# TS514

## Precision quad operational amplifier

**Datasheet −production data**

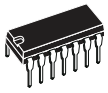
## Features

- Low input offset voltage: 500 µV max.
- Low power consumption
- Short-circuit protection
- Low distortion, low noise
- High gain bandwidth product
- High channel separation
- ESD protection 2 kV

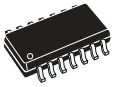
## Description

The TS514 device is a high-performance quad operational amplifier with frequency and phase compensation built into the chip. The internal phase compensation allows stable operation as a voltage follower in spite of its high gain bandwidth.

The circuit presents very stable electrical characteristics over the entire supply voltage range, and is particularly intended for professional and telecom applications (such as active filters, for example).

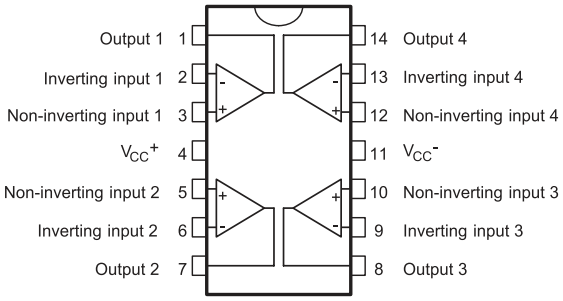


**N**
**DIP14**
(plastic package)



**D**
**SO-14**
(plastic micropackage)

**Pin connections**
(top view)



# 1 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CC}$ | Supply voltage | ±18 | V |
| $V_i$ | Input voltage | $V_{DD}$-0.2 to $V_{CC}$+0.2 | V |
| $V_{id}$(1) | Differential input voltage | ±$V_{CC}$ | V |
| $T_{stg}$ | Storage temperature range | -65 to +150 | °C |
| $R_{thja}$ | Thermal resistance junction-to-ambient<br>SO-14<br>DIP14 | <br>103<br>80 | °C/W |
| $R_{thjc}$ | Thermal resistance junction-to-case<br>SO-14<br>DIP14 | <br>31<br>33 | °C/W |
| ESD | HBM: human body model(2) | 2 | kV |
| | MM: machine model(3) | 200 | V |
| | CDM: charged device model(4) | 1.5 | kV |

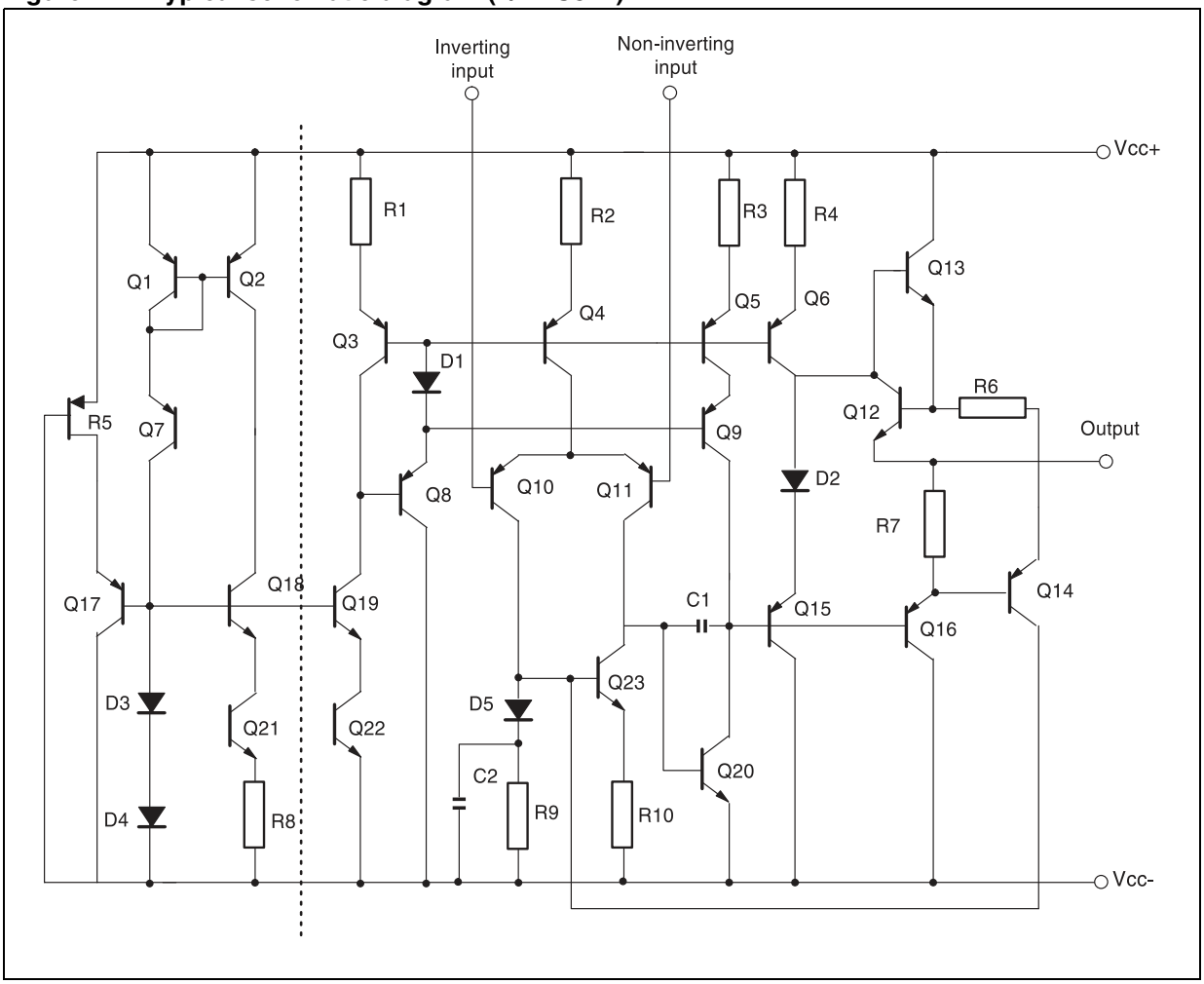
1. Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
2. Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5kΩ resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
3. 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 Ω). This is done for all couples of connected pin combinations while the other pins are floating.
4. Charged device model: all pins and the package are charged together to the specified voltage and then discharged directly to ground through only one pin. This is done for all pins.

