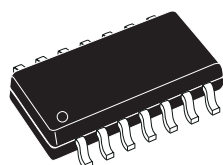
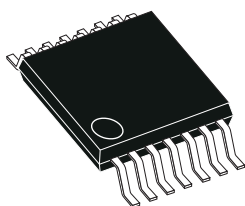


## Low-power quad operational amplifiers

Datasheet - production data



**D**  
**SO14**  
(plastic micropackage)



**P**  
**TSSOP14**  
(thin shrink small outline package)

### Features

- Wide gain bandwidth: 1.3 MHz
- Input common mode voltage range includes ground
- Large voltage gain: 100 dB
- Very low supply current/amplifier: 375  $\mu$ A
- Low input bias current: 20 nA
- Low input offset voltage: 3 mV max.
- Low input offset current: 2 nA
- Wide power supply range:
  - Single supply: +3 V to +30 V
  - Dual supplies:  $\pm 1.5$  V to  $\pm 15$  V

### Description

These circuits consist of four independent, high gain operational amplifiers with frequency compensation implemented internally. They operate from a single power supply over a wide range of voltages.

Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

**Table 1. Device summary**

| Order code | Temperature range | Package | Packaging     |
|------------|-------------------|---------|---------------|
| LM224ADT   | -40 °C to 105 °C  | SO14    | Tape and reel |
| LM224APT   |                   | TSSOP14 |               |
| LM324ADT   | 0 °C to 70 °C     | SO14    |               |
| LM324APT   |                   | TSSOP14 |               |

## Contents

|          |                                                    |           |
|----------|----------------------------------------------------|-----------|
| <b>1</b> | <b>Pin connections and schematic diagram .....</b> | <b>3</b>  |
| <b>2</b> | <b>Absolute maximum ratings .....</b>              | <b>4</b>  |
| <b>3</b> | <b>Electrical characteristics .....</b>            | <b>5</b>  |
| <b>4</b> | <b>Typical single-supply applications .....</b>    | <b>10</b> |
| <b>5</b> | <b>Package information .....</b>                   | <b>12</b> |
|          | 5.1 SO14 package information .....                 | 13        |
|          | 5.2 TSSOP14 package information .....              | 14        |
| <b>6</b> | <b>Revision history .....</b>                      | <b>15</b> |

# 1 Pin connections and schematic diagram

Figure 1. Pin connections (top view)

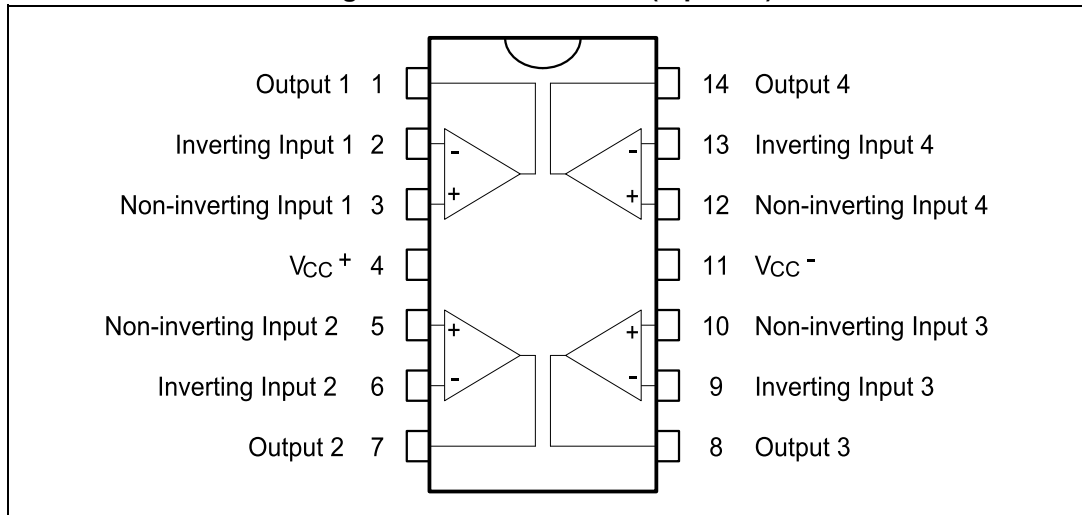
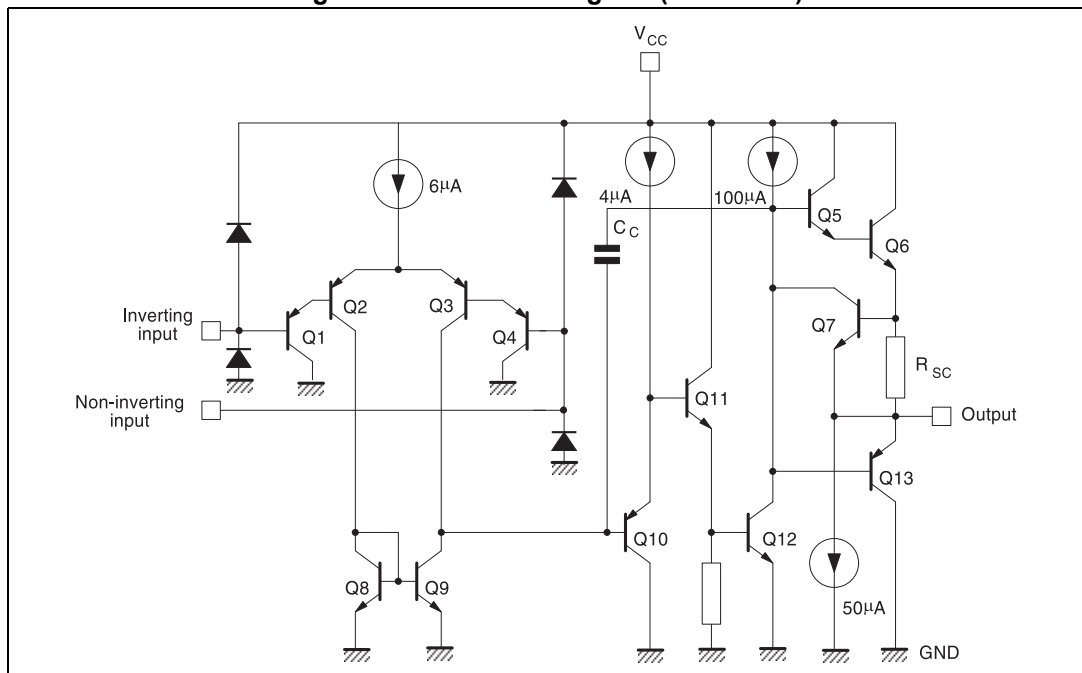


