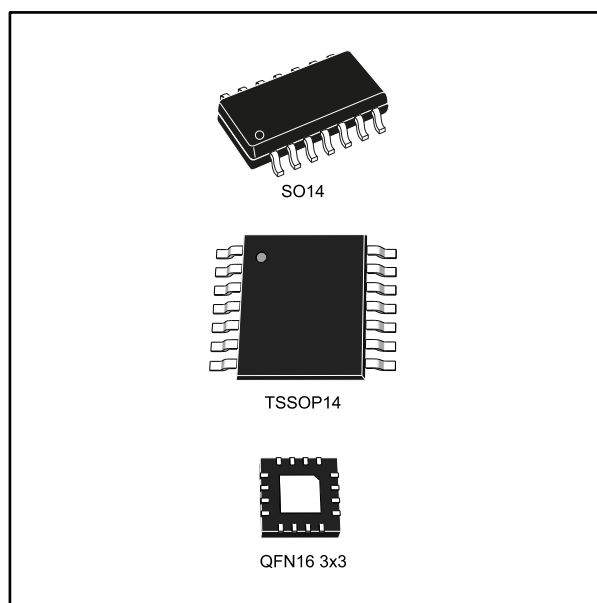


## Low-power quad operational amplifiers

Datasheet - production data



## Description

This circuit consists of four independent, high-gain operational amplifiers (op amps) which employ internal frequency compensation and are specifically designed for automotive and industrial control systems.

The device 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 from the power supply voltage magnitude.

## Features

- Wide gain bandwidth: 1.3 MHz
- Input common-mode voltage range includes negative rail
- Large voltage gain: 100 dB
- Supply current per amplifier: 375  $\mu$ A
- Low input bias current: 20 nA
- 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