**Table 2. Operating conditions**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CC}$ | Supply voltage | 6 to 30 | V |
| $V_{icm}$ | Common mode input voltage range | $V_{DD}$ +0.8 to $V_{CC}$ -1.5 | V |
| $T_{oper}$ | Operating free air temperature range | -40 to +125 | °C |

# 2 Schematic diagram

**Figure 1. Typical schematic diagram (1/4 TS514)**



# 3 Electrical characteristics

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

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| $I_{CC}$ | Supply current (per operator)<br>at $T_{min} \le T_{op} \le T_{max}$ | | 0.5 | 0.6<br>0.75 | mA |
| $I_{ib}$ | Input bias current<br>– at 25 °C<br>– at $T_{min} \le T_{op} \le T_{max}$ | | 50 | 150<br>300 | nA |
| $R_i$ | Input resistance, F= 1 kHz | | 1 | | MΩ |
| $V_{io}$ | Input offset voltage<br>– at 25 °C<br>TS514<br>TS514A<br>– at $T_{min} \le T_{op} \le T_{max}$<br>TS514<br>TS514A | | 0.5 | 2.5<br>0.5<br><br>4<br>1.5 | mV |
| $\Delta V_{io}$ | Input offset voltage drift at $T_{min} \le T_{op} \le T_{max}$ | | 5 | | µV/°C |
| $I_{io}$ | Input offset current<br>at 25 °C<br>at $T_{min} \le T_{op} \le T_{max}$ | | 5 | 20<br>40 | nA |
| $\Delta I_{io}$ | Input offset current drift<br>$T_{min} \le T_{op} \le T_{max}$ | | 0.08 | | $\frac{nA}{°C}$ |
| $I_{os}$ | Output short-circuit current | | 23 | | mA |
| $A_{vd}$ | Large signal voltage gain, $R_L$ = 2 kΩ<br>$V_{CC}$ = ±15 V, at $T_{min} \le T_{op} \le T_{max}$<br>$V_{CC}$ = ± 4 V | 90 | 100<br>95 | | dB |
| GBP | Gain bandwidth product, F = 100 kHz | 1.8 | 3 | | MHz |
| $e_n$ | Equivalent input noise voltage, F = 1 kHz<br>Rs = 50 Ω<br>Rs = 1 kΩ<br>Rs = 10 kΩ | | 8<br>10<br>18 | 15 | $\frac{nV}{\sqrt{Hz}}$ |
| THD | Total harmonic distortion<br>$A_v$ = 20 dB, $R_L$ = 2 kΩ, $V_o$ = 2 $V_{pp}$, f = 1 kHz | | 0.03 | 0.1 | % |
| $\pm V_{opp}$ | Output voltage swing, $R_L$ = 2 kΩ<br>$V_{CC}$ = ±15 V, at $T_{min} \le T_{op} \le T_{max}$<br>$V_{CC}$ = ± 4 V | ±13 | <br>±3 | | V |
| $V_{opp}$ | Large signal voltage swing, $R_L$ = 10 kΩ, F = 10 kHz | | 28 | | $V_{pp}$ |
| SR | Slew rate, unity gain, $R_L$ = 2 kΩ | 0.8 | 1.5 | | V/µs |

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

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| CMR | Common mode rejection ratio<br>CMR = 20 log ($\Delta V_{ic}/\Delta V_{io}$)<br>($V_{ic}$ = -10 V to 10 V, $V_{out} = V_{CC}/2$, $R_L$ > 1 MΩ) | 90 | | | dB |
| SVR | Supply voltage rejection ratio<br>20 log ($\Delta V_{CC}/\Delta V_{io}$)<br>($V_{CC}$ = ±5 V to ±15 V, $V_{out} = V_{icm} = V_{CC}/2$) | 90 | | | dB |
| $V_{o1}/V_{o2}$ | Channel separation, F = 1 kHz | | 120 | | dB |

