

## Low power quad operational amplifier

### Features

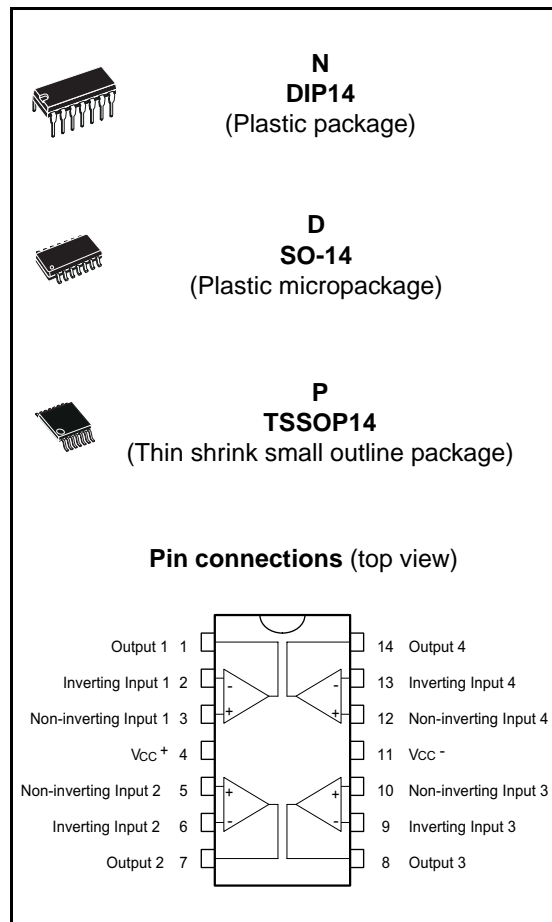
- Wide gain bandwidth: 1.3MHz
- Input common-mode voltage range includes negative rail
- Large voltage gain: 100dB
- Very low supply current per amp: 375 $\mu$ A
- Low input bias current: 20nA
- Low input offset current: 2nA
- ESD internal protection: 800V
- Wide power supply range:
- Single supply: +3V to +30V
- Dual supplies:  $\pm$ 1.5V to  $\pm$ 15V

### Description

This circuit consists of four independent, high-gain, internally frequency-compensated operational amplifiers designed especially for automotive and industrial control systems.

It operates 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.

All the pins are protected against electrostatic discharges up to 800V.



# 1 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings**

| Symbol     | Parameter   | Value                    | Unit |
|------------|---|--------------------------|------|
| $V_{CC}$   | Supply voltage  | $\pm 16$ to 32           | V    |
| $V_{id}$   | Differential input voltage                            | +32                      | V    |
| $V_i$      | Input voltage   | -0.3 to $V_{CC}^+ + 0.3$ | V    |
|            | Output short-circuit to ground <sup>(1)</sup>         | Infinite                 |      |
| $I_{in}$   | Input current <sup>(2)</sup>                          | 50                       | mA   |
| $T_{stg}$  | Storage temperature range                             | -65 to +150              | °C   |
| $R_{thja}$ | Thermal resistance junction to ambient <sup>(3)</sup> |                          | °C/W |
|            | SO-14   | 105                      |      |
|            | TSSOP14<br>DIP14                                      | 100<br>80                |      |
| $R_{thjc}$ | Thermal resistance junction to case <sup>(3)</sup>    |                          | °C/W |
|            | SO-14   | 31                       |      |
|            | TSSOP14<br>DIP14                                      | 32<br>33                 |      |
| ESD        | HBM: human body model <sup>(4)</sup>                  | 800                      | V    |
|            | MM: machine model <sup>(5)</sup>                      | 100                      | V    |
|            | CDM: charged device model <sup>(6)</sup>              | 1500                     | V    |

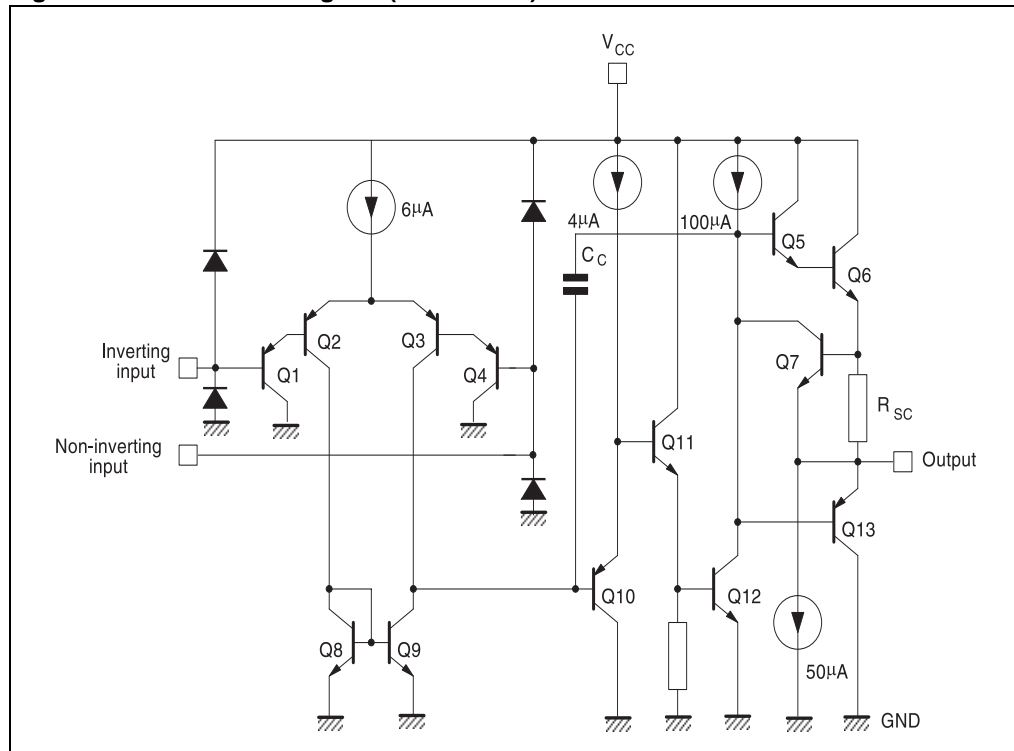
- Short-circuits from the output to  $V_{CC}^+$  can cause excessive heating and potential destruction. The maximum output current is approximately 20mA, independent of the magnitude of  $V_{CC}^+$ .
- This input current only exists when the voltage at any of the input leads is driven negative. It is 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 is restored for input voltages higher than -0.3V.
- $R_{thja/c}$  are typical values.
- Human body model: A 100pF capacitor is charged to the specified voltage, then discharged through a 1.5k $\Omega$  resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
- Machine model: A 200pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 $\Omega$ ). This is done for all couples of connected pin combinations while the other pins are floating.
- Charged device model: all pins and the package are charged together to the specified voltage and then discharged directly to the ground through only one pin. This is done for all pins.

