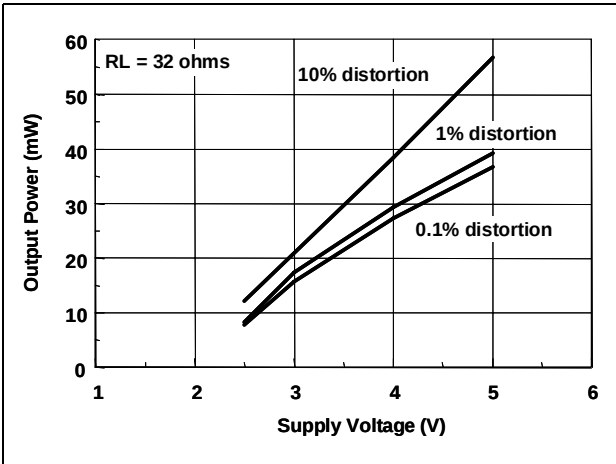


Figure 4. Input offset voltage drift vs. temperature

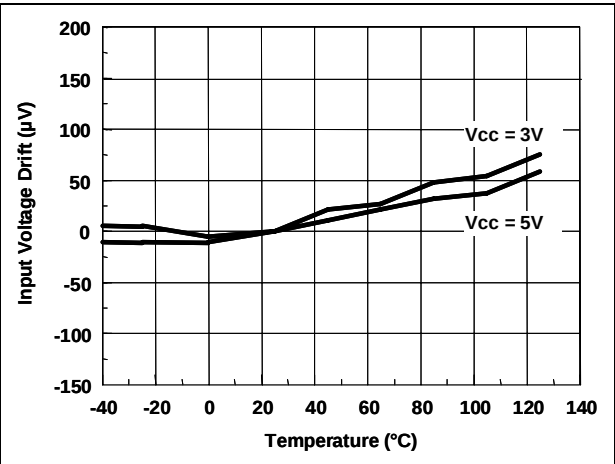


Figure 5. Input bias current vs. temperature

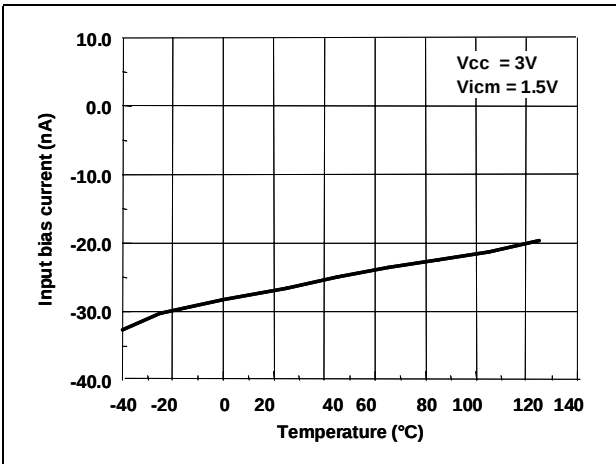


Figure 6. Open loop gain vs. temperature at VCC = 5 V

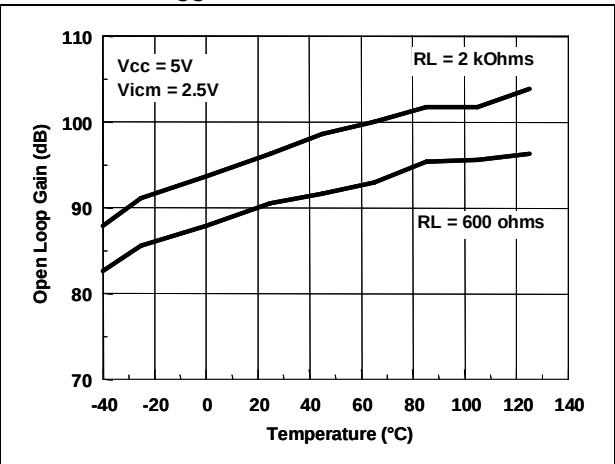


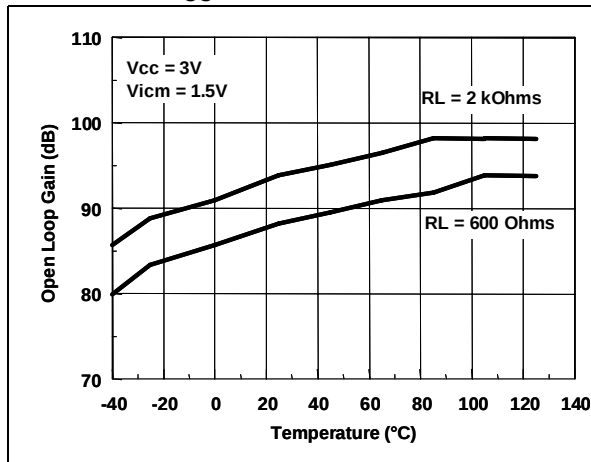
Figure 7. Open loop gain vs. temperature at  $V_{CC} = 3\text{ V}$ 