**Figure 2. $V_{io}$ distribution at $V_{CC}$ = ±15 V and T = 25 °C**

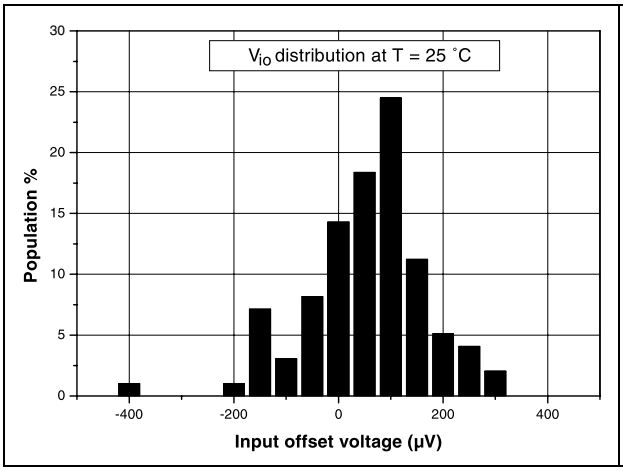



**Figure 3. $V_{io}$ distribution at $V_{CC}$ = ±15 V and T = 125 °C**

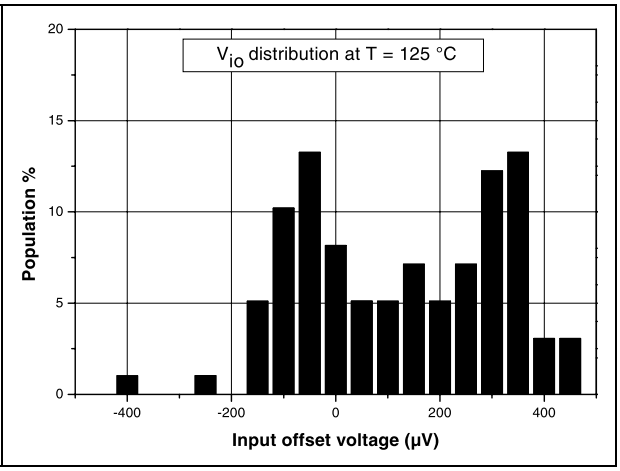



**Figure 4. Input offset voltage vs. supply voltage at $V_{icm} = V_{CC}/2$**

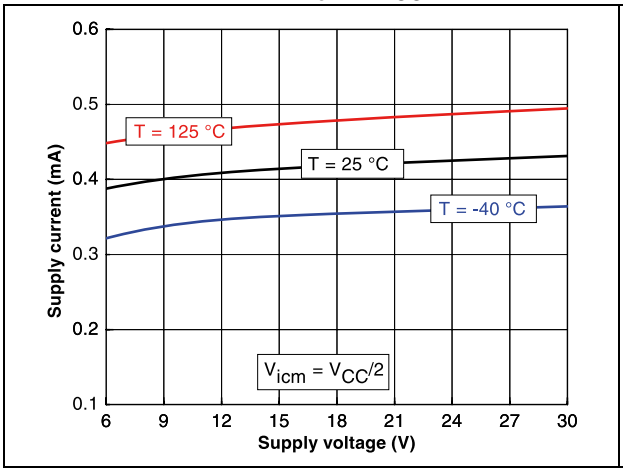



**Figure 5. Input offset voltage vs. input common mode voltage at $V_{CC}$ = 6 V**

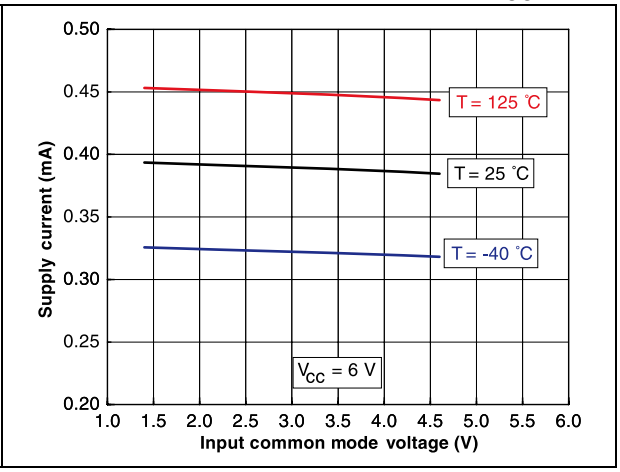



**Figure 6. Input offset voltage vs. input common mode voltage at $V_{CC}$ = 10 V**

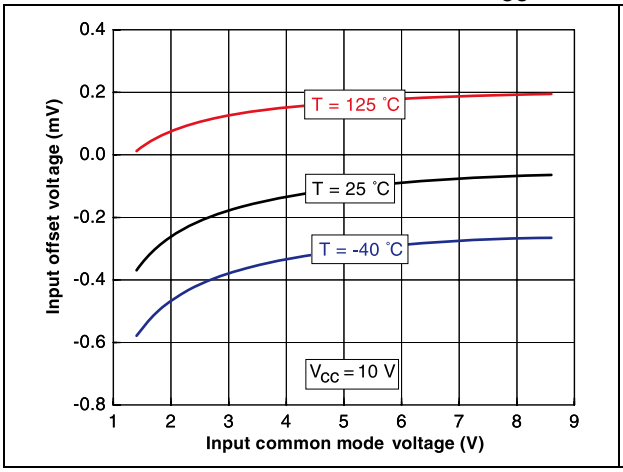



**Figure 7. Input offset voltage vs. input common mode voltage at $V_{CC}$ = 30 V**

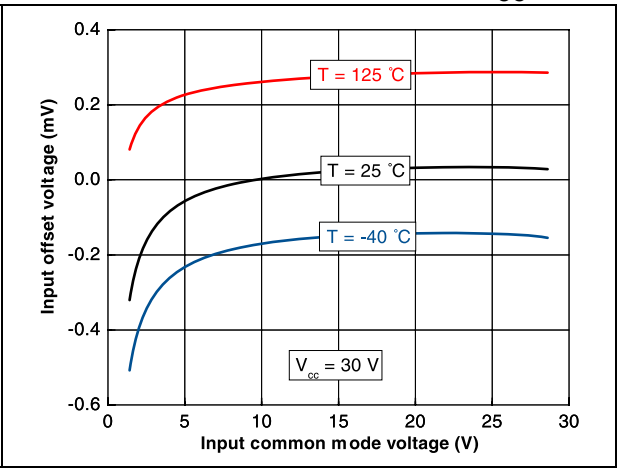