Figure 2. Schematic diagram (1/4 LM124)



## 2 Absolute maximum ratings

Table 2. Absolute maximum ratings

| Symbol            | Parameter                                                                  | LM224A                        | LM324A   | Unit |
|-------------------|----------------------------------------------------------------------------|-------------------------------|----------|------|
| V <sub>CC</sub>   | Supply voltage                                                             | ±16 or 32                     |          | V    |
| V <sub>i</sub>    | Input voltage                                                              | -0.3 to V <sub>CC</sub> + 0.3 |          |      |
| V <sub>id</sub>   | Differential input voltage <sup>(1)</sup>                                  | 32                            |          |      |
| P <sub>tot</sub>  | Power dissipation:<br>D suffix                                             | 400                           |          | mW   |
|                   | Output short-circuit duration <sup>(2)</sup>                               | Infinite                      |          |      |
| I <sub>in</sub>   | Input current <sup>(3)</sup>                                               | 50                            |          | mA   |
| T <sub>oper</sub> | Operating free-air temperature range                                       | -40 to +105                   | 0 to +70 | °C   |
| T <sub>stg</sub>  | Storage temperature range                                                  | -65 to +150                   |          |      |
| T <sub>j</sub>    | Maximum junction temperature                                               | 150                           |          |      |
| R <sub>thja</sub> | Thermal resistance junction to ambient <sup>(4)</sup> :<br>SO14<br>TSSOP14 | 103<br>100                    |          | °C/W |
| R <sub>thjc</sub> | Thermal resistance junction to case:<br>SO14<br>TSSOP14                    | 31<br>32                      |          |      |
| ESD               | HBM: human body model <sup>(5)</sup>                                       | 800                           |          | V    |
|                   | MM: machine model <sup>(6)</sup>                                           | 100                           |          |      |
|                   | CDM: charged device model                                                  | 1500                          |          |      |

1. Neither of the input voltages must exceed the magnitude of  $V_{CC}^+$  or  $V_{CC}^-$ .
2. Short-circuits from the output to  $V_{CC}$  can cause excessive heating if  $V_{CC} > 15$  V. The maximum output current is approximately 40 mA independent of the magnitude of  $V_{CC}$ . Destructive dissipation can result from simultaneous short-circuits on all amplifiers.
3. This input current only exists when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistor becoming forward biased and thereby acting as input diode clamps. In addition to this diode action, there is also NPN parasitic action on the IC chip. This transistor action can cause the output voltages of the op-amps to go to the  $V_{CC}$  voltage level (or to ground for a large overdrive) for the time during which an input is driven negative. This is not destructive and normal output will set up again for input voltage higher than  $-0.3$  V.
4. Short-circuits can cause excessive heating. Destructive dissipation can result from simultaneous short-circuits on all amplifiers. These are typical values given for a single layer board (except for TSSOP which is a two-layer board).
5. 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.
6. Machine model: a 200 pF cap 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.

### 3 Electrical characteristics

**Table 3.  $V_{CC}^+ = +5\text{ V}$ ,  $V_{CC}^- = \text{Ground}$ ,  $V_o = 1.4\text{ V}$ ,  $T_{\text{amb}} = +25\text{ }^\circ\text{C}$   
(unless otherwise specified)**

| Symbol              | Parameter                                                                                                                                                                                                                                                   | Min.     | Typ.                         | Max.                           | Unit                |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|------------------------------|--------------------------------|---------------------|
| $V_{io}$            | Input offset voltage <sup>(1)</sup> :<br>$T_{\text{amb}} = +25\text{ }^\circ\text{C}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                                                                                                           |          | 2                            | 3<br>5                         | mV                  |
| $I_{io}$            | Input offset current:<br>$T_{\text{amb}} = +25\text{ }^\circ\text{C}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                                                                                                                           |          | 2                            | 20<br>40                       | nA                  |
| $I_{ib}$            | Input bias current <sup>(2)</sup> :<br>$T_{\text{amb}} = +25\text{ }^\circ\text{C}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                                                                                                             |          | 20                           | 100<br>200                     |                     |
| $A_{vd}$            | Large signal voltage gain:<br>$V_{CC}^+ = +15\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $V_o = 1.4\text{ V to } 11.4\text{ V}$<br>$T_{\text{amb}} = +25\text{ }^\circ\text{C}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                     | 50<br>25 | 100                          |                                | V/mV                |
| SVR                 | Supply voltage rejection ratio ( $R_s \leq 10\text{ k}\Omega$ ):<br>$V_{CC}^+ = 5\text{ V to } 30\text{ V}$<br>$T_{\text{amb}} = +25\text{ }^\circ\text{C}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                                     | 65<br>65 | 110                          |                                | dB                  |
| $I_{CC}$            | Supply current, all Amp, no load:<br>– $T_{\text{amb}} = +25\text{ }^\circ\text{C}$<br>$V_{CC} = +5\text{ V}$<br>$V_{CC} = +30\text{ V}$<br>– $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$<br>$V_{CC} = +5\text{ V}$<br>$V_{CC} = +30\text{ V}$ |          | 0.7<br>1.5<br><br>0.8<br>1.5 | 1.2<br>3<br><br>1.2<br>3       | mA                  |
| $V_{icm}$           | Input common mode voltage range:<br>$V_{CC} = +30\text{ V}$ <sup>(3)</sup><br>$T_{\text{amb}} = +25\text{ }^\circ\text{C}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                                                                      | 0<br>0   |                              | $V_{CC} - 1.5$<br>$V_{CC} - 2$ | V                   |
| CMR                 | Common mode rejection ratio ( $R_s \leq 10\text{ k}\Omega$ ):<br>$T_{\text{amb}} = +25\text{ }^\circ\text{C}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                                                                                   | 70<br>60 | 80                           |                                | dB                  |
| $I_{\text{source}}$ | Output current source ( $V_{id} = +1\text{ V}$ ):<br>$V_{CC} = +15\text{ V}$ , $V_o = +2\text{ V}$                                                                                                                                                          | 20       | 40                           | 70                             | mA                  |
| $I_{\text{sink}}$   | Output sink current ( $V_{id} = -1\text{ V}$ ):<br>$V_{CC} = +15\text{ V}$ , $V_o = +2\text{ V}$<br>$V_{CC} = +15\text{ V}$ , $V_o = +0.2\text{ V}$                                                                                                         | 10<br>12 | 20<br>50                     |                                | mA<br>$\mu\text{A}$ |