Figure 8. High level output voltage vs. temperature

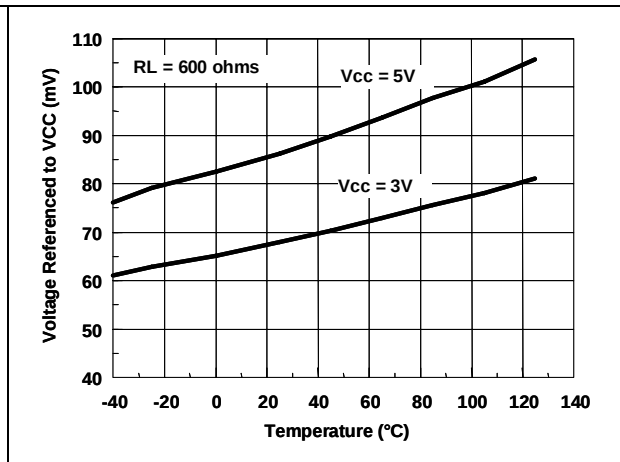


Figure 9. Low level output voltage vs. temperature

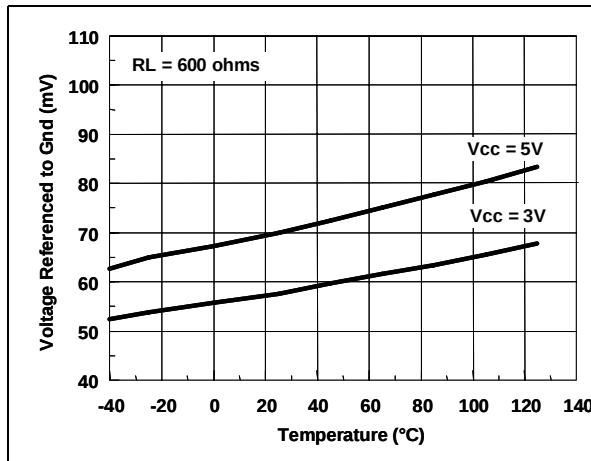
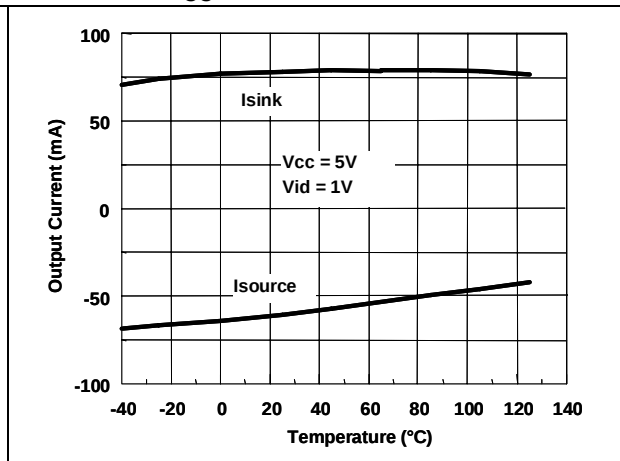
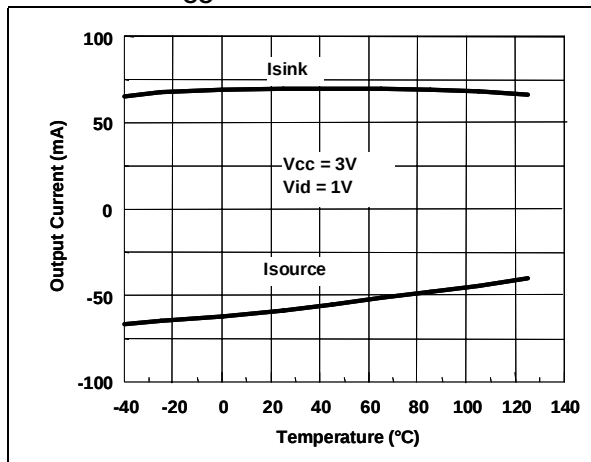
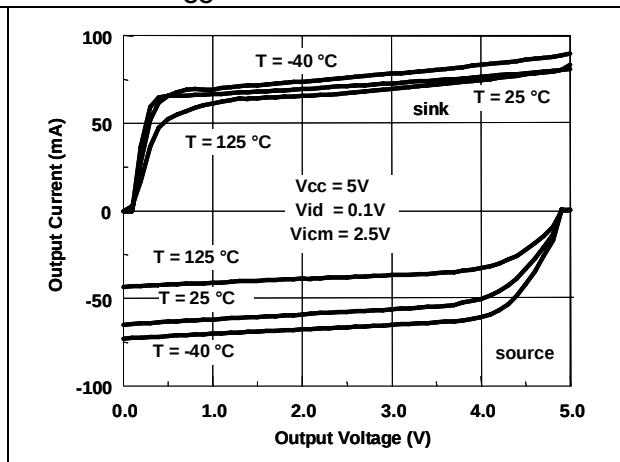
Figure 10. Output current vs. temperature at  $V_{CC} = 5\text{ V}$ Figure 11. Output current vs. temperature at  $V_{CC} = 3\text{ V}$ Figure 12. Output current vs. output voltage at  $V_{CC} = 5\text{ V}$ 