**Figure 8. Supply current (per operator) vs. supply voltage at $V_{icm} = V_{CC}/2$**

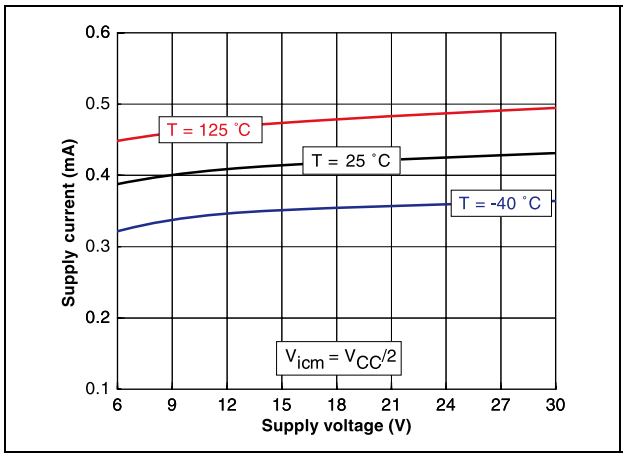



**Figure 9. Supply current (per operator) vs. input common mode voltage at $V_{CC} = 6$ V**

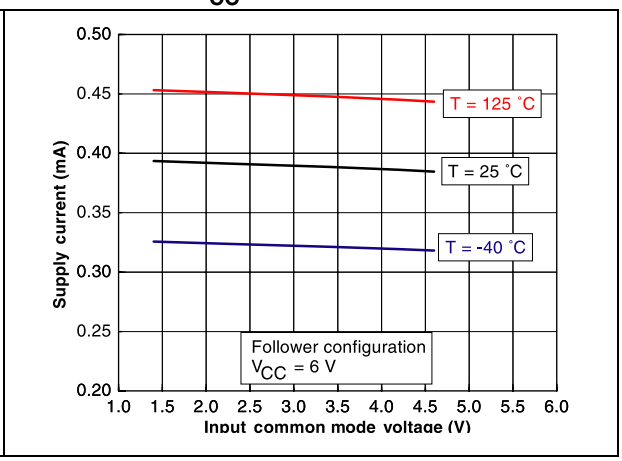



**Figure 10. Supply current (per operator) vs. input common mode voltage at $V_{CC} = 10$ V**

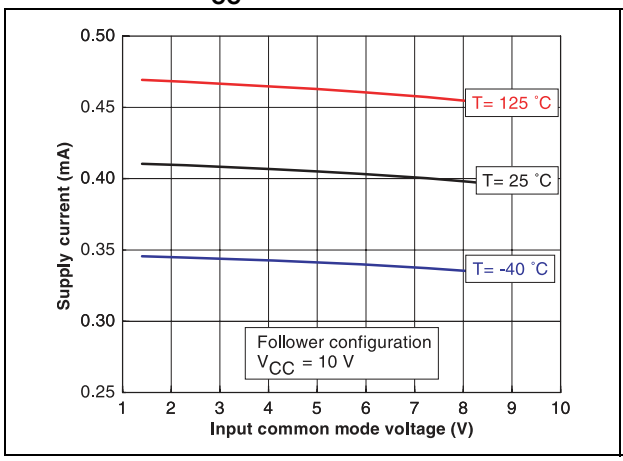



**Figure 11. Supply current (per operator) vs. input common mode voltage at $V_{CC} = 30$ V**

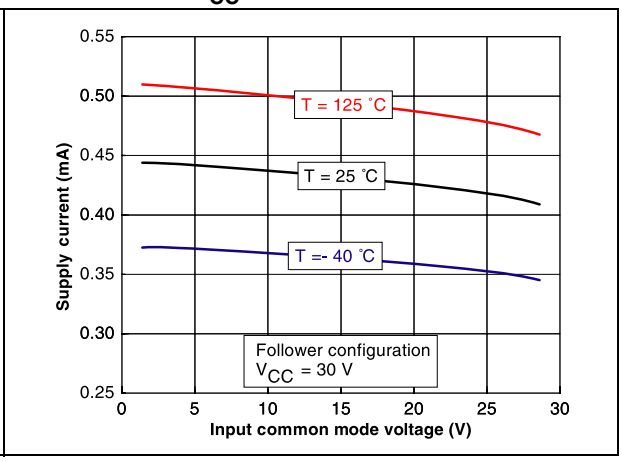



**Figure 12. Output current vs. supply voltage at $V_{icm} = V_{CC}/2$**

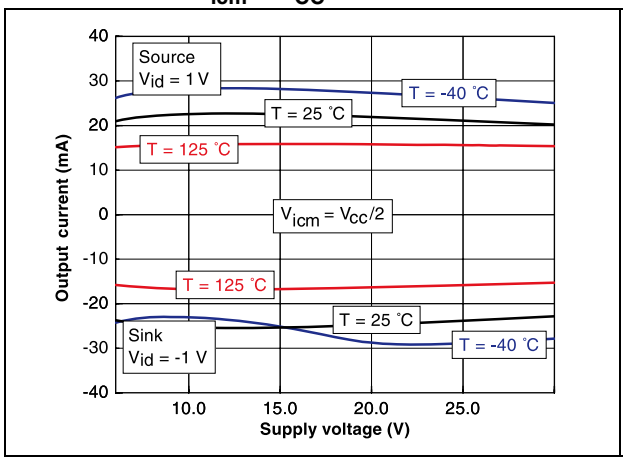