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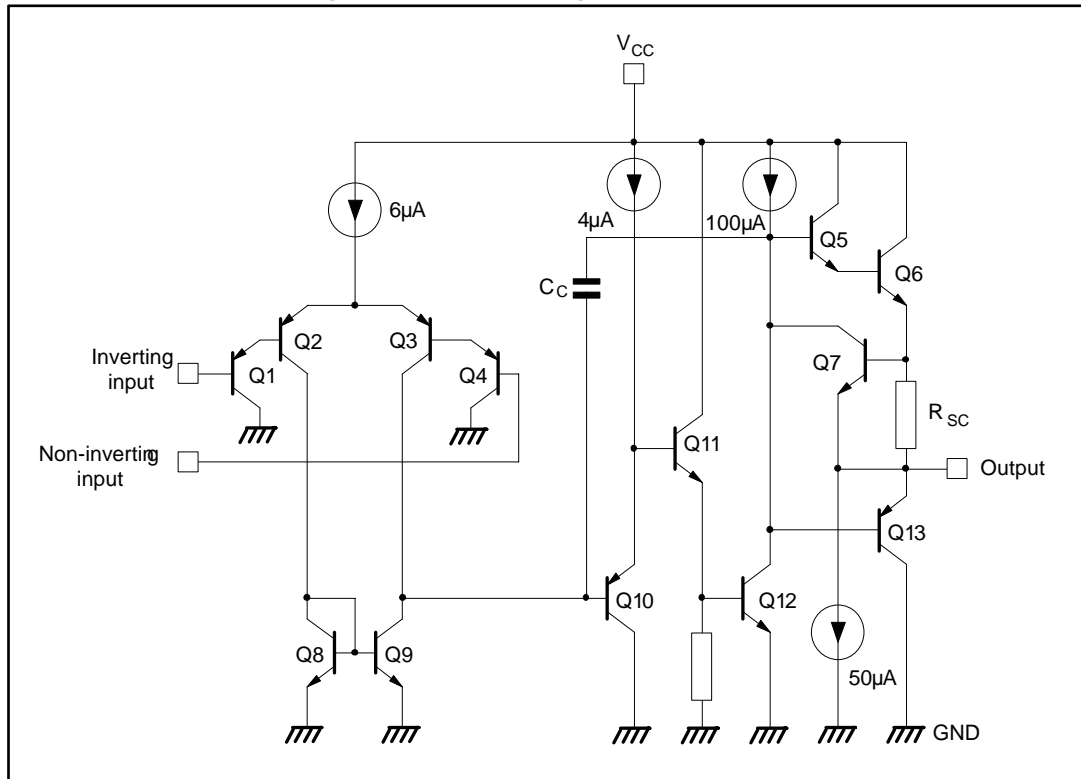
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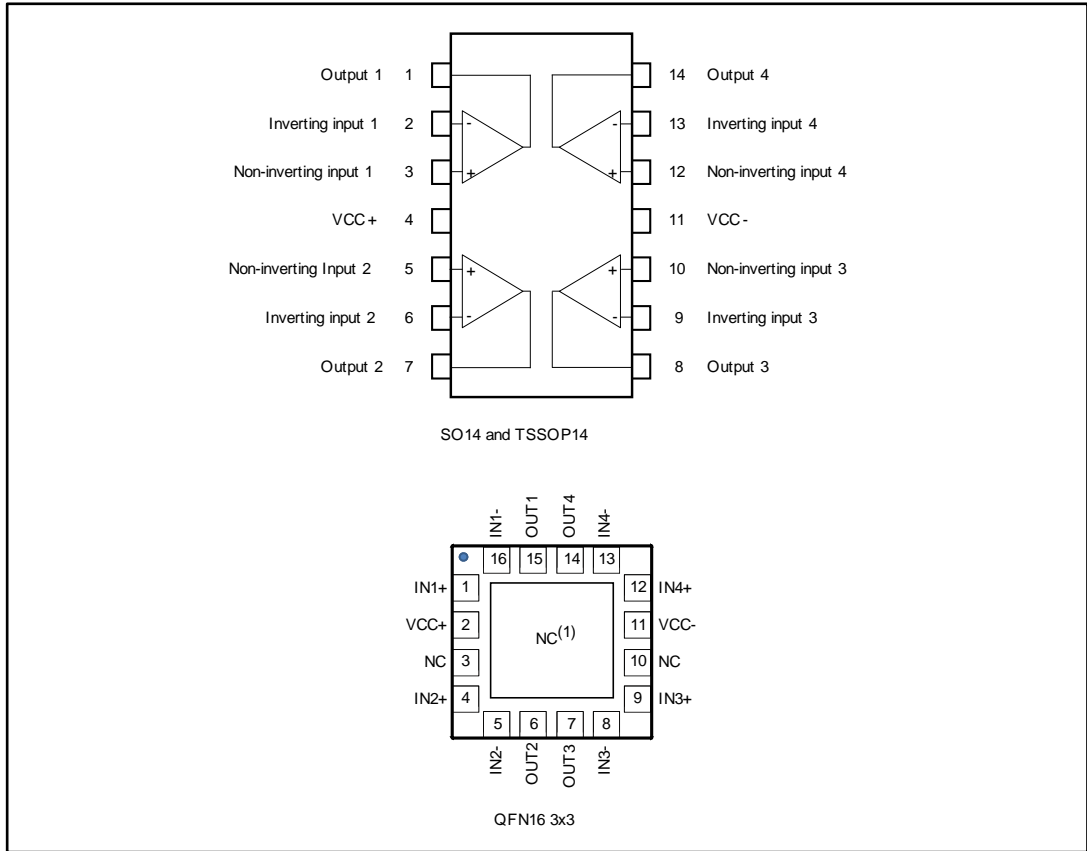
# 1 Schematic diagram

Figure 1: Schematic diagram (1/4 LM2902)



## 2 Pinout information

Figure 2: Package pin connections (top view)



1. The exposed pads of the QFN16 3x3 can be connected to VCC- or left floating.

### 3 Absolute maximum ratings and operating conditions

Table 1: Absolute maximum ratings (AMR)