Figure 13. Output current vs. output voltage at  $V_{CC} = 3\text{ V}$

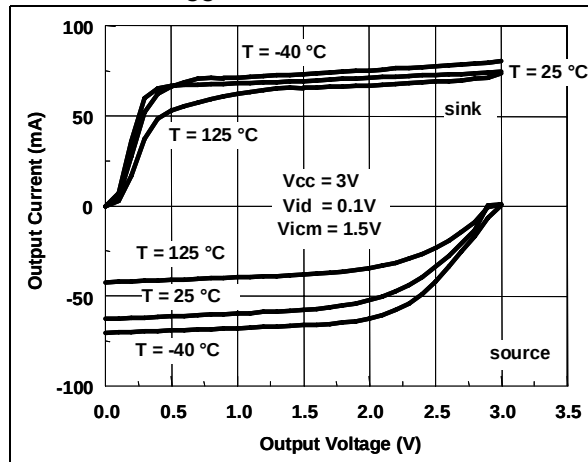


Figure 14. Gain and phase vs. frequency at  $V_{CC} = 5\text{ V}$

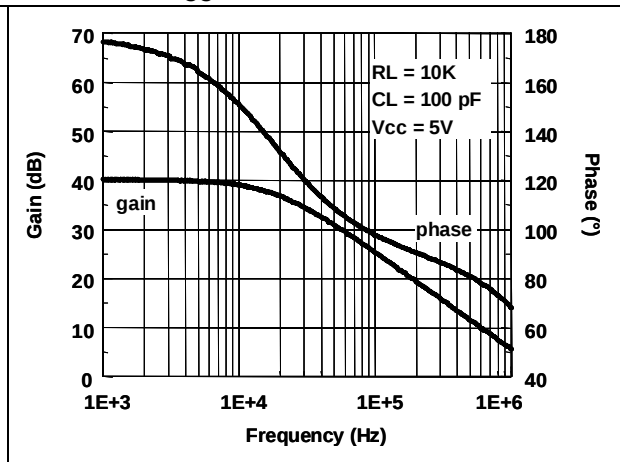


Figure 15. Gain and phase vs. frequency at  $V_{CC} = 3\text{ V}$

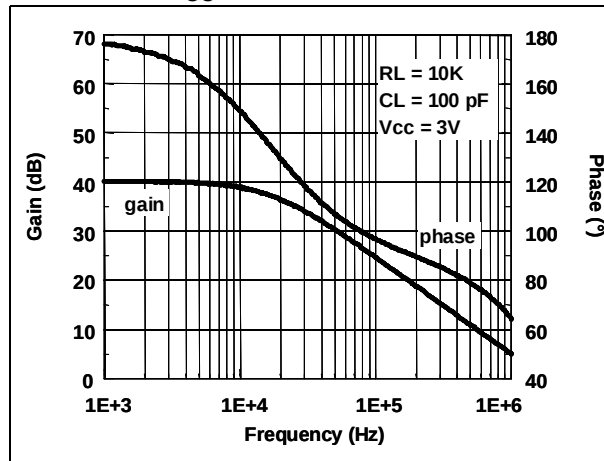


Figure 16. Slew rate vs. temperature at  $V_{CC} = 5\text{ V}$

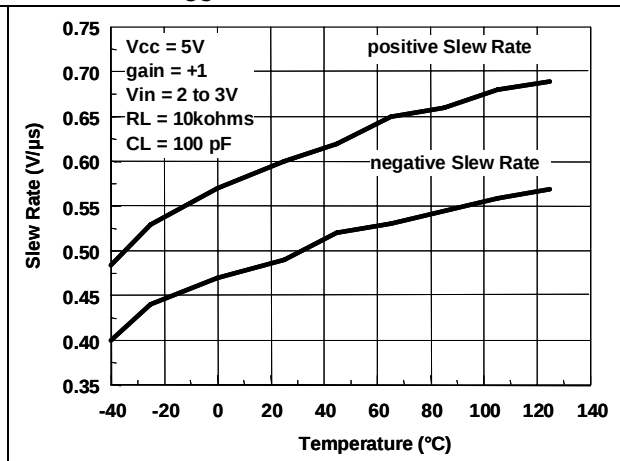


Figure 17. Slew rate vs. temperature at  $V_{CC} = 3\text{ V}$

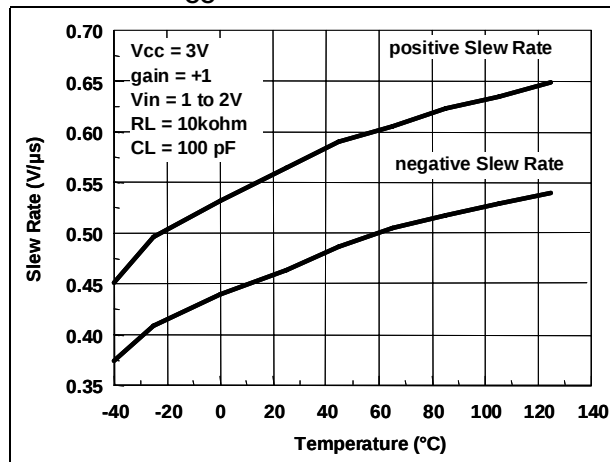
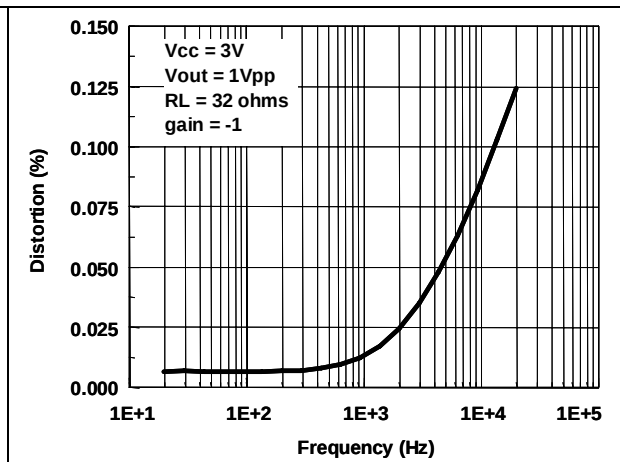


Figure 18. Distortion vs. frequency



### 3 Package information

In order to meet environmental requirements, STMicroelectronics offers these devices in ECOPACK® packages. These packages have a lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an STMicroelectronics trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com).

#### 3.1 SOT23-5 package information

Figure 19. SOT23-5 package mechanical drawing