**Figure 13. Output current vs. output voltage at $V_{CC} = 6$ V**

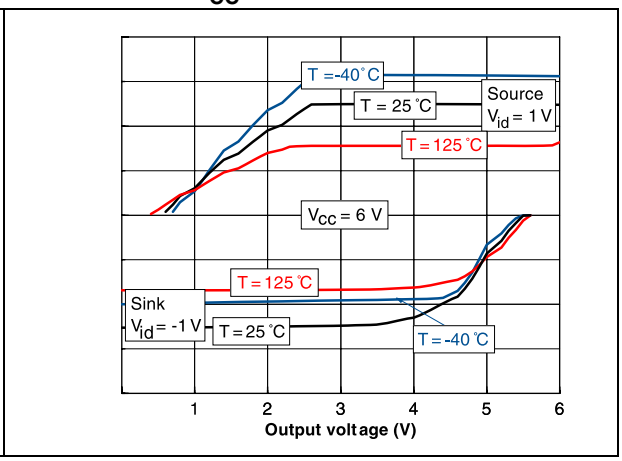


**Figure 14. Output current vs. output voltage at $V_{CC}$ = 10 V**

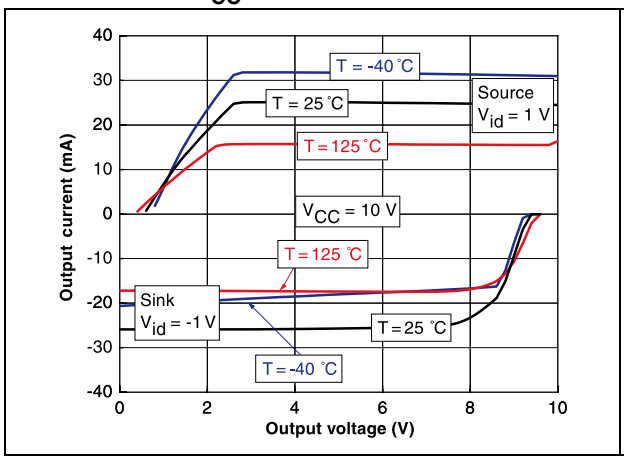



**Figure 15. Output current vs. output voltage at $V_{CC}$ = 30 V**

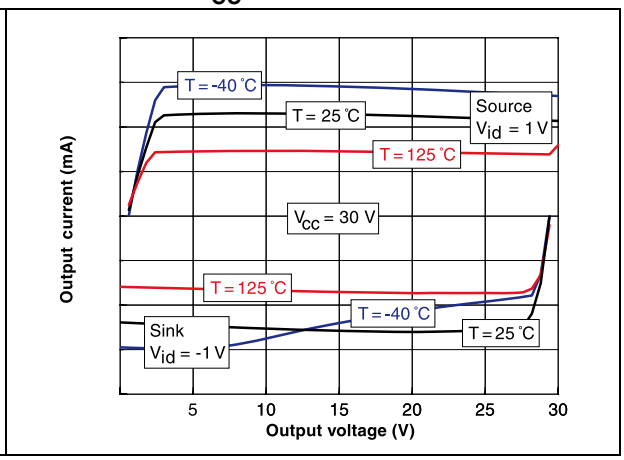



**Figure 16. Voltage gain and phase for different capacitive load at $V_{CC}$ = 6 V, $V_{icm}$ = 3 V and T = 25 °C**

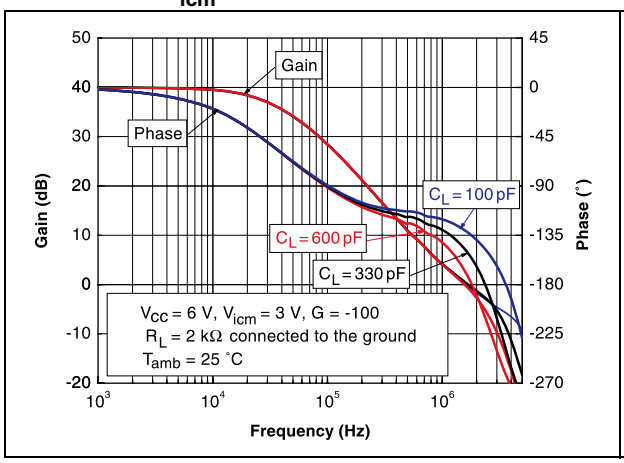



**Figure 17. Voltage gain and phase for different capacitive load at $V_{CC}$ = 10 V, $V_{icm}$ = 5 V and T = 25 °C**

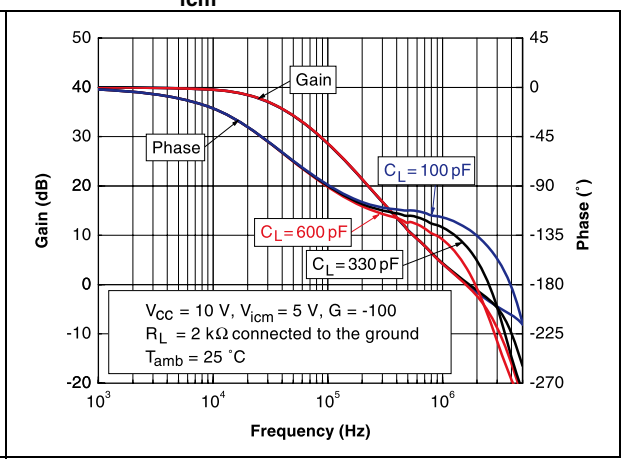