**Table 2. Operating conditions**

| Symbol     | Parameter  | Value  | Unit |
|------------|--|--|------|
| $V_{CC}$   | Supply voltage   | 3 to 30  | V    |
| $V_{icm}$  | Common mode input voltage range<br>$T_{min} \leq T_{amb} \leq T_{max}$ | $V_{CC}^-$ to $V_{CC}^+ - 1.5$<br>$V_{CC}^-$ to $V_{CC}^+ - 2$ | V    |
| $T_{oper}$ | Operating free-air temperature range                                   | -40 to +125  | °C   |

## 2 Circuit schematics

Figure 1. Schematic diagram (1/4 LM2902)



### 3 Electrical characteristics

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

| Symbol            | Parameter                                | Test conditions  | Min.     | Typ. | Max. | Unit                         |
|-------------------|--|--|----------|------|------|------------------------------|
| $V_{i_o}$         | Input offset voltage <sup>(1)</sup>      | $T_{\text{amb}} = +25^\circ\text{C}$   |          | 2    | 7    | mV                           |
|                   |  | $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$   |          |      | 9    |                              |
| $DV_{i_o}$        | Input offset voltage drift               |  |          | 7    | 30   | $\mu\text{V}/^\circ\text{C}$ |
| $I_{i_o}$         | Input offset current                     | $T_{\text{amb}} = +25^\circ\text{C}$   |          | 2    | 30   | nA                           |
|                   |  | $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$   |          |      | 40   |                              |
| $DI_{i_o}$        | Input offset current drift               |  |          | 10   | 200  | $\text{pA}/^\circ\text{C}$   |
| $I_{i_b}$         | Input bias current <sup>(2)</sup>        | $T_{\text{amb}} = +25^\circ\text{C}$   |          | 20   | 150  | nA                           |
|                   |  | $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$   |          |      | 300  |                              |
| $A_{v_d}$         | Large signal voltage gain                | $V_{CC^+} = +15V$ , $R_L = 2k\Omega$ ,<br>$V_O = 1.4V$ to $11.4V$ , $T_{\text{amb}} = +25^\circ\text{C}$                                     | 50       | 100  |      | V/mV                         |
|                   |  | $V_{CC^+} = +15V$ , $R_L = 2k\Omega$ ,<br>$V_O = 1.4V$ to $11.4V$ ,<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$              | 25       |      |      |                              |
| SVR               | Supply voltage rejection ratio           | $R_S \leq 10k\Omega$ , $T_{\text{amb}} = +25^\circ\text{C}$  | 65       | 110  |      | dB                           |
|                   |  | $R_S \leq 10k\Omega$ , $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$  | 65       |      |      |                              |
| $I_{CC}$          | Supply current<br>(all op-amps, no load) | $T_{\text{amb}} = +25^\circ\text{C}$ , $V_{CC^+} = +5V$  |          | 0.7  | 1.2  | mA                           |
|                   |  | $T_{\text{amb}} = +25^\circ\text{C}$ , $V_{CC^+} = +30V$   |          | 1.5  | 3    |                              |
|                   |  | $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ , $V_{CC^+} = +5V$  |          | 0.9  | 1.2  |                              |
|                   |  | $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ , $V_{CC^+} = +30V$   |          | 1.5  | 3    |                              |
| CMR               | Common-mode rejection ratio              | $R_S \leq 10k\Omega$ , $T_{\text{amb}} = +25^\circ\text{C}$  | 70       | 80   |      | dB                           |
|                   |  | $R_S \leq 10k\Omega$ , $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$  | 60       |      |      |                              |
| $I_o$             | Output short-circuit current             | $V_{id} = +1V$ , $V_{CC^+} = +15V$ , $V_O = +2V$   | 20       | 40   | 70   | mA                           |
| $I_{\text{sink}}$ | Output sink current                      | $V_{id} = -1V$ , $V_{CC^+} = +15V$ , $V_O = +2V$   | 10       | 20   |      | mA                           |
|                   |  | $V_{id} = -1V$ , $V_{CC^+} = +15V$ , $V_O = +0.2V$   | 12       | 50   |      | $\mu\text{A}$                |
| $V_{OH}$          | High level output voltage                | $V_{CC^+} = 30V$ , $R_L = 2k\Omega$ ,<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                            |
|                   |  | $V_{CC^+} = 30V$ , $R_L = 10k\Omega$ ,<br>$T_{\text{amb}} = +25^\circ\text{C}$ ,<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | 27<br>27 | 28   |      |                              |
|                   |  | $V_{CC^+} = 5V$ , $R_L = 2k\Omega$ ,<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ ,<br>$T_{\text{amb}} = +25^\circ\text{C}$   | 3.5<br>3 |      |      |                              |
| $V_{OL}$          | Low level output voltage                 | $R_L = 10k\Omega$ , $T_{\text{amb}} = +25^\circ\text{C}$   |          | 5    | 20   | mV                           |
|                   |  | $R_L = 10k\Omega$ , $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$   |          |      | 20   |                              |