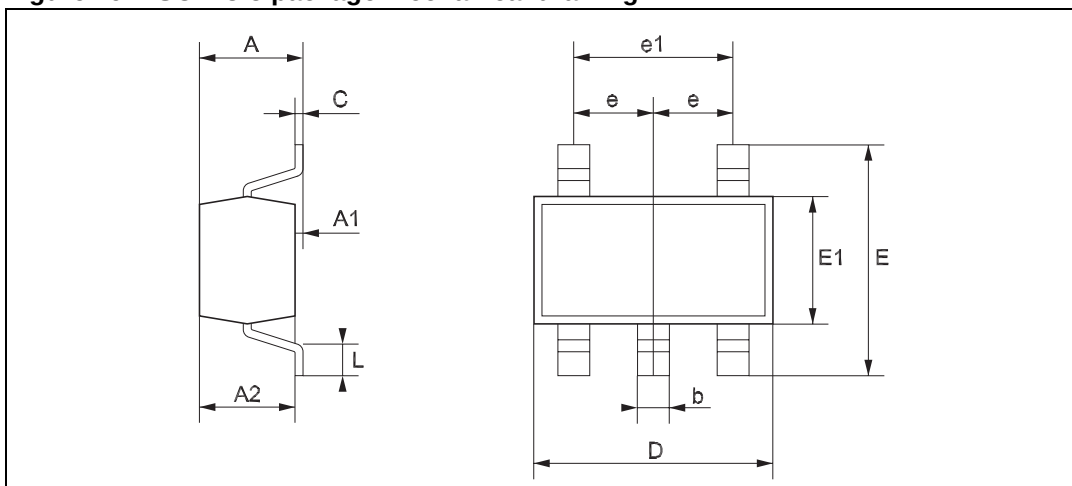


Table 5. SOT23-5 package mechanical data

| Ref. | Dimensions  |      |      |       |      |       |
|------|-------------|------|------|-------|------|-------|
|      | Millimeters |      |      | Mils  |      |       |
|      | Min.        | Typ. | Max. | Min.  | Typ. | Max.  |
| A    | 0.90        |      | 1.45 | 35.4  |      | 57.1  |
| A1   | 0.00        |      | 0.15 | 0.00  |      | 5.9   |
| A2   | 0.90        |      | 1.30 | 35.4  |      | 51.2  |
| b    | 0.35        |      | 0.50 | 13.7  |      | 19.7  |
| C    | 0.09        |      | 0.20 | 3.5   |      | 7.8   |
| D    | 2.80        |      | 3.00 | 110.2 |      | 118.1 |
| E    | 2.60        |      | 3.00 | 102.3 |      | 118.1 |
| E1   | 1.50        |      | 1.75 | 59.0  |      | 68.8  |
| e    |             | 0.95 |      |       | 37.4 |       |
| e1   |             | 1.9  |      |       | 74.8 |       |
| L    | 0.35        |      | 0.55 | 13.7  |      | 21.6  |