| Symbol            | Parameter  | Value   | Unit |       |
|-------------------|--|---|------|-------|
| V <sub>CC</sub>   | Supply voltage <sup>(1)</sup>  | ± 16 to 32  | V    |       |
| V <sub>id</sub>   | Differential input voltage <sup>(2)</sup>                                      | 32  |      |       |
| V <sub>in</sub>   | Input voltage  | -0.3 to 32  |      |       |
|                   | Output short-circuit duration <sup>(3)</sup>                                   | Infinite  | s    |       |
| T <sub>j</sub>    | Maximum junction temperature   | 150   | ° C  |       |
| T <sub>stg</sub>  | Storage temperature range  | -65 to 150  |      |       |
| I <sub>in</sub>   | Input current : V <sub>in</sub> driven negative <sup>(4)</sup>                 | 5 in DC or 50 in AC<br>(duty cycle = 10 %, T = 1 s) | mA   |       |
|                   | Input current : V <sub>in</sub> driven positive above AMR value <sup>(5)</sup> | 0.4   |      |       |
| R <sub>thja</sub> | Thermal resistance junction-to-ambient <sup>(6)</sup>                          | SO14  | 105  | ° C/W |
|                   |  | TSSOP14   | 100  |       |
|                   |  | QFN16 3x3   | 45   |       |
| R <sub>thjc</sub> | Thermal resistance junction-to-case  | SO14  | 31   |       |
|                   |  | TSSOP14   | 32   |       |
|                   |  | QFN16 3x3   | 14   |       |
| ESD               | HBM: human body model <sup>(7)</sup>   | 370   | V    |       |
|                   | MM: machine model <sup>(8)</sup>   | 150   |      |       |
|                   | CDM: charged device model <sup>(9)</sup>                                       | 1500  |      |       |

#### Notes:

<sup>(1)</sup>All voltage values, except the differential voltage are with respect to the network ground terminal.

<sup>(2)</sup>Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.

<sup>(3)</sup>Short-circuits from the output to V<sub>CC</sub><sup>+</sup> can cause excessive heating and eventual destruction. The maximum output current is approximately 20 mA, independent of the magnitude of V<sub>CC</sub><sup>+</sup>.

<sup>(4)</sup>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 an input diode clamp. In addition to this diode action, there is an NPN parasitic action on the IC chip. This transistor action can cause the output voltages of the op amps to go to the V<sub>CC</sub> 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 above -0.3 V.

<sup>(5)</sup>The junction base/substrate of the input PNP transistor polarized in reverse must be protected by a resistor in series with the inputs to limit the input current to 400 μ A max (R = (V<sub>in</sub> - 36 V)/400 μ A).

<sup>(6)</sup>R<sub>thja/c</sub> are typical values.

<sup>(7)</sup>Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 kΩ resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.

<sup>(8)</sup>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.

<sup>(9)</sup>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 <sub>CC</sub>   | Supply voltage                       | 3 to 30   | V    |
| V <sub>icm</sub>  | Common mode input voltage range      | (V <sub>CC</sub> <sup>+</sup> ) - 1.5   |      |
|                   |                                      | $T_{\min} \leq T_{\text{amb}} \leq T_{\max}$<br>(V <sub>CC</sub> <sup>+</sup> ) - 2 |      |
| T <sub>oper</sub> | Operating free-air temperature range | -40 to 125  | °C   |