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

| Symbol          | Parameter                         | Test conditions   | Min.         | Typ.  | Max. | Unit            |
|-----------------|-----------------------------------|---|--------------|-------|------|-----------------|
| SR              | Slew rate                         | $V_{CC+} = 15V$ , $V_{in} = 0.5$ to $3V$ ,<br>$R_L = 2k\Omega$ , $C_L = 100pF$ , unity gain<br>$T_{min} < T_{op} < T_{max}$ | 0.24<br>0.14 | 0.4   |      | V/ $\mu$ s      |
| GBP             | Gain bandwidth product            | $V_{CC+} = 30V$ , $V_{in} = 10mV$ , $R_L = 2k\Omega$ ,<br>$C_L = 100pF$   |              | 1.3   |      | MHz             |
| THD             | Total harmonic distortion         | $f = 1kHz$ , $A_V = 20dB$ , $R_L = 2k\Omega$ ,<br>$V_o = 2V_{pp}$ , $C_L = 100pF$ , $V_{CC+} = 30V$                         |              | 0.015 |      | %               |
| $e_n$           | Equivalent input noise voltage    | $f = 1kHz$ , $R_S = 100\Omega$ , $V_{CC+} = 30V$  |              | 40    |      | nV/ $\sqrt{Hz}$ |
| $V_{O1}/V_{O2}$ | Channel separation <sup>(3)</sup> | $1kHz \leq f \leq 20kHz$  |              | 120   |      | dB              |

1.  $V_O = 1.4V$ ,  $R_S = 0\Omega$ ,  $5V < V_{CC+} < 30V$ ,  $0V < V_{ic} < V_{CC+} - 1.5V$ .

2. 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 change in the load on the input lines.

3. Due to the proximity of external components ensure that stray capacitance does not cause coupling between these external parts. This typically can be detected as this type of capacitance increases at higher frequencies.