## 3.2 SO-8 package information

Figure 20. SO-8 package mechanical drawing

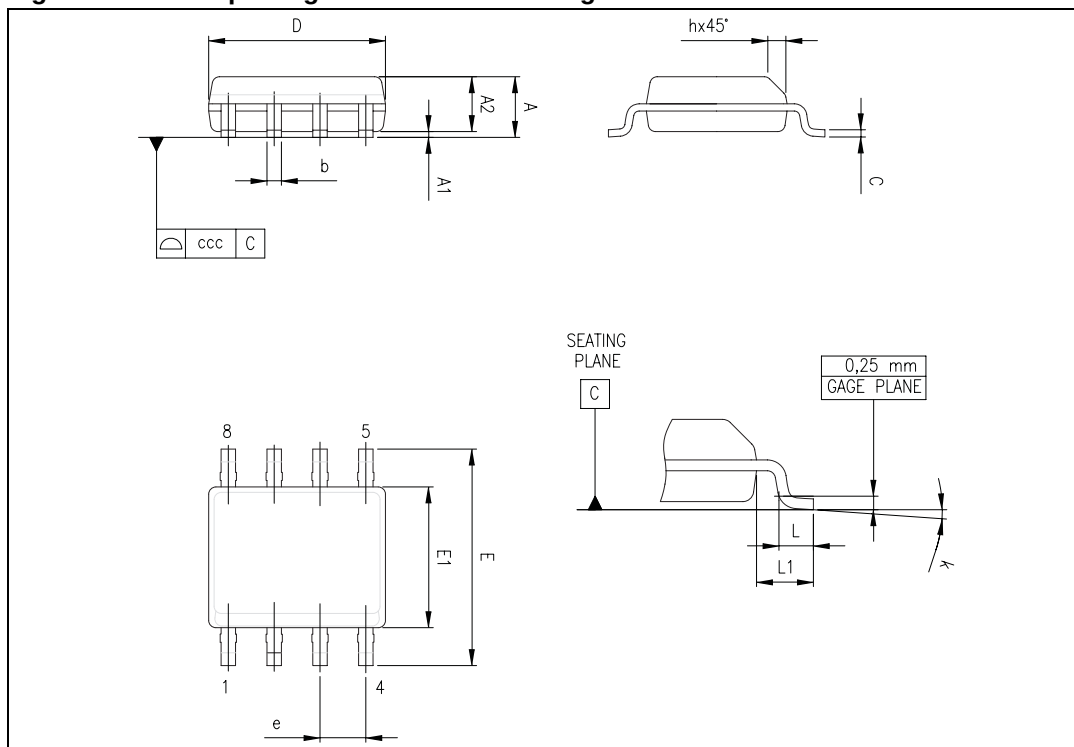


Table 6. SO-8 package mechanical data

| 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 |
| k    | 1°          |      | 8°   | 1°     |       | 8°    |
| ccc  |             |      | 0.10 |        |       | 0.004 |