**Table 3.  $V_{CC}^+ = +5\text{ V}$ ,  $V_{CC}^- = \text{Ground}$ ,  $V_o = 1.4\text{ V}$ ,  $T_{\text{amb}} = +25\text{ }^\circ\text{C}$   
(unless otherwise specified) (continued)**

| Symbol          | Parameter                                                                                                                                                                        | Min.     | Typ.  | Max.     | Unit                                 |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------|----------|--------------------------------------|
| $V_{OH}$        | High level output voltage $V_{CC} = +30\text{ V}$ , $R_L = 2\text{ k}\Omega$<br>$T_{\text{amb}} = +25^\circ\text{C}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | 26<br>26 | 27    |          | V                                    |
|                 | $V_{CC} = +30\text{ V}$ , $R_L = 10\text{ k}\Omega$<br>$T_{\text{amb}} = +25^\circ\text{C}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                          | 27<br>27 | 28    |          |                                      |
|                 | $V_{CC} = +5\text{ V}$ , $R_L = 2\text{ k}\Omega$<br>$T_{\text{amb}} = +25^\circ\text{C}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                            | 3.5<br>3 |       |          |                                      |
| $V_{OL}$        | Low level output voltage ( $R_L = 10\text{ k}\Omega$ ):<br>$T_{\text{amb}} = +25^\circ\text{C}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                      |          | 5     | 20<br>20 | mV                                   |
| SR              | Slew rate:<br>$V_{CC} = 15\text{ V}$ , $V_i = 0.5\text{ to }3\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$ ,<br>unity gain                                       |          | 0.4   |          | V/ $\mu\text{s}$                     |
| GBP             | Gain bandwidth product:<br>$V_{CC} = 30\text{ V}$ , $f = 100\text{ kHz}$ , $V_{in} = 10\text{ mV}$ , $R_L = 2\text{ k}\Omega$ ,<br>$C_L = 100\text{ pF}$                         |          | 1.3   |          | MHz                                  |
| THD             | Total harmonic distortion:<br>$f = 1\text{ kHz}$ , $A_v = 20\text{ dB}$ , $R_L = 2\text{ k}\Omega$ , $V_o = 2V_{pp}$ , $C_L =$<br>$100\text{ pF}$ , $V_{CC} = 30\text{ V}$       |          | 0.015 |          | %                                    |
| $e_n$           | Equivalent input noise voltage:<br>$f = 1\text{ kHz}$ , $R_s = 100\text{ }\Omega$ , $V_{CC} = 30\text{ V}$                                                                       |          | 40    |          | $\frac{\text{nV}}{\sqrt{\text{Hz}}}$ |
| $DV_{io}$       | Input offset voltage drift                                                                                                                                                       |          | 7     | 30       | $\mu\text{V}/^\circ\text{C}$         |
| $DI_{io}$       | Input offset current drift                                                                                                                                                       |          | 10    | 200      | $\text{pA}/^\circ\text{C}$           |
| $V_{o1}/V_{o2}$ | Channel separation <sup>(4)</sup> - $1\text{ kHz} \leq f \leq 20\text{ kHz}$                                                                                                     |          | 120   |          | dB                                   |

- $V_o = 1.4\text{ V}$ ,  $R_s = 0\text{ }\Omega$ ,  $5\text{ V} < V_{CC}^+ < 30\text{ V}$ ,  $0 < V_{ic} < V_{CC}^+ - 1.5\text{ V}$
- The direction of the input current is out of the IC. This current is essentially constant, independent of the state of the output so there is no load change on the input lines.
- The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than  $0.3\text{ V}$ . The upper end of the common-mode voltage range is  $V_{CC}^+ - 1.5\text{ V}$ , but either or both inputs can go to  $+32\text{ V}$  without damage.
- Due to the proximity of external components, ensure that there is no coupling originating from stray capacitance between these external parts. Typically, this can be detected at higher frequencies because this type of capacitance increases.