Figure 2. Input bias current vs.  $T_{amb}$

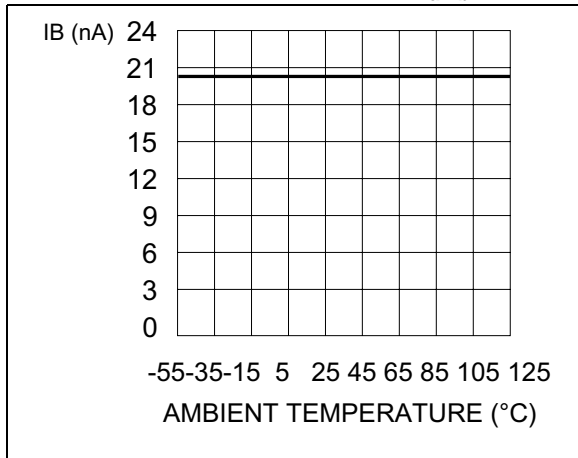


Figure 3. Input voltage range

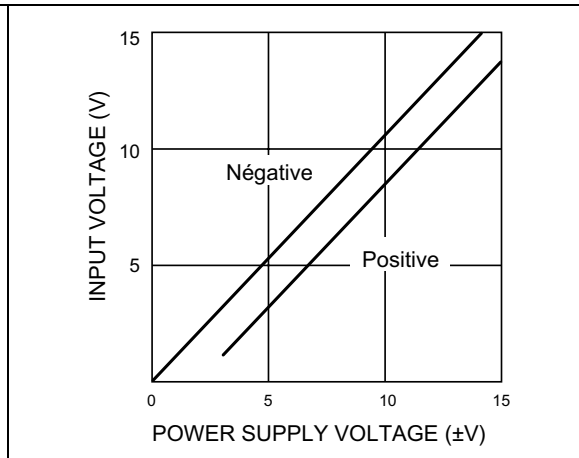


Figure 4. Current limiting

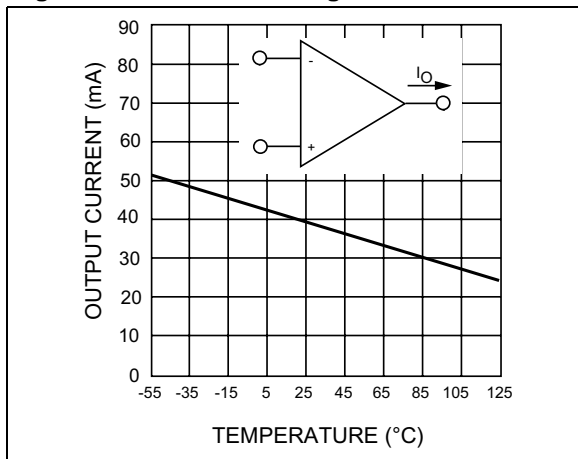


Figure 5. Supply current

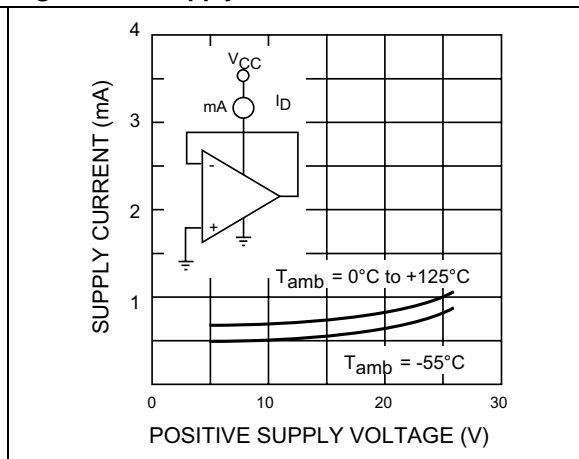


Figure 6. Gain bandwidth product

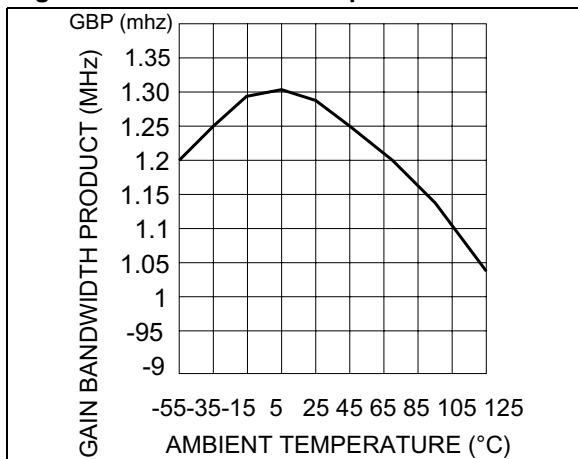


Figure 7. Voltage follower pulse response

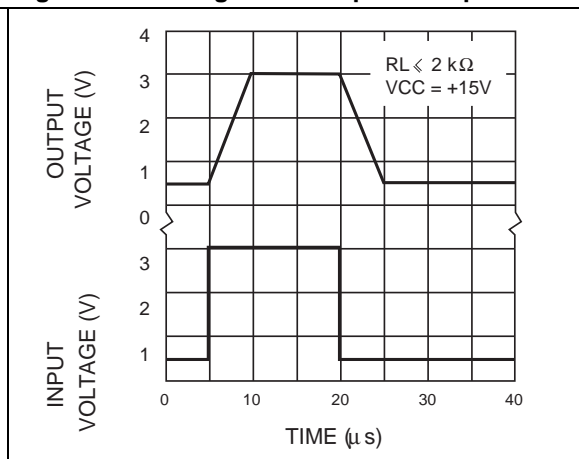


Figure 8. Common mode rejection ratio

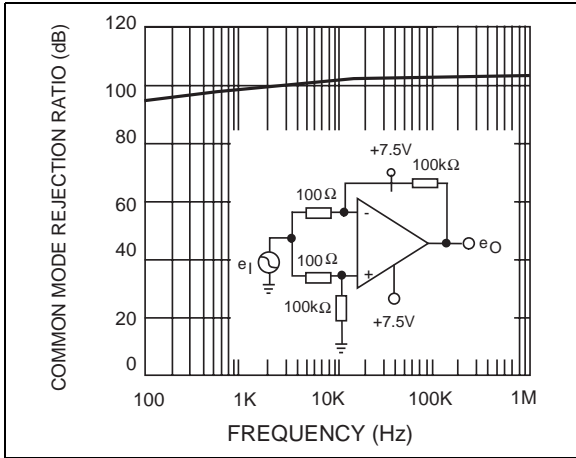


Figure 9. Output characteristics

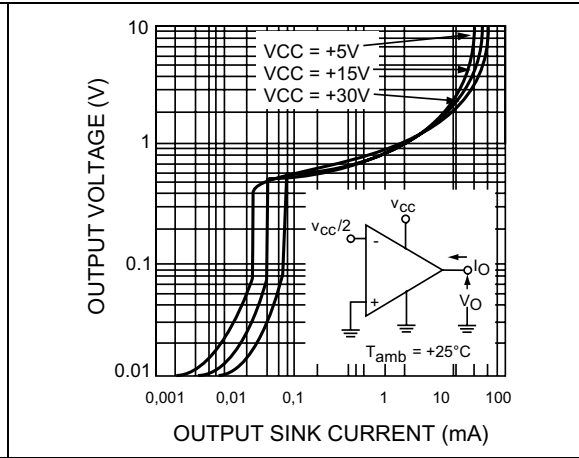