**Figure 18. Voltage gain and phase for different capacitive load at $V_{CC}$ = 30 V, $V_{icm}$ = 15 V and T = 25 °C**

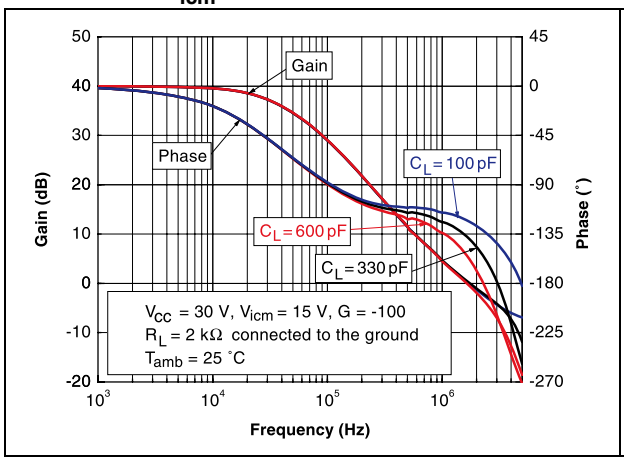



**Figure 19. Frequency response for different capacitive load at $V_{CC}$ = 6 V, $V_{icm}$ = 3 V and T = 25 °C**

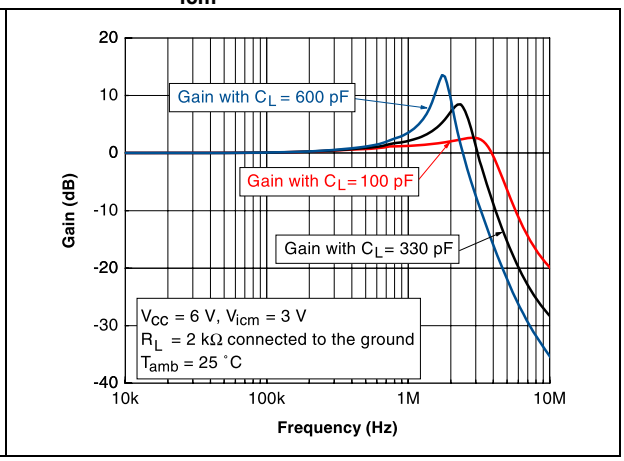


**Figure 20. Frequency response for different capacitive load at $V_{CC}$= 10 V, $V_{icm}$ = 5 V and T = 25 °C**

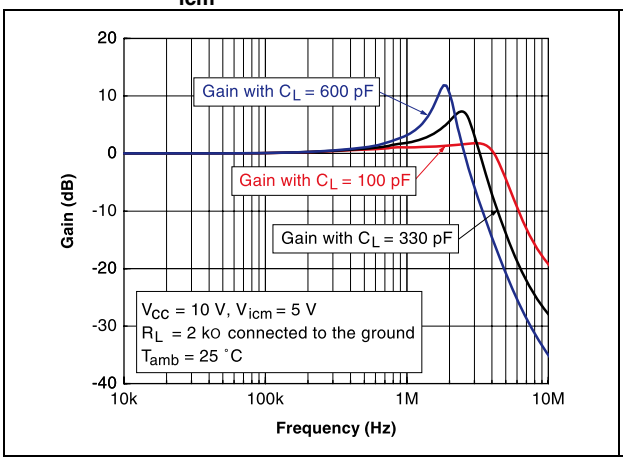



**Figure 21. Frequency response for different capacitive load at $V_{CC}$ = 30 V, $V_{icm}$ = 15 V and T = 25 °C**

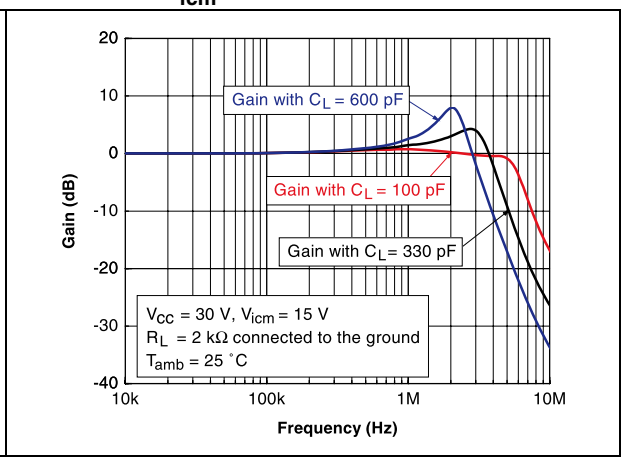