Figure 3. Input bias current vs. temperature

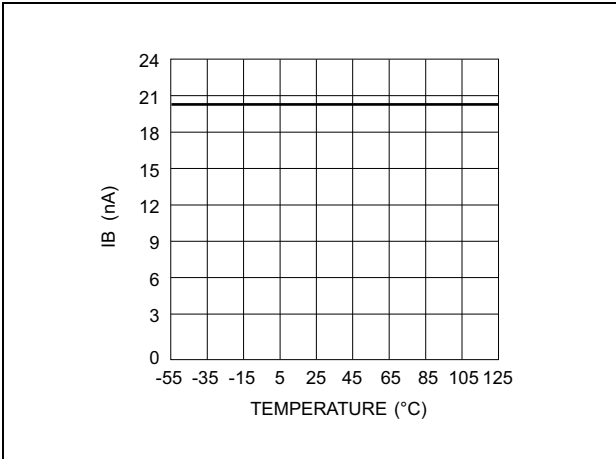


Figure 4. Output current limitation

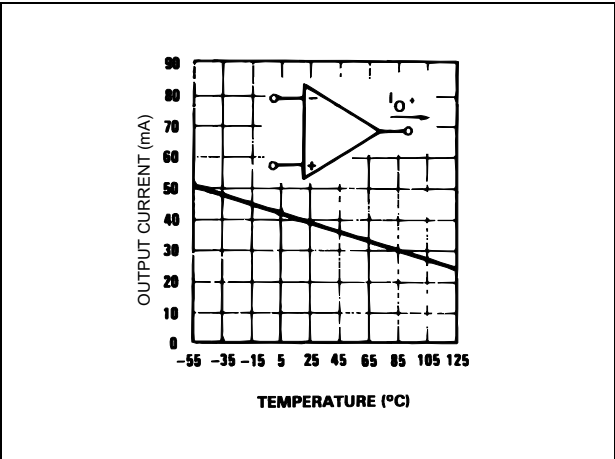


Figure 5. Input voltage range

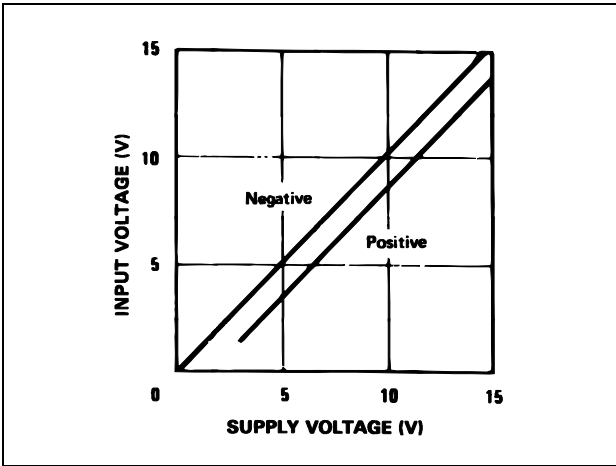


Figure 6. Supply current vs. supply voltage

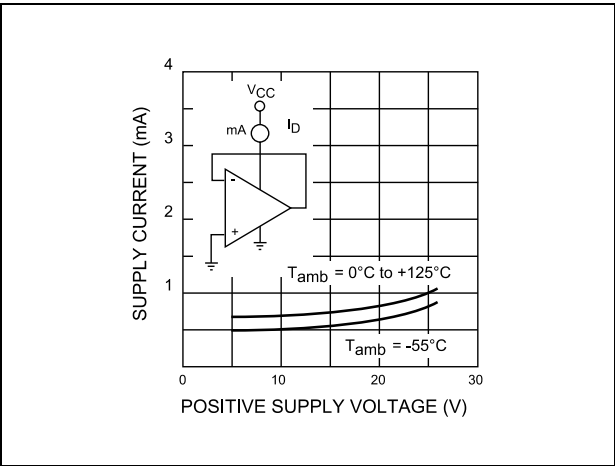


Figure 7. Gain bandwidth product vs. temperature

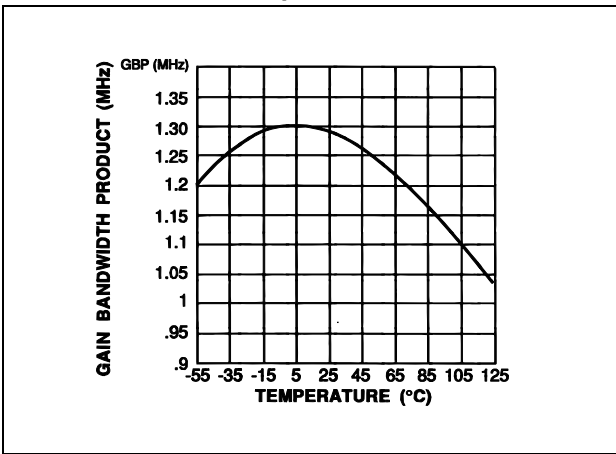


Figure 8. Common mode rejection ratio

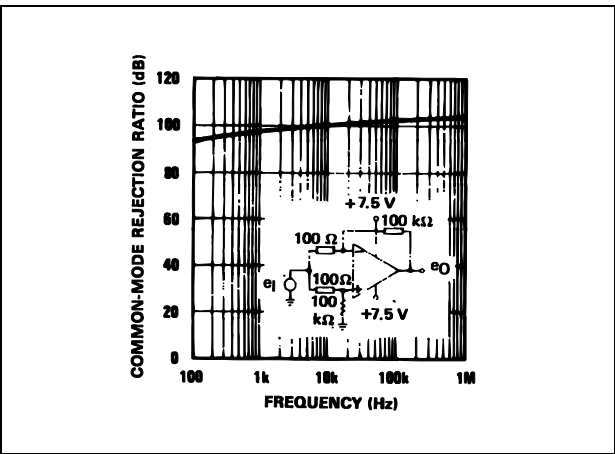