Figure 10. Open loop frequency response

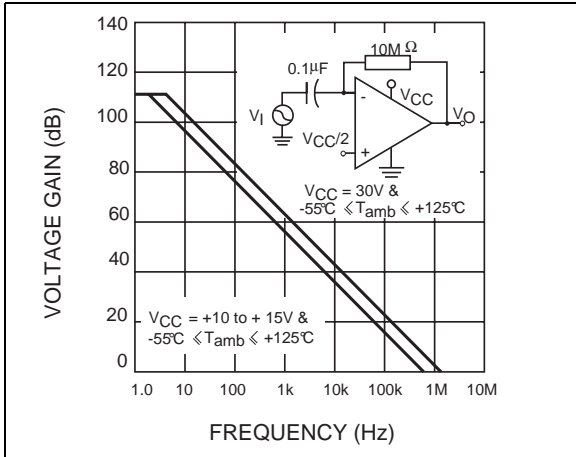


Figure 11. Voltage follower pulse response

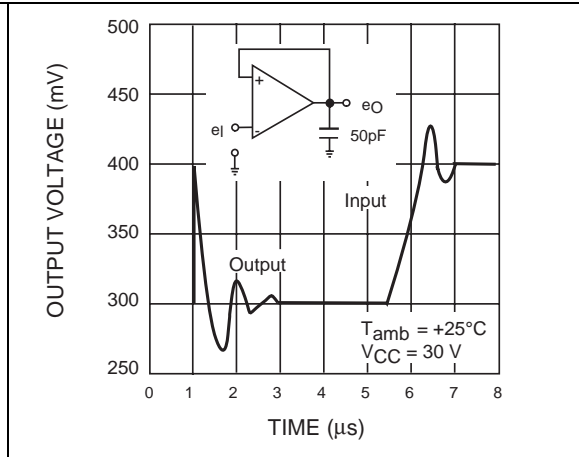


Figure 12. Large signal frequency response

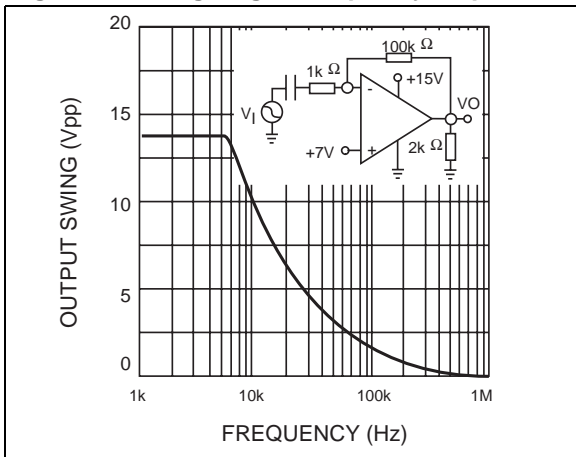


Figure 13. Output characteristics

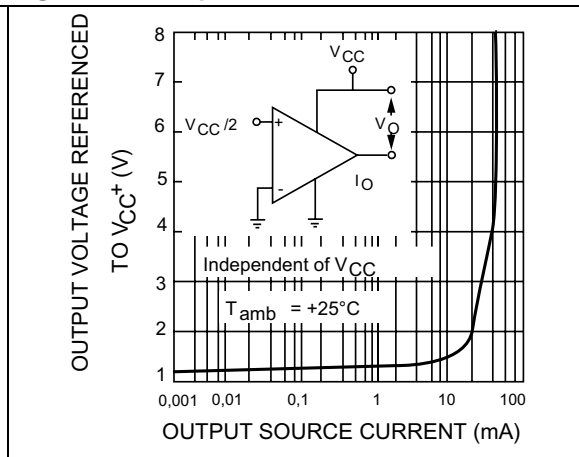


Figure 14. Input current

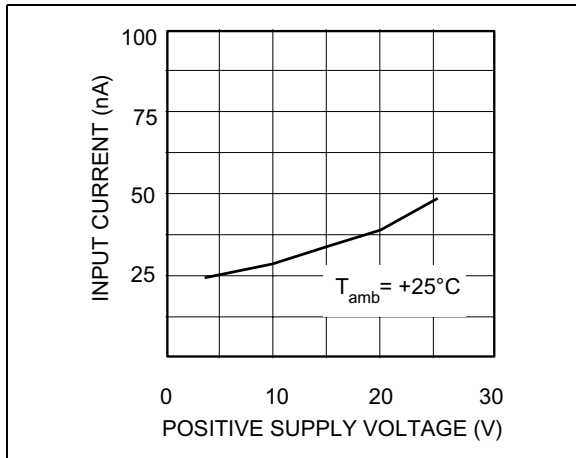


Figure 15. Voltage gain

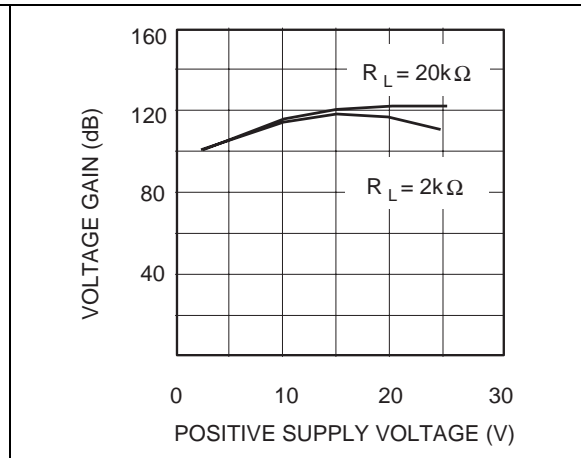


Figure 16. Power supply and common mode rejection ratio

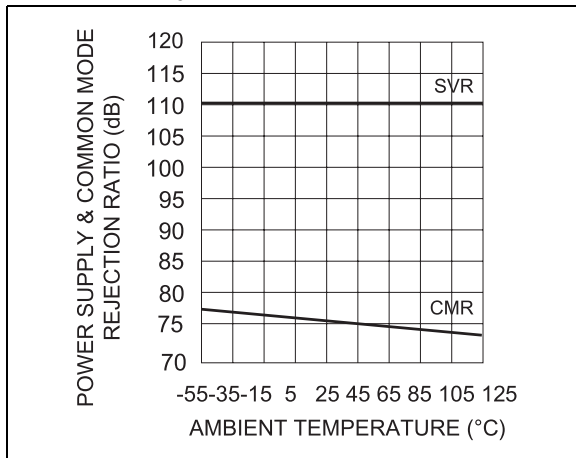
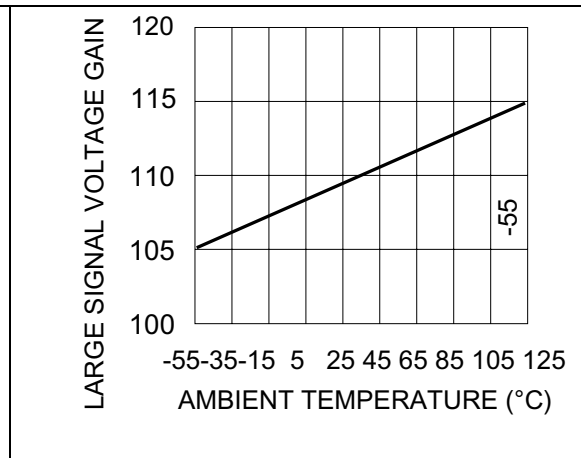