**Figure 22. Gain margin vs. output current, at $V_{CC}$ = 6 V, $V_{icm}$ = 3 V and T = 25 °C**

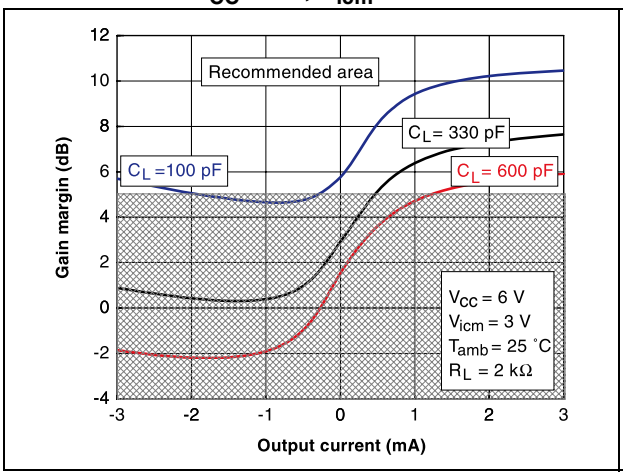



**Figure 23. Gain margin vs. output current, at $V_{CC}$ = 10 V, $V_{icm}$ = 5 V and T = 25 °C**

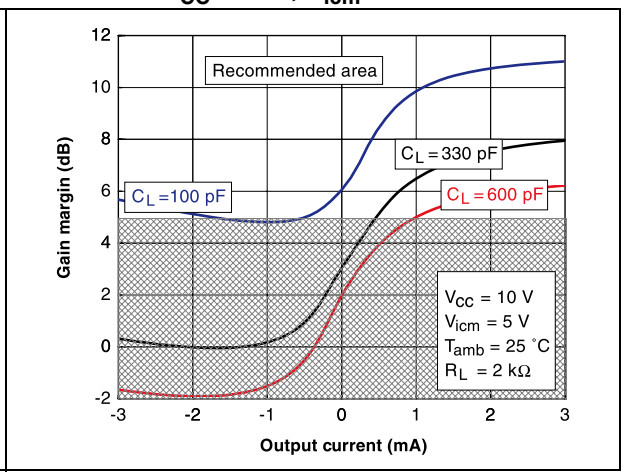



**Figure 24. Gain margin vs. output current, at $V_{CC}$ = 30 V, $V_{icm}$ = 15 V and T = 25 °C**

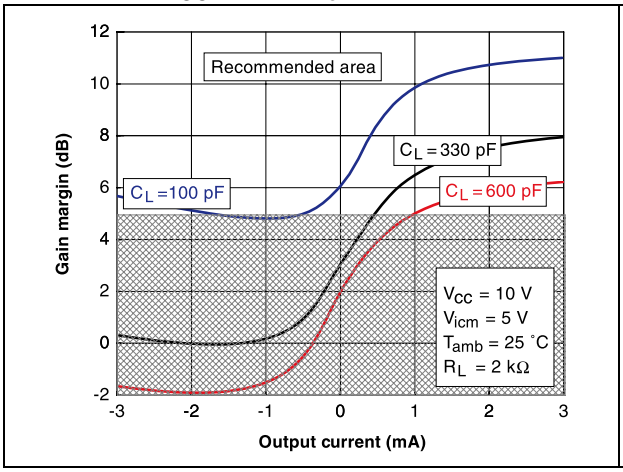



**Figure 25. Phase margin vs. output current, at $V_{CC}$ = 6 V, $V_{icm}$ = 3 V and T = 25 °C**

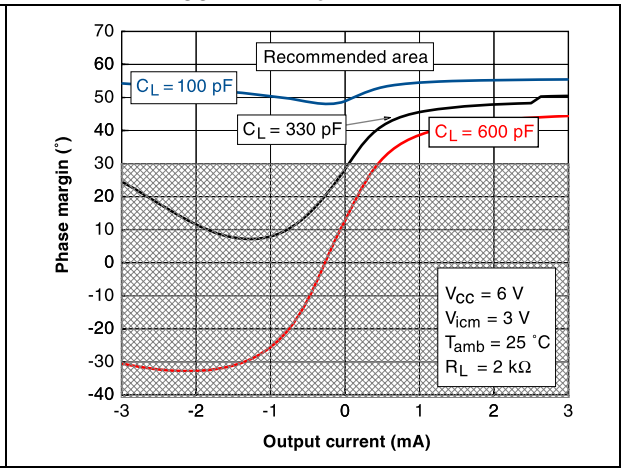


**Figure 26. Phase margin vs. output current, at $V_{CC}$ = 10 V, $V_{icm}$ = 5 V and T = 25 °C**

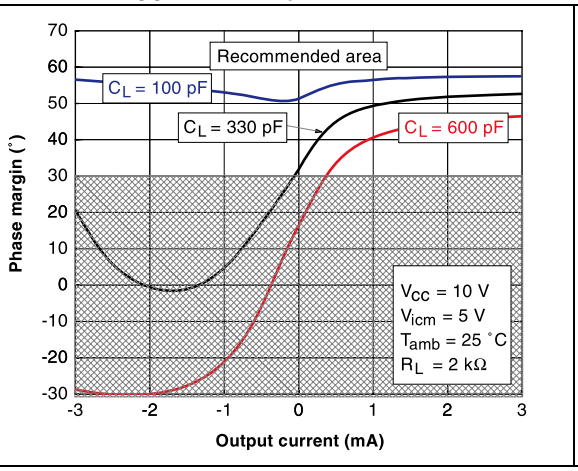
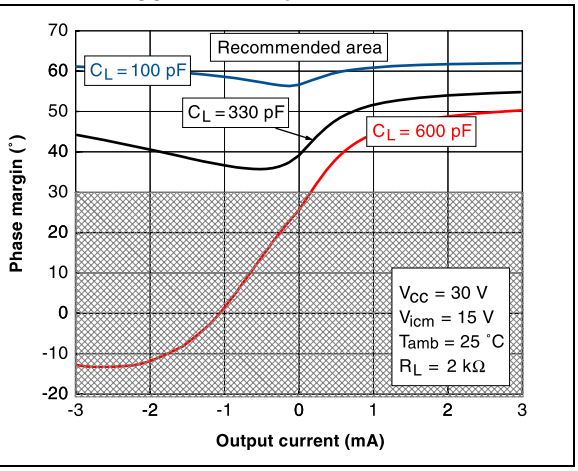