Figure 9. Open loop frequency response

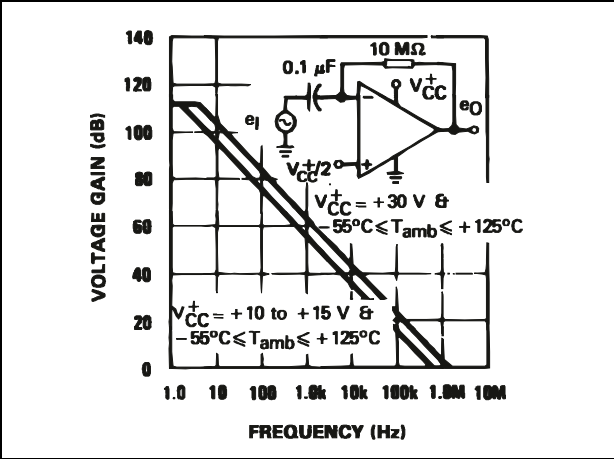


Figure 10. Large signal frequency response

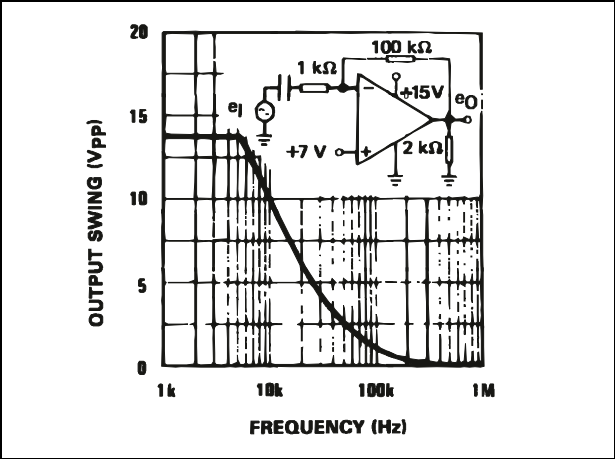


Figure 11. Voltage follower pulse response

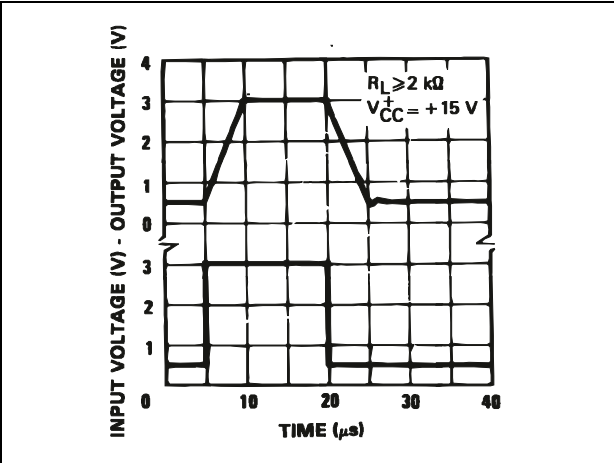


Figure 12. Output characteristics (current sinking)

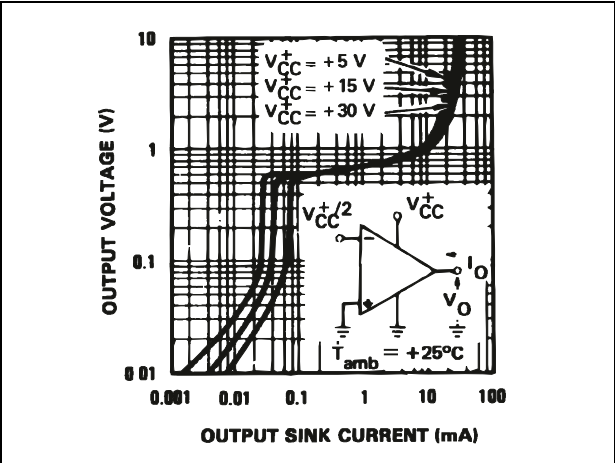


Figure 13. Voltage follower pulse response (small signal)

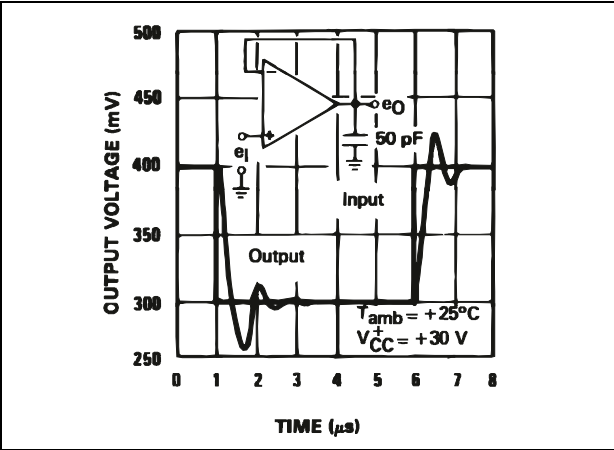


Figure 14. Output characteristics (current sourcing)