### 3.3 TSSOP8 package information

Figure 21. TSSOP8 package mechanical drawing

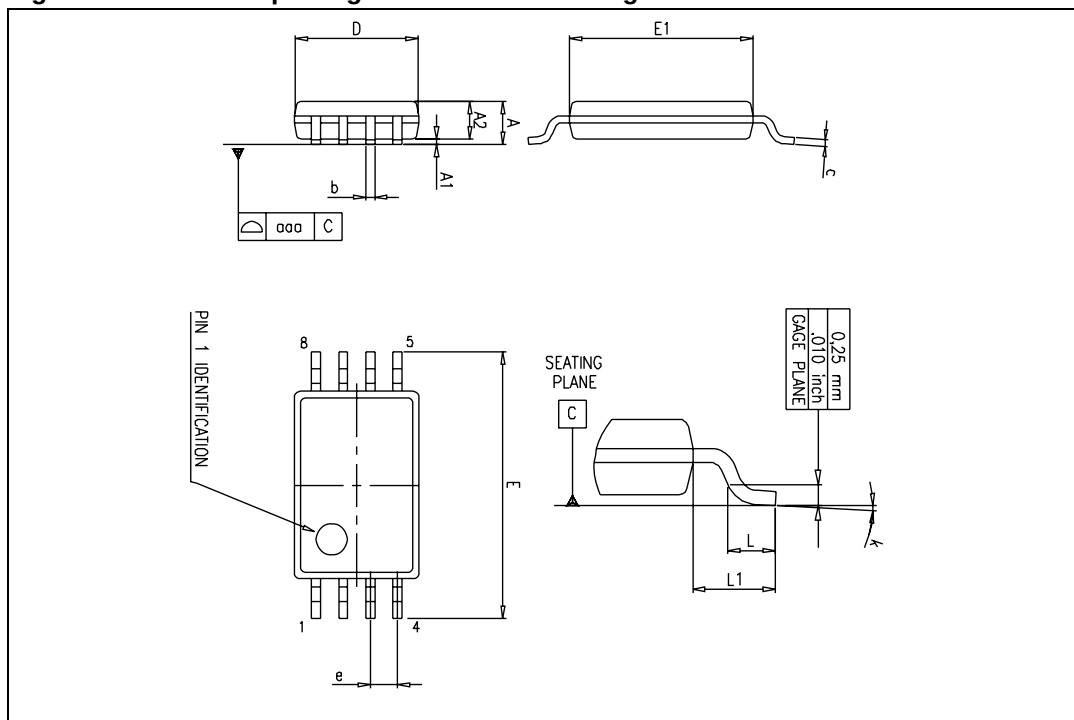


Table 7. TSSOP8 package mechanical data

| Ref. | Dimensions  |      |      |        |        |       |
|------|-------------|------|------|--------|--------|-------|
|      | Millimeters |      |      | Inches |        |       |
|      | Min.        | Typ. | Max. | Min.   | Typ.   | Max.  |
| A    |             |      | 1.2  |        |        | 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  |             | 0.1  |      |        | 0.004  |       |