Figure 17. Large signal voltage gain





## 4 Typical single-supply applications

Figure 18. AC coupled inverting amplifier

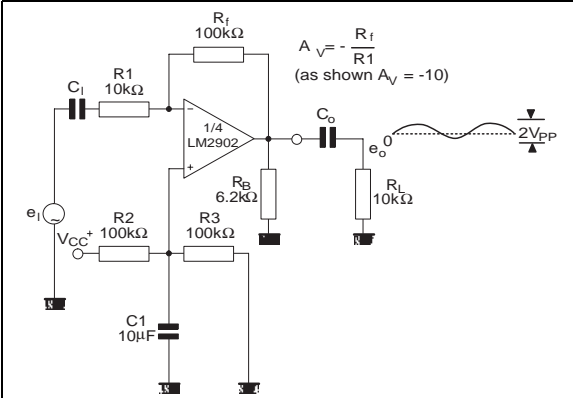


Figure 19. AC coupled non-inverting amplifier

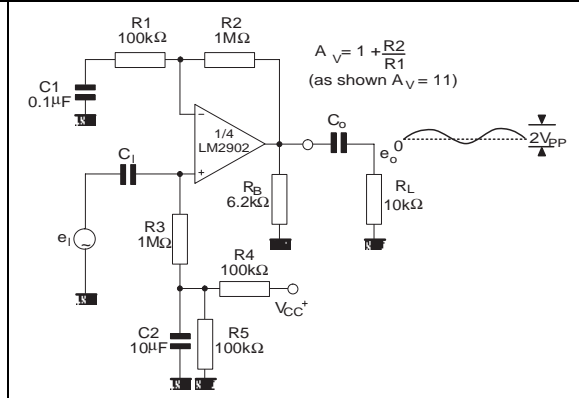


Figure 20. Non-inverting DC gain

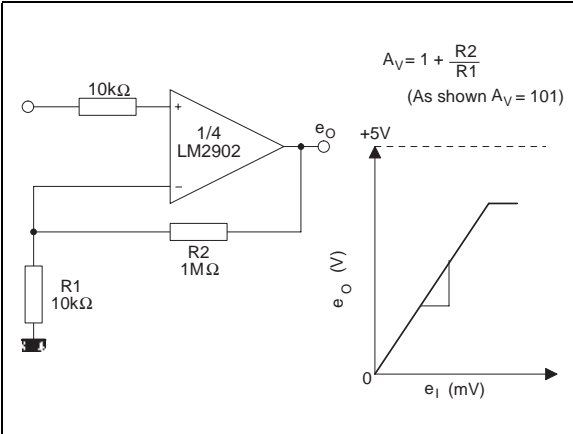


Figure 21. DC summing amplifier

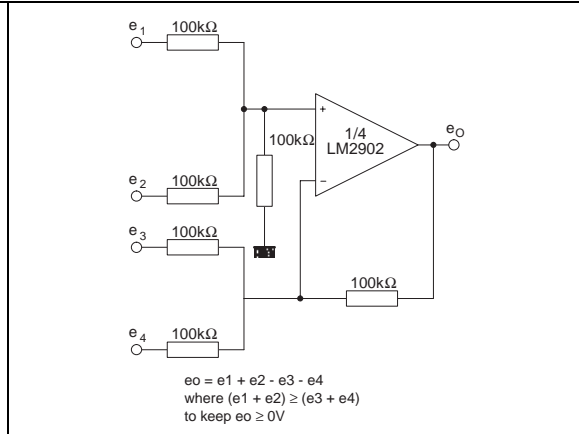


Figure 22. Active bandpass filter

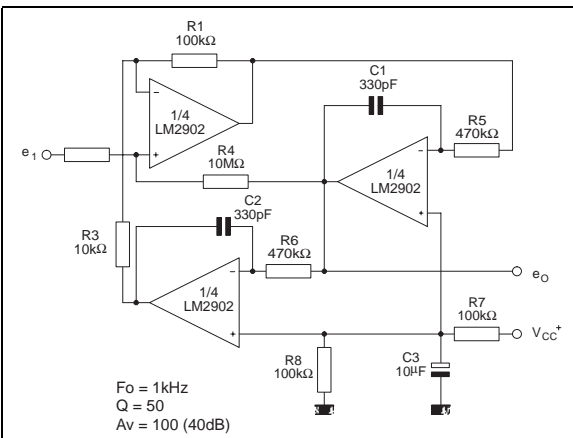


Figure 23. High input Z adjustable gain DC instrumentation amplifier

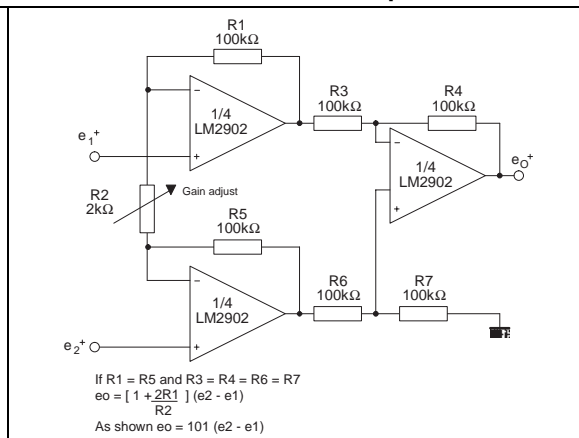


Figure 24. High input Z, DC differential amplifier

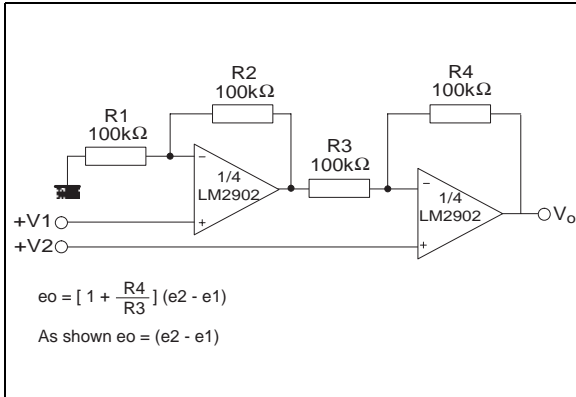


Figure 25. Low drift peak detector

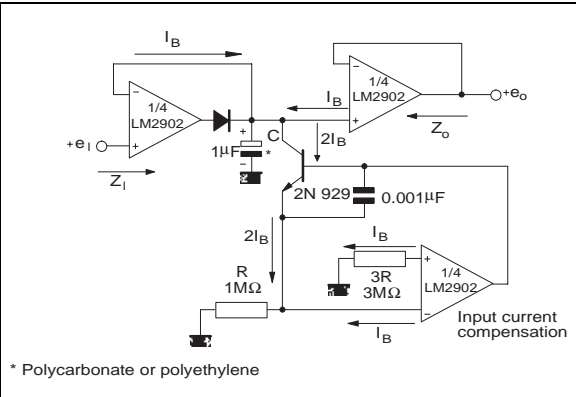
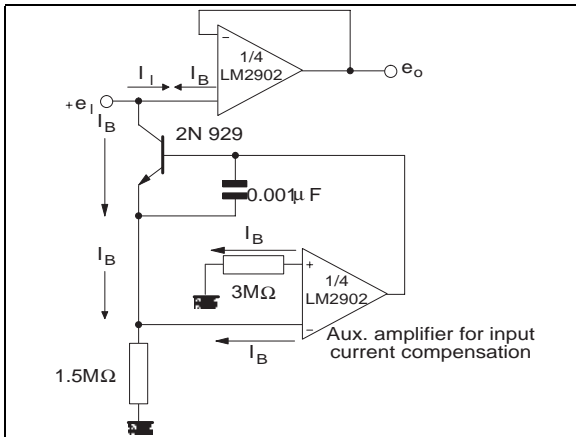


Figure 26. Using symmetrical amplifiers to reduce input current (general concept)



## 5 Macromodel

### 5.1 Important note concerning this macromodel

Please consider the following remarks before using this macromodel.