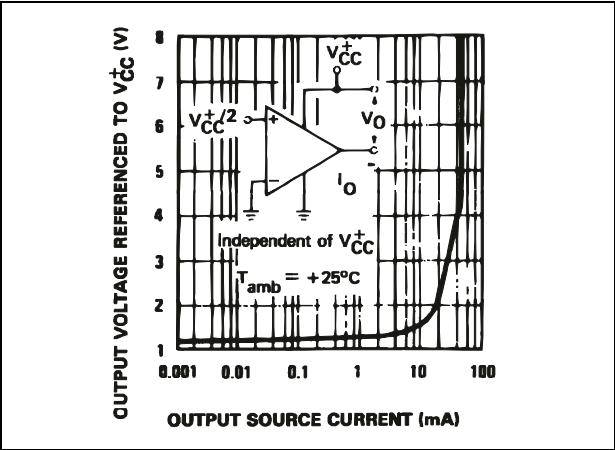


Figure 15. Input current vs. supply voltage

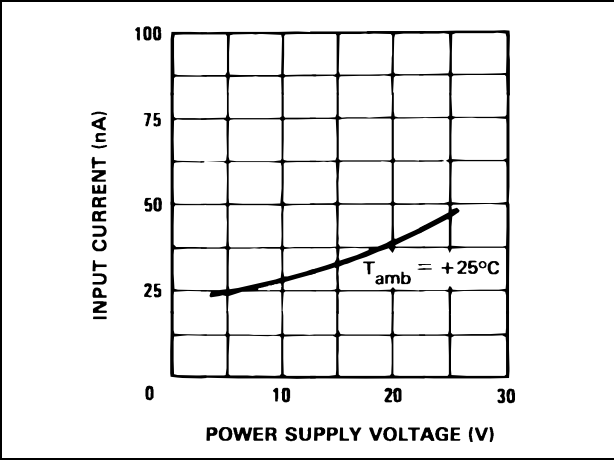


Figure 16. Large signal voltage gain vs. temperature

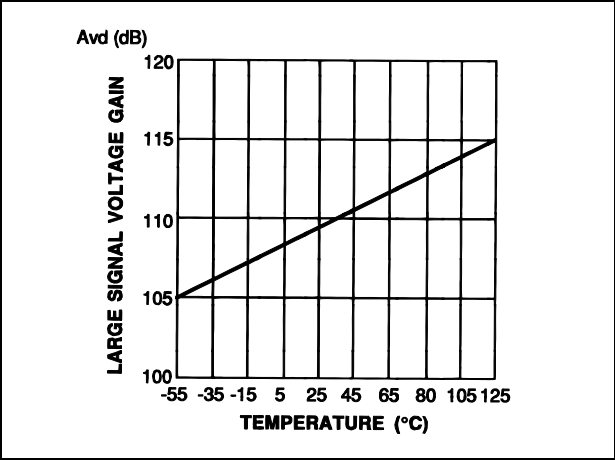


Figure 17. Power supply and common mode rejection ratio vs. temperature

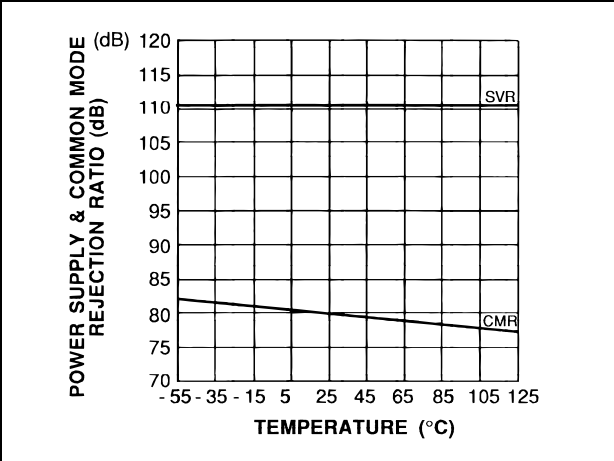
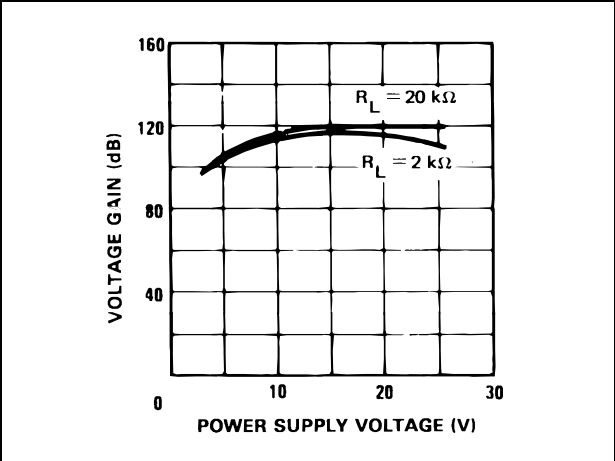