**Figure 27. Phase margin vs. output current, at $V_{CC}$ = 30 V, $V_{icm}$ = 15 V and T = 25 °C**



# 4 Package information

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

## 4.1 DIP14 package information

**Figure 28. DIP14 package outline**

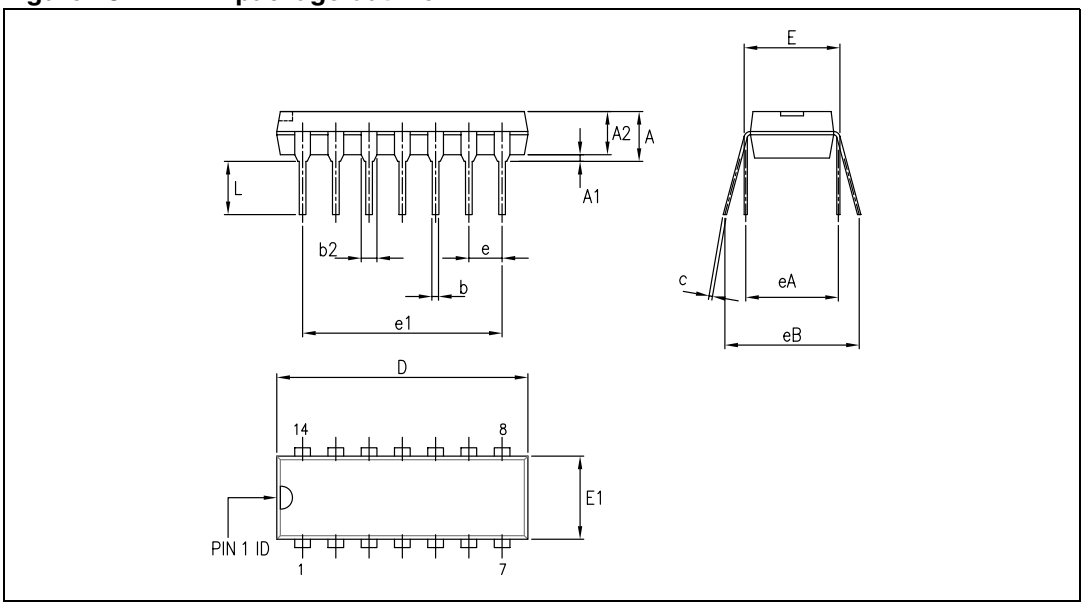



**Table 4. DIP14 package mechanical data**

| Symbol | Dimensions | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 5.33 | | | 0.21 |
| A1 | 0.38 | | | 0.015 | | |
| A2 | 2.92 | 3.30 | 4.95 | 0.11 | 0.13 | 0.19 |
| b | 0.36 | 0.46 | 0.56 | 0.014 | 0.018 | 0.022 |
| b2 | 1.14 | 1.52 | 1.78 | 0.04 | 0.06 | 0.07 |
| c | 0.20 | 0.25 | 0.36 | 0.007 | 0.009 | 0.01 |
| D | 18.67 | 19.05 | 19.69 | 0.73 | 0.75 | 0.77 |
| E | 7.62 | 7.87 | 8.26 | 0.30 | 0.31 | 0.32 |
| E1 | 6.10 | 6.35 | 7.11 | 0.24 | 0.25 | 0.28 |
| e | | 2.54 | | | 0.10 | |
| e1 | | 15.24 | | | 0.60 | |
| eA | | 7.62 | | | 0.30 | |
| eB | | | 10.92 | | | 0.43 |
| L | 2.92 | 3.30 | 3.81 | 0.11 | 0.13 | 0.15 |

*Note: D and E1 dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.25 mm.*

## 4.2 SO-14 package information

**Figure 29. SO-14 package outline**

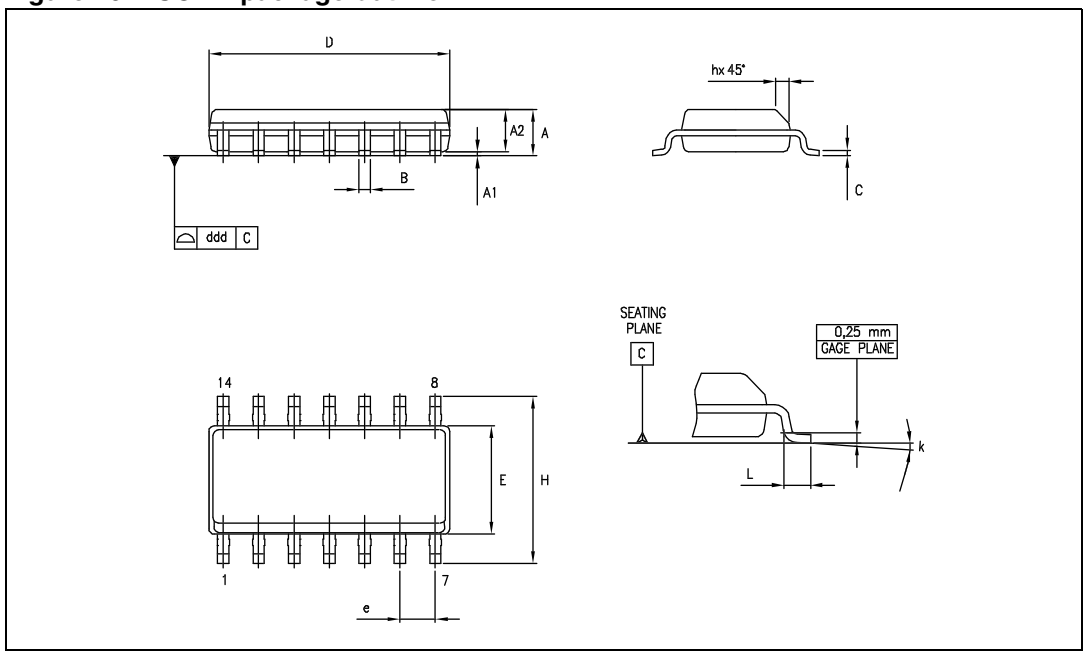



**Table 5. SO-14 package mechanical data**

| Symbol | Dimensions | | | | | |
|---|---|---|---|---|---|---|
| | 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 |

*Note: D and F dimensions do not include mold flash or protrusions. Mold flash or protrusions must not exceed 0.15 mm.*

# 5 Ordering information

**Table 6. Order codes**

| Order code | Temperature range | Package | Packaging | Marking |
|---|---|---|---|---|
| TS514IN | -40, + 125 °C | DIP14 | Tube | TS514IN |
| TS514AIN | | | | TS514AIN |
| TS514ID<br>TS514IDT | | SO-14 | Tube<br>or<br>tape and reel | 514I |
| TS514AID<br>TS514AIDT | | | | 514AI |

# 6 Revision history

**Table 7. Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 09-Mar-2001 | 1 | Initial release. |
| 23-Jun-2005 | 2 | Automotive grade part references inserted in the datasheet (see *Chapter 5: Ordering information on page 14*). |
| 30-Sep-2005 | 3 | The following changes were made in this revision.<br>– An error in the device description was corrected on page 1.<br>– *Chapter 5: Ordering information on page 14* updated with complete list of markings.<br>– Addition of supplementary data in *Table 1: Absolute maximum ratings on page 2*.<br>– Addition of *Table 2: Operating conditions on page 2*.<br>– Reorganization of *Chapter 4: Package information on page 11*.<br>– Minor grammatical and formatting changes throughout. |
| 24-Oct-2008 | 4 | Added performance AC and DC characteristic curves for $V_{CC}$=6 V, $V_{CC}$=10 V and $V_{CC}$=30 V in *Chapter 3: Electrical characteristics*.<br>Modified $I_{CC}$ typ, added parameters over temperature in *Table 3*.<br>Deleted old macromodel.<br>Added $R_{thjc}$, $R_{thja}$ in *Table 1*.<br>Corrected $V_i$ and $V_{id}$ AMR values in *Table 1*.<br>Added input common mode range $V_{icm}$ in *Table 2: Operating conditions*.<br>Updated *Section 4.1: DIP14 package information* and *Section 4.2: SO-14 package information*. |
| 12-Sep-2012 | 5 | Updated *Features* (removed “macromodel”).<br>Updated CMR and SVR test conditions in *Table 3*.<br>Updated ECOPACK text in *Section 4*.<br>Removed TS514IYD, TS514IYDT, TS514AIYD, and TS514AIYDT order code from *Table 6*.<br>Minor corrections throughout document. |

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