### 3.4 MiniSO-8 package information

Figure 22. MiniSO-8 package mechanical drawing

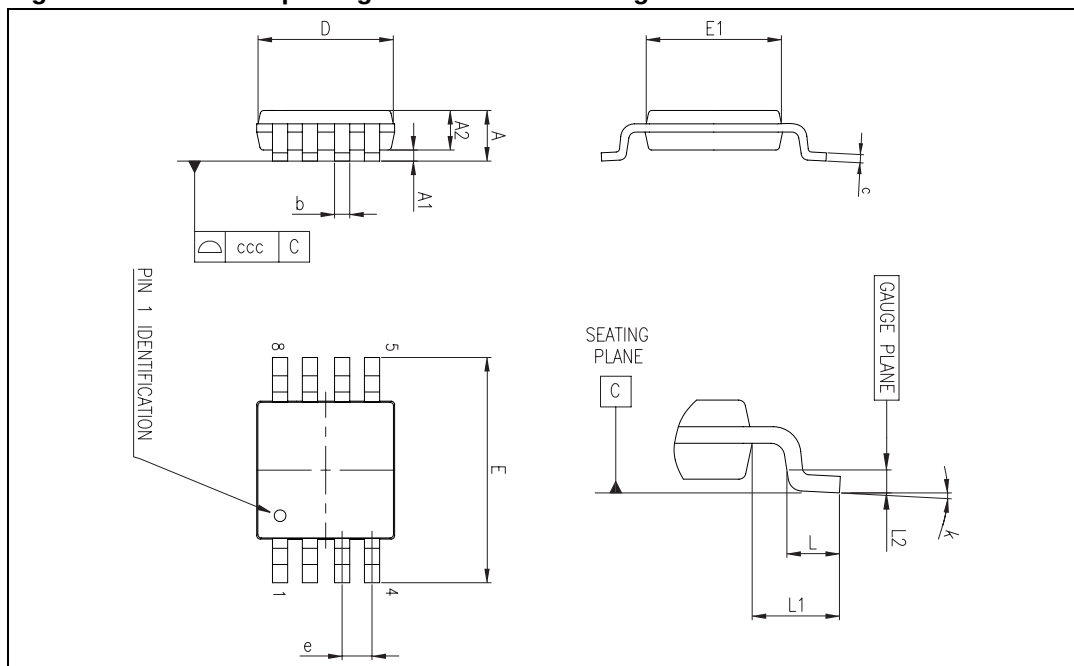


Table 8. MiniSO-8 package mechanical data

| 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 |

### 3.5 SO-14 package information

Figure 23. SO-14 package mechanical drawing

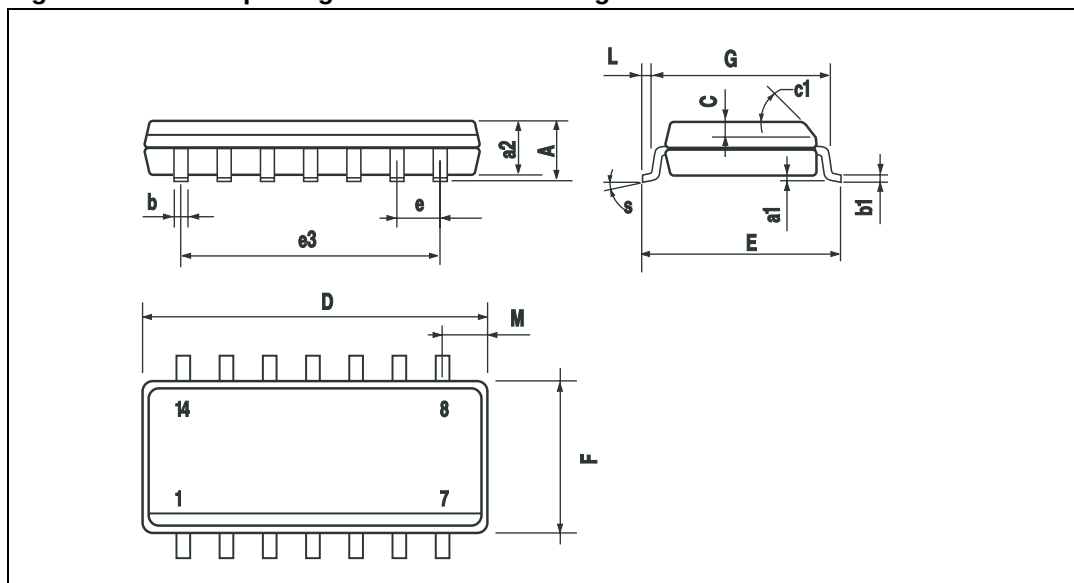


Table 9. SO-14 package mechanical data

| Ref. | Dimensions  |      |      |        |       |       |
|------|-------------|------|------|--------|-------|-------|
|      | Millimeters |      |      | Inches |       |       |
|      | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A    |             |      | 1.75 |        |       | 0.068 |
| a1   | 0.1         |      | 0.2  | 0.003  |       | 0.007 |
| a2   |             |      | 1.65 |        |       | 0.064 |
| b    | 0.35        |      | 0.46 | 0.013  |       | 0.018 |
| b1   | 0.19        |      | 0.25 | 0.007  |       | 0.010 |
| C    |             | 0.5  |      |        | 0.019 |       |
| c1   | 45° (typ.)  |      |      |        |       |       |
| D    | 8.55        |      | 8.75 | 0.336  |       | 0.344 |
| E    | 5.8         |      | 6.2  | 0.228  |       | 0.244 |
| e    |             | 1.27 |      |        | 0.050 |       |
| e3   |             | 7.62 |      |        | 0.300 |       |
| F    | 3.8         |      | 4.0  | 0.149  |       | 0.157 |
| G    | 4.6         |      | 5.3  | 0.181  |       | 0.208 |
| L    | 0.5         |      | 1.27 | 0.019  |       | 0.050 |
| M    |             |      | 0.68 |        |       | 0.026 |
| S    | 8° (max.)   |      |      |        |       |       |

### 3.6 TSSOP14 package information

Figure 24. TSSOP14 package mechanical drawing

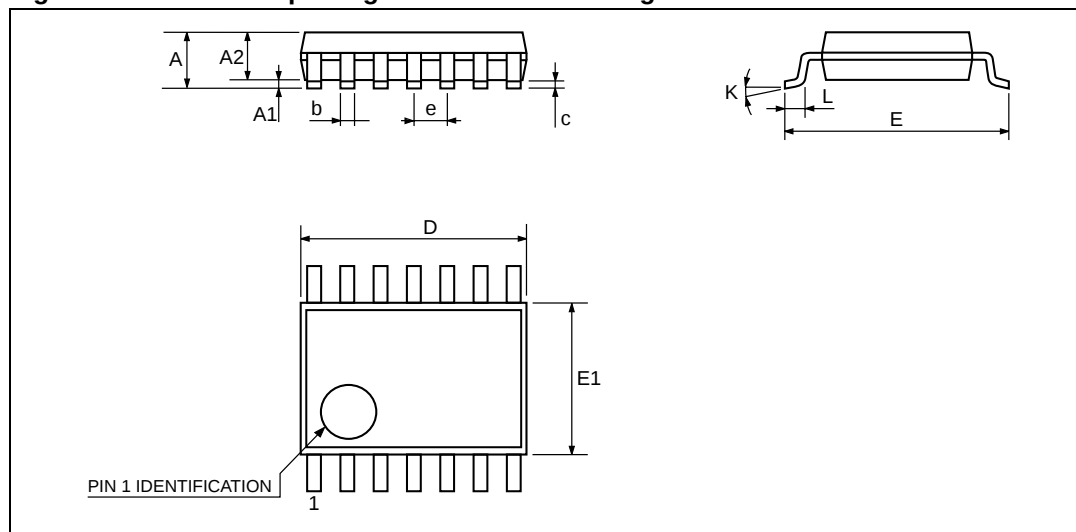


Figure 25. TSSOP14 package mechanical data

| Ref. | Dimensions  |          |      |        |            |        |
|------|-------------|----------|------|--------|------------|--------|
|      | Millimeters |          |      | Inches |            |        |
|      | Min.        | Typ.     | Max. | Min.   | Typ.       | Max.   |
| A    |             |          | 1.2  |        |            | 0.047  |
| A1   | 0.05        |          | 0.15 | 0.002  | 0.004      | 0.006  |
| A2   | 0.8         | 1        | 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    | 4.9         | 5        | 5.1  | 0.193  | 0.197      | 0.201  |
| E    | 6.2         | 6.4      | 6.6  | 0.244  | 0.252      | 0.260  |
| E1   | 4.3         | 4.4      | 4.48 | 0.169  | 0.173      | 0.176  |
| e    |             | 0.65 BSC |      |        | 0.0256 BSC |        |
| K    | 0°          |          | 8°   | 0°     |            | 8°     |
| L1   | 0.45        | 0.60     | 0.75 | 0.018  | 0.024      | 0.030  |