- All models are a trade-off between accuracy and complexity (i.e. simulation time).
- Macromodels are not a substitute to breadboarding; rather, they confirm the validity of a design approach and help to select surrounding component values.
- A macromodel emulates the **nominal** performance of a **typical** device within **specified operating conditions** (temperature, supply voltage, for example). Thus the macromodel is often not as exhaustive as the datasheet, its purpose is to illustrate the main parameters of the product.

Data derived from macromodels used outside of the specified conditions ( $V_{CC}$ , temperature, for example) or even worse, outside of the device operating conditions ( $V_{CC}$ ,  $V_{icm}$ , for example), is not reliable in any way.

### 5.2 Macromodel code

```
** Standard Linear Ics Macromodels, 1993.
** ESD diodes added to the initial macromodel (2007).
** CONNECTIONS :
* 1 INVERTING INPUT
* 2 NON-INVERTING INPUT
* 3 OUTPUT
* 4 POSITIVE POWER SUPPLY
* 5 NEGATIVE POWER SUPPLY
.SUBCKT LM2902W 1 2 3 4 5
*****
.MODEL MDTH D IS=1E-8 KF=3.104131E-15 CJO=10F
D1A 1 4 MDTH 400E-12
D1B 5 1 MDTH 400E-12
D2A 2 4 MDTH 400E-12
D2B 5 2 MDTH 400E-12
* INPUT STAGE
CIP 2 5 1.000000E-12
CIN 1 5 1.000000E-12
EIP 10 5 2 5 1
EIN 16 5 1 5 1
RIP 10 11 2.600000E+01
RIN 15 16 2.600000E+01
RIS 11 15 2.003862E+02
DIP 11 12 MDTH 400E-12
DIN 15 14 MDTH 400E-12
VOFP 12 13 DC 0
VOFN 13 14 DC 0
IPOL 13 5 1.000000E-05
CPS 11 15 3.783376E-09
DINN 17 13 MDTH 400E-12
VIN 17 5 0.000000e+00
```

```
DINR 15 18 MDTH 400E-12
VIP 4 18 2.000000E+00
FCP 4 5 VOFP 3.400000E+01
FCN 5 4 VOFN 3.400000E+01
FIBP 2 5 VOFN 2.000000E-03
FIBN 5 1 VOFP 2.000000E-03
* AMPLIFYING STAGE
FIP 5 19 VOFP 3.600000E+02
FIN 5 19 VOFN 3.600000E+02
RG1 19 5 3.652997E+06
RG2 19 4 3.652997E+06
CC 19 5 6.000000E-09
DOPM 19 22 MDTH 400E-12
DONM 21 19 MDTH 400E-12
HOPM 22 28 VOUT 7.500000E+03
VIPM 28 4 1.500000E+02
HONM 21 27 VOUT 7.500000E+03
VINM 5 27 1.500000E+02
EOUT 26 23 19 5 1
VOUT 23 5 0
ROUT 26 3 20
COUT 3 5 1.000000E-12
DOP 19 25 MDTH 400E-12
VOP 4 25 2.242230E+00
DON 24 19 MDTH 400E-12
VON 24 5 7.922301E-01
.ENDS
```

## 6 Package information

In order to meet environmental requirements, STMicroelectronics offers these devices in ECOPACK<sup>®</sup> 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).

### 6.1 DIP14 package information

Figure 27. DIP14 package mechanical drawing

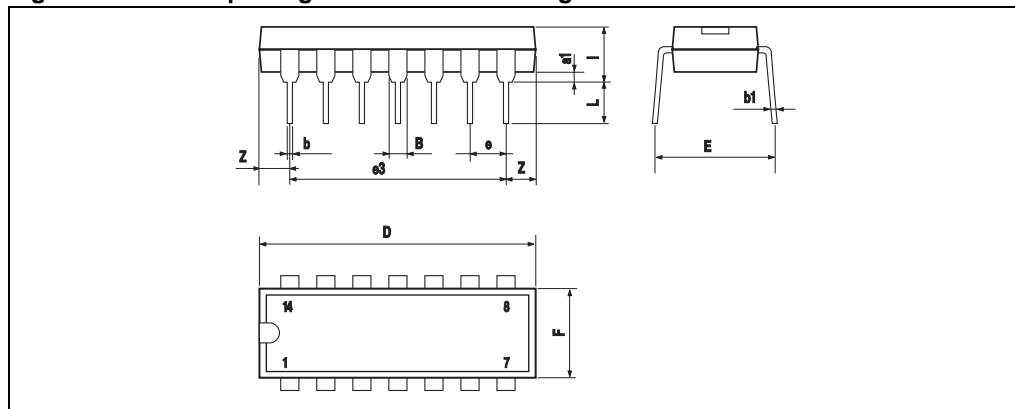


Table 4. DIP14 package mechanical data

| Ref. | Dimensions  |       |      |        |       |       |
|------|-------------|-------|------|--------|-------|-------|
|      | Millimeters |       |      | Inches |       |       |
|      | Min.        | Typ.  | Max. | Min.   | Typ.  | Max.  |
| a1   | 0.51        |       |      | 0.020  |       |       |
| B    | 1.39        |       | 1.65 | 0.055  |       | 0.065 |
| b    |             | 0.5   |      |        | 0.020 |       |
| b1   |             | 0.25  |      |        | 0.010 |       |
| D    |             |       | 20   |        |       | 0.787 |
| E    |             | 8.5   |      |        | 0.335 |       |
| e    |             | 2.54  |      |        | 0.100 |       |
| e3   |             | 15.24 |      |        | 0.600 |       |
| F    |             |       | 7.1  |        |       | 0.280 |
| l    |             |       | 5.1  |        |       | 0.201 |
| L    |             | 3.3   |      |        | 0.130 |       |
| Z    | 1.27        |       | 2.54 | 0.050  |       | 0.100 |