Figure 18. Voltage gain vs. supply voltage



## 4 Typical single-supply applications

Figure 19. AC coupled inverting amplifier

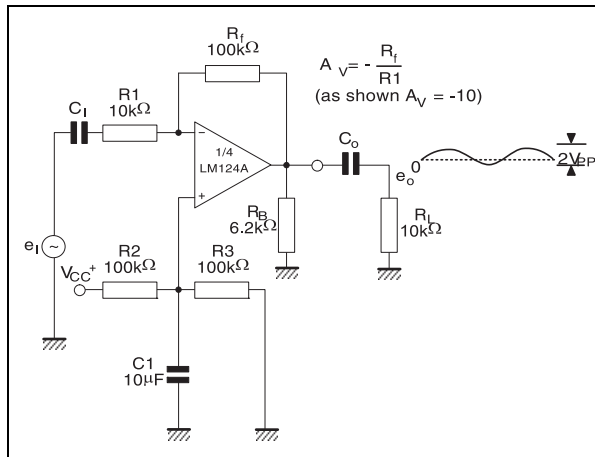


Figure 20. High input Z adjustable gain DC instrumentation amplifier

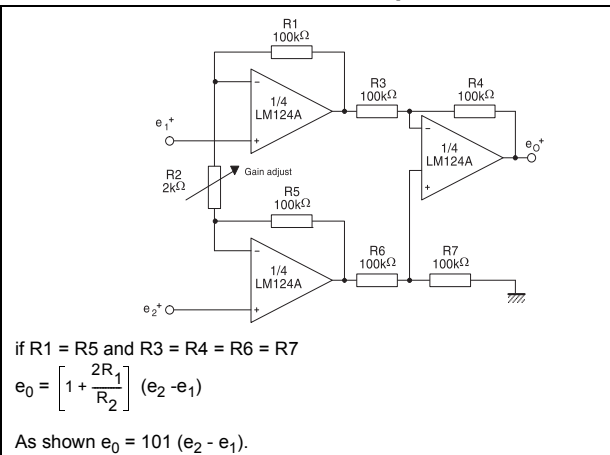


Figure 21. AC coupled non inverting amplifier

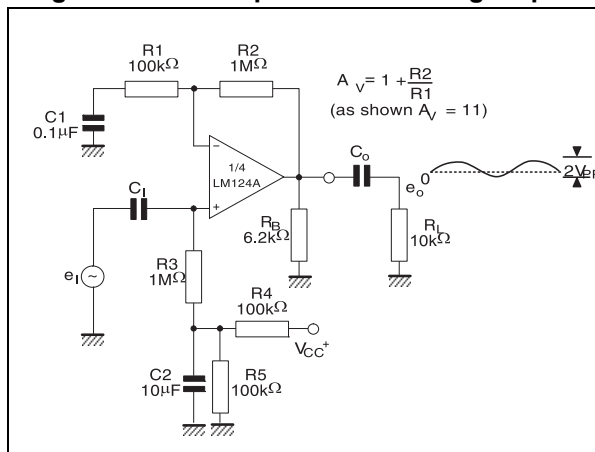


Figure 22. DC summing amplifier

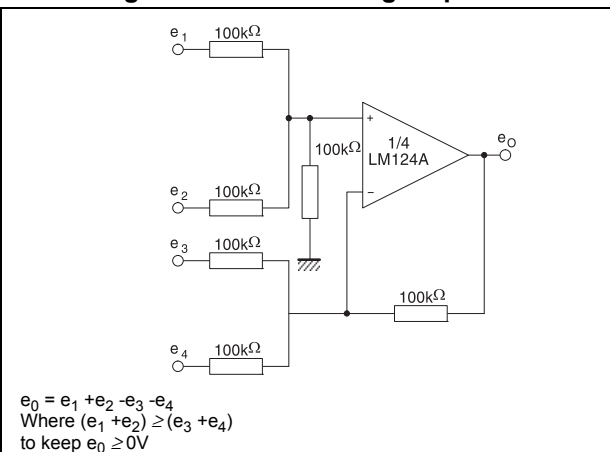


Figure 23. Non-inverting DC gain

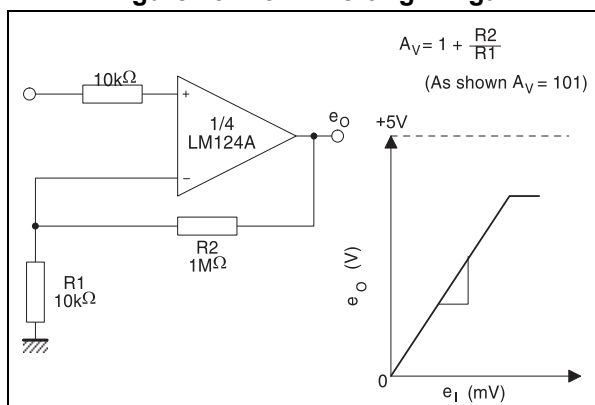


Figure 24. Low drift peak detector

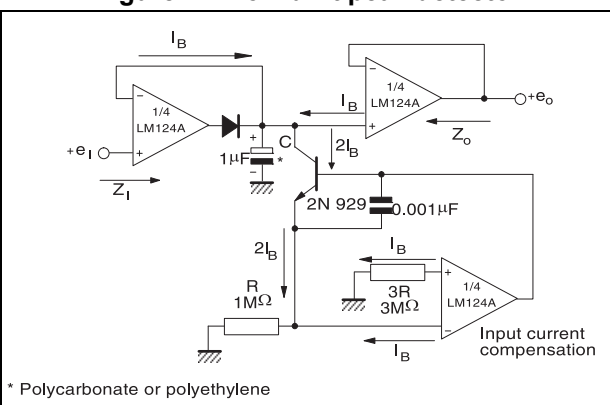


Figure 25. Active bandpass filter

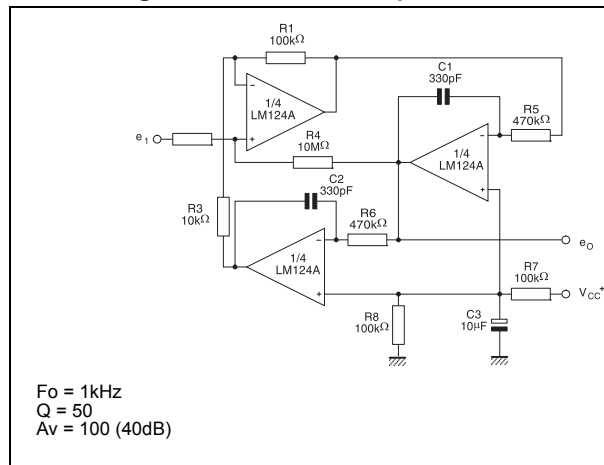
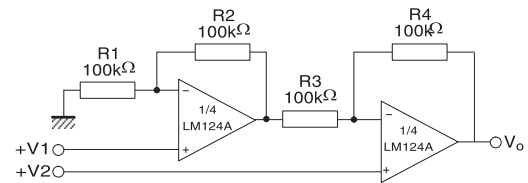


Figure 26. High input Z, DC differential amplifier

$$\text{For } \frac{R_1}{R_2} = \frac{R_4}{R_3}$$

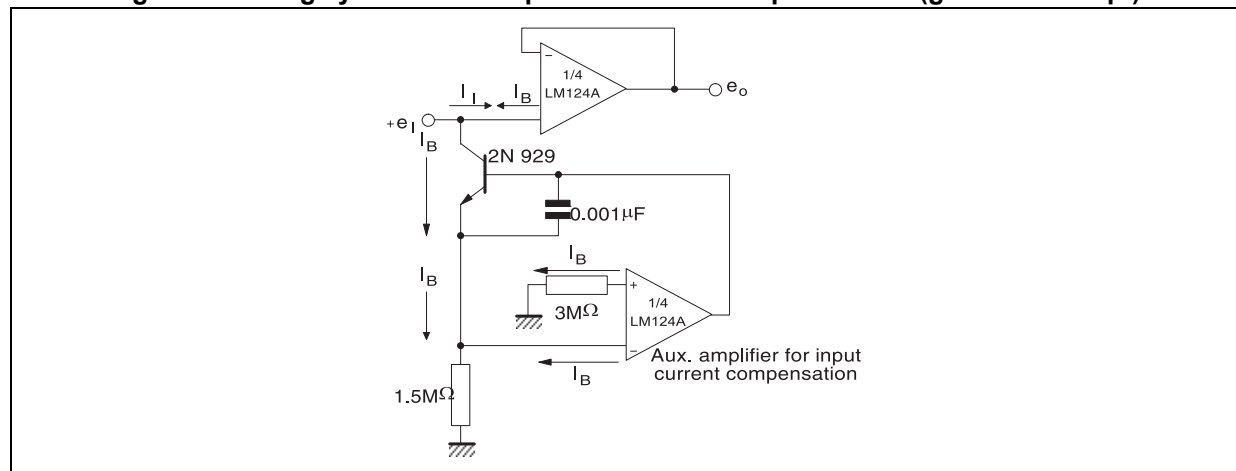
(CMRR depends on this resistor ratio match)



$$e_0 \left( 1 + \frac{R_4}{R_3} \right) (e_2 - e_1)$$

As shown  $e_0 = (e_2 - e_1)$

Figure 27. Using symmetrical amplifiers to reduce input current (general concept)