## 4 Ordering information

Table 10. Order codes

| Order code                      | Temperature range | Package                                  | Packaging              | Marking |
|---------------------------------|-------------------|------------------------------------------|------------------------|---------|
| TSV321RILT                      | -40°C to +125°C   | SOT23-5                                  | Tape & reel            | K174    |
| TSV321RAILT                     |                   |                                          |                        | K178    |
| TSV321RIYLT <sup>(1)</sup>      |                   | SOT23-5<br>(Automotive grade level)      | Tape & reel            | K179    |
| TSV321RAIYLT <sup>(1)</sup>     |                   |                                          |                        | K187    |
| TSV321ID/IDT                    |                   | SO-8                                     | Tube or<br>tape & reel | V321ID  |
| TSV321IYD/IYDT <sup>(1)</sup>   |                   | SO-8<br>(Automotive grade level)         | Tube or<br>tape & reel | V321Y   |
| TSV321AID/IDT                   |                   | SO-8                                     | Tube or<br>tape & reel | V321AI  |
| TSV358ID/IDT                    |                   | SO-8                                     | Tube or<br>tape & reel | V358ID  |
| TSV358AID/IDT                   |                   |                                          |                        | V358AID |
| TSV358IYD/IYDT <sup>(1)</sup>   |                   | SO-8<br>(Automotive grade level)         | Tube or<br>tape & reel | V358YD  |
| TSV358AIYD/AIYDT <sup>(1)</sup> |                   |                                          |                        | V358AY  |
| TSV358IPT                       |                   | TSSOP8<br>(Thin shrink outline package)  | Tape & reel            | V358I   |
| TSV358AIPT                      |                   |                                          |                        | V358A   |
| TSV358IYPT <sup>(1)</sup>       |                   | TSSOP8<br>(Automotive grade level)       | Tape & reel            | V358Y   |
| TSV358AIYPT <sup>(1)</sup>      |                   |                                          |                        | V58AY   |
| TSV358IST                       |                   | MiniSO-8                                 | Tape & reel            | K175    |
| TSV358AIST                      |                   |                                          |                        | K184    |
| TSV324ID/IDT                    |                   | SO-14                                    | Tube or<br>tape & reel | V324ID  |
| TSV324AID/AIDT                  |                   |                                          |                        | V324AI  |
| TSV324IYD/IYDT <sup>(1)</sup>   |                   | SO-14<br>(Automotive grade level)        | Tube or tape & reel    | V324YD  |
| TSV324AIYD/AIYDT <sup>(1)</sup> |                   |                                          |                        | V324AY  |
| TSV324IPT                       |                   | TSSOP14<br>(Thin shrink outline package) | Tape & reel            | V324IP  |
| TSV324AIPT                      |                   |                                          |                        | V324A   |
| TSV324AIYPT <sup>(1)</sup>      |                   | TSSOP14<br>(Automotive grade level)      | Tape & reel            | V324AY  |
| TSV324IYPT <sup>(1)</sup>       |                   |                                          |                        | V324Y   |

1. Qualification and characterization according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent are on-going.

## 5 Revision history

**Table 11. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|-------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2-Aug-2005  | 1        | First release - Products in full production.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 20-Sep-2005 | 2        | Addition of TS321A/TS324A/TS358A data in tables in <a href="#">Section 2: Electrical characteristics on page 4</a> .<br>Minor formatting and grammatical changes.                                                                                                                                                                                                                                                                                                                                                                                                          |
| 7-Dec-2005  | 3        | Missing PPAP references inserted see <a href="#">Section 4: Ordering information on page 15</a> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 28-Jun-2007 | 4        | Correction made on output drive capability, 80mA in description on cover page.<br>SVR measurement conditions inserted in electrical characteristics tables.<br>Offset voltage limit in temperature added in <a href="#">Section 2: Electrical characteristics on page 4</a> .<br>Correction made on Input Bias Current typical value in <a href="#">Section 2: Electrical characteristics on page 4</a> .<br>Captions of electrical characteristics figures updated.<br>Automotive grade order codes added to <a href="#">Section 4: Ordering information on page 15</a> . |
| 21-Feb-2008 | 5        | Corrected SO-14 $R_{thja}$ value to 105 °C/W.<br>Updated presentation of package information.<br>Corrected footnote for automotive grade order codes in order code table.                                                                                                                                                                                                                                                                                                                                                                                                  |

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