## 6.2 SO-14 package information

Figure 28. SO-14 package mechanical drawing

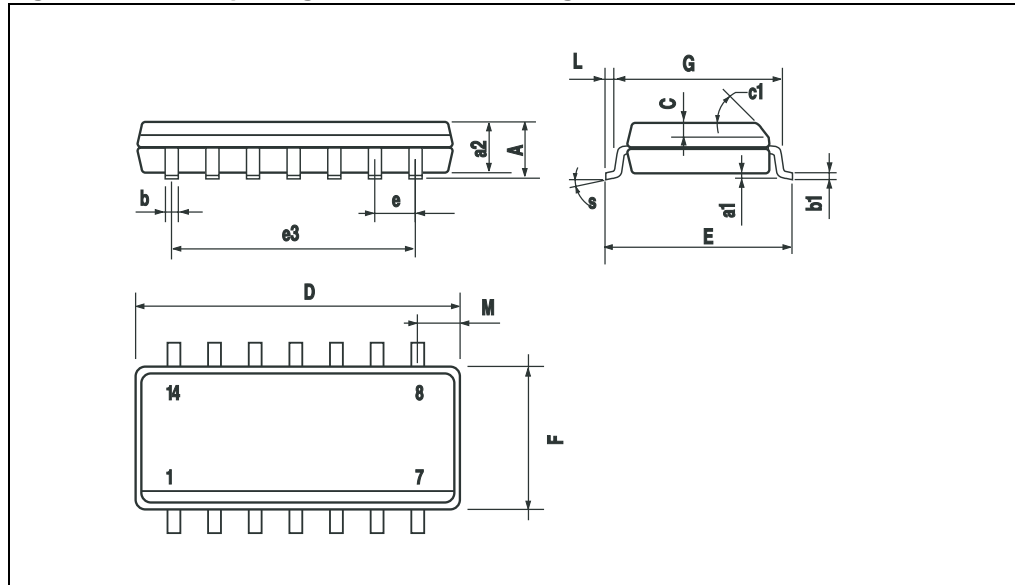


Table 5. SO-14 package mechanical data

| 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.)   |      |      |        |       |       |

### 6.3 TSSOP14 package information

Figure 29. TSSOP14 package mechanical drawing

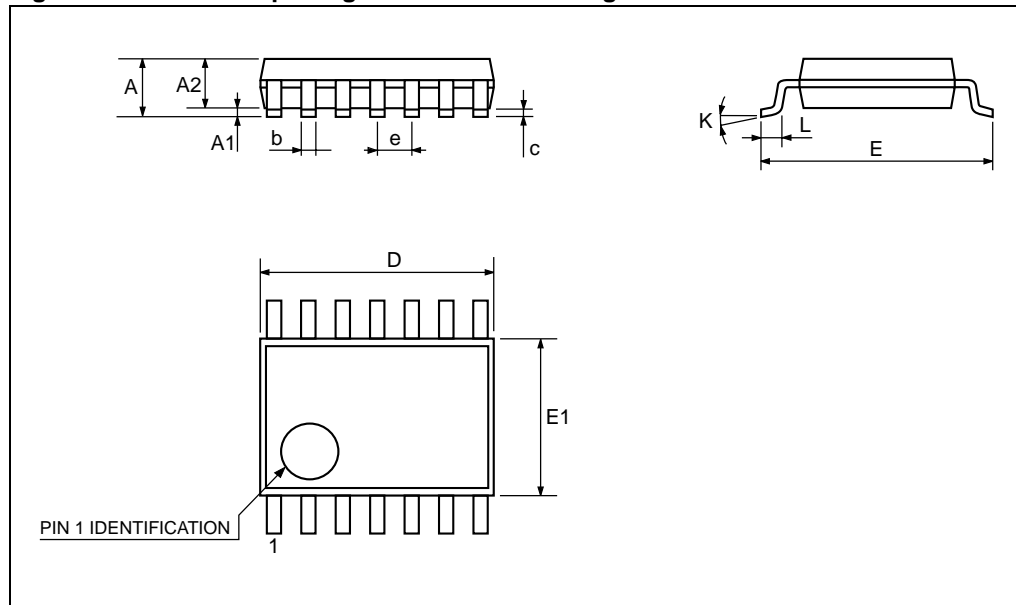


Table 6. TSSOP14 package mechanical data

| 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  |

## 7 Ordering information

Table 7. Order codes

| Order code                  | Temperature range | Package                             | Packing             | Marking |
|-----------------------------|-------------------|-------------------------------------|---------------------|---------|
| LM2902WN                    | -40°C to + 125°C  | DIP14                               | Tube                | 2902W   |
| LM2902WD/DT                 |                   | SO-14                               | Tube or tape & reel | 2902W   |
| LM2902WYD/DT <sup>(1)</sup> |                   | SO-14<br>(Automotive grade level)   |                     | 2902WY  |
| LM2902WPT                   |                   | TSSOP14                             | Tape & reel         | 2902W   |
| LM2902WYPT <sup>(2)</sup>   |                   | TSSOP14<br>(Automotive grade level) |                     | 2902WY  |

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

## 8 Revision history

Table 8. Document revision history

| Date        | Revision | Changes  |
|-------------|----------|--|
| 1-Sep-2003  | 1        | Initial release.   |
| 1-Nov-2005  | 2        | Table data reformatted for easier use in <a href="#">Electrical characteristics on page 4</a> .<br>Minor grammatical and formatting changes throughout.  |
| 1-Jan-2006  | 3        | LM2902WYPT PPAP reference inserted in order codes table, see <a href="#">Section 7 on page 16</a> .  |
| 1-May-2006  | 4        | Minimum value of slew rate at 25°C and on full temperature range added in <a href="#">Table 3 on page 4</a> .  |
| 20-Jul-2007 | 5        | Corrected document title to "quad operational amplifier".<br>Corrected ESD value for HBM to 800V.<br>Corrected thermal resistance junction to ambient values in <a href="#">Table 1: Absolute maximum ratings</a> .<br>Updated electrical characteristics curves.<br>Added <a href="#">Section 5: Macromodel</a> .<br>Added automotive grade order codes in <a href="#">Section 7 on page 16</a> . |
| 15-Jan-2008 | 6        | Corrected footnotes for automotive grade order codes.  |



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