## 5 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.

## 5.1 SO14 package information

Figure 28. SO14 package mechanical drawing

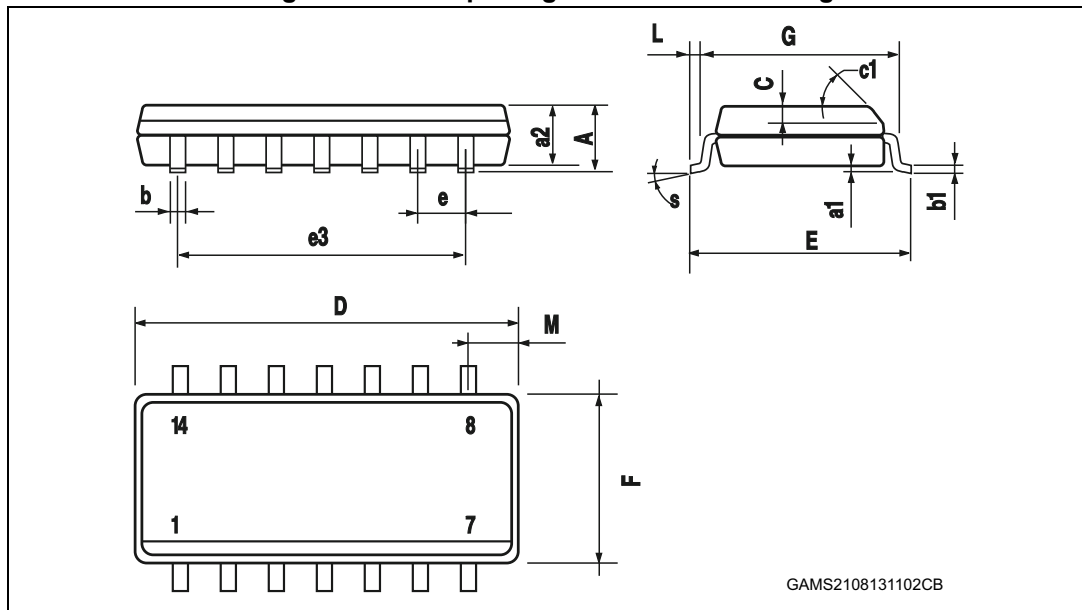


Figure 29. SO14 package mechanical data

| 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 ° |      |        | 45 °  |       |
| 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 °  |        |       | 8 °   |

## 5.2 TSSOP14 package information

Figure 30. TSSOP14 package mechanical drawing

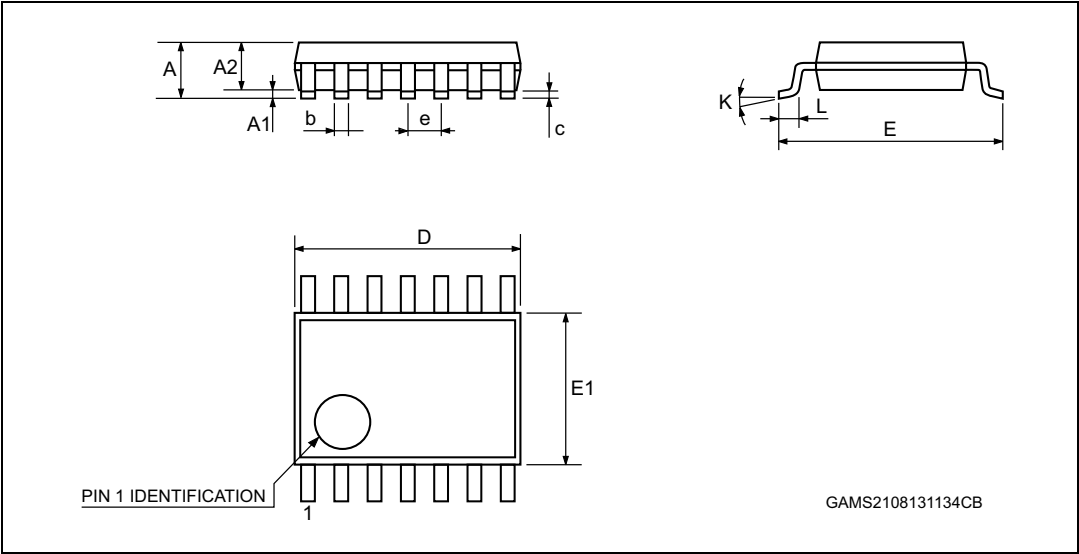


Figure 31. TSSOP14 package mechanical data

| 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 °    |
| L    | 0.45        | 0.60     | 0.75 | 0.018  | 0.024      | 0.030  |

## 6 Revision history

**Table 4. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1-Mar-2001  | 1        | First Release                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 1-Feb-2005  | 2        | Added explanation of $V_{id}$ and $V_i$ limits in <a href="#">Table 2 on page 4</a> .<br>Updated macromodel.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 1-Jun-2005  | 3        | ESD protection inserted in <a href="#">Table 2 on page 4</a> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 25-Sep-2006 | 4        | Editorial update.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 22-Aug-2013 | 5        | Removed DIP package and all information pertaining to it<br><a href="#">Table 1: Device summary</a> : Removed order codes LM224AN, LM224AD, LM324AN, and LM324AD; updated packaging.<br><a href="#">Table 2: Absolute maximum ratings</a> : removed N suffix power dissipation data; updated footnotes <a href="#">5</a> and <a href="#">6</a> .<br>Renamed <a href="#">Figure 3</a> , <a href="#">Figure 4</a> , <a href="#">Figure 6</a> , <a href="#">Figure 7</a> , <a href="#">Figure 16</a> , <a href="#">Figure 17</a> , <a href="#">Figure 18</a> , and <a href="#">Figure 19</a> .<br>Updated axes titles of <a href="#">Figure 4</a> , <a href="#">Figure 5</a> , <a href="#">Figure 7</a> , and <a href="#">Figure 17</a> .<br>Removed duplicate figures.<br>Removed <a href="#">Section 5: Macromodels</a> |
| 06-Dec-2013 | 6        | <a href="#">Table 2: Absolute maximum ratings</a> : updated ESD data for HBM and MM.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

**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.**

**ST PRODUCTS ARE NOT DESIGNED OR AUTHORIZED FOR USE IN: (A) SAFETY CRITICAL APPLICATIONS SUCH AS LIFE SUPPORTING, ACTIVE IMPLANTED DEVICES OR SYSTEMS WITH PRODUCT FUNCTIONAL SAFETY REQUIREMENTS; (B) AERONAUTIC APPLICATIONS; (C) AUTOMOTIVE APPLICATIONS OR ENVIRONMENTS, AND/OR (D) AEROSPACE APPLICATIONS OR ENVIRONMENTS. WHERE ST PRODUCTS ARE NOT DESIGNED FOR SUCH USE, THE PURCHASER SHALL USE PRODUCTS AT PURCHASER'S SOLE RISK, EVEN IF ST HAS BEEN INFORMED IN WRITING OF SUCH USAGE, UNLESS A PRODUCT IS EXPRESSLY DESIGNATED BY ST AS BEING INTENDED FOR "AUTOMOTIVE, AUTOMOTIVE SAFETY OR MEDICAL" INDUSTRY DOMAINS ACCORDING TO ST PRODUCT DESIGN SPECIFICATIONS. PRODUCTS FORMALLY ESCC, QML OR JAN QUALIFIED ARE DEEMED SUITABLE FOR USE IN AEROSPACE BY THE CORRESPONDING GOVERNMENTAL AGENCY.**

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.

© 2013 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)