## 4 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 stated)

| Symbol                   | Parameter                            | Test conditions  | Min. | Typ.  | Max. | Unit                         |
|--------------------------|--------------------------------------|--|------|-------|------|------------------------------|
| $V_{iO}$                 | Input offset voltage <sup>(1)</sup>  | $T_{\text{amb}} = 25\text{ }^\circ\text{C}$  |      | 2     | 7    | mV                           |
|                          |                                      | $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$   |      |       | 9    |                              |
| $\Delta V_{iO}/\Delta T$ | Input offset voltage drift           |  |      | 7     | 30   | $\mu\text{V}/^\circ\text{C}$ |
| $I_{iO}$                 | Input offset current                 | $T_{\text{amb}} = 25\text{ }^\circ\text{C}$  |      | 2     | 30   | nA                           |
|                          |                                      | $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$   |      |       | 40   |                              |
| $DI_{iO}$                | Input offset current drift           |  |      | 10    | 200  | $\text{pA}/^\circ\text{C}$   |
| $I_{iB}$                 | Input bias current <sup>(2)</sup>    | $T_{\text{amb}} = 25\text{ }^\circ\text{C}$  |      | 20    | 150  | nA                           |
|                          |                                      | $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$   |      |       | 300  |                              |
| $A_{vd}$                 | Large signal voltage gain            | $V_{CC+} = 15\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $V_O = 1.4\text{ V to } 11.4\text{ V}$ , $T_{\text{amb}} = 25\text{ }^\circ\text{C}$              | 50   | 100   |      | V/mV                         |
|                          |                                      | $V_{CC+} = 15\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $V_O = 1.4\text{ V to } 11.4\text{ V}$ , $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | 25   |       |      |                              |
| SVR                      | Supply voltage rejection ratio       | $R_S \leq 10\text{ k}\Omega$ , $T_{\text{amb}} = 25\text{ }^\circ\text{C}$   | 65   | 110   |      | dB                           |
|                          |                                      | $R_S \leq 10\text{ k}\Omega$ , $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$  | 65   |       |      |                              |
| $I_{CC}$                 | Supply current, all op amps, no load | $T_{\text{amb}} = 25\text{ }^\circ\text{C}$ , $V_{CC+} = 5\text{ V}$   |      | 0.7   | 1.2  | mA                           |
|                          |                                      | $T_{\text{amb}} = 25\text{ }^\circ\text{C}$ , $V_{CC+} = 30\text{ V}$  |      | 1.5   | 3    |                              |
|                          |                                      | $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ , $V_{CC+} = 5\text{ V}$  |      | 0.8   | 1.2  |                              |
|                          |                                      | $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ , $V_{CC+} = 30\text{ V}$   |      | 1.5   | 3    |                              |
| CMR                      | Common-mode rejection ratio          | $R_S \leq 10\text{ k}\Omega$ , $T_{\text{amb}} = 25\text{ }^\circ\text{C}$   | 70   | 80    |      | dB                           |
|                          |                                      | $R_S \leq 10\text{ k}\Omega$ , $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$  | 60   |       |      |                              |
| $I_O$                    | Output short-circuit current         | $V_{iD} = 1\text{ V}$ , $V_{CC+} = 15\text{ V}$ , $V_O = 2\text{ V}$   | 20   | 40    | 70   | mA                           |
| $I_{\text{sink}}$        | Output sink current                  | $V_{iD} = -1\text{ V}$ , $V_{CC+} = 15\text{ V}$ , $V_O = 2\text{ V}$  | 10   | 20    |      | $\mu\text{A}$                |
|                          |                                      | $V_{iD} = -1\text{ V}$ , $V_{CC+} = 15\text{ V}$ , $V_O = 0.2\text{ V}$  | 12   | 50    |      |                              |
| $V_{OH}$                 | High-level output voltage            | $V_{CC+} = 30\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $T_{\text{amb}} = 25\text{ }^\circ\text{C}$   | 26   | 27    |      | V                            |
|                          |                                      | $V_{CC+} = 30\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$  | 26   |       |      |                              |
|                          |                                      | $V_{CC+} = 30\text{ V}$ , $R_L = 10\text{ k}\Omega$ , $T_{\text{amb}} = 25\text{ }^\circ\text{C}$  | 27   | 28    |      |                              |
|                          |                                      | $V_{CC+} = 30\text{ V}$ , $R_L = 10\text{ k}\Omega$ , $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$   | 27   |       |      |                              |
|                          |                                      | $V_{CC+} = 5\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $T_{\text{amb}} = 25\text{ }^\circ\text{C}$  | 3    |       |      |                              |
|                          |                                      | $V_{CC+} = 5\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$   | 3.5  |       |      |                              |
| $V_{OL}$                 | Low-level output voltage             | $R_L = 10\text{ k}\Omega$ , $T_{\text{amb}} = 25\text{ }^\circ\text{C}$  |      | 5     | 20   | mV                           |
|                          |                                      | $R_L = 10\text{ k}\Omega$ , $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$   |      |       | 20   |                              |
| SR                       | Slew rate                            | $V_{CC+} = 15\text{ V}$ , $V_{in} = 0.5\text{ to } 3\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , unity gain                         |      | 0.4   |      | $\text{V}/\mu\text{s}$       |
| GBP                      | Gain bandwidth product               | $V_{CC+} = 30\text{ V}$ , $V_{in} = 10\text{ mV}$ , $R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$   |      | 1.3   |      | MHz                          |
| THD                      | Total harmonic distortion            | $f = 1\text{ kHz}$ , $A_V = 20\text{ dB}$ , $R_L = 2\text{ k}\Omega$ , $V_O = 2\text{ V}_{pp}$ , $C_L = 100\text{ pF}$ , $V_{CC+} = 30\text{ V}$       |      | 0.015 |      | %                            |

## Electrical characteristics

LM2902

| Symbol          | Parameter                         | Test conditions  | Min. | Typ. | Max. | Unit                         |
|-----------------|-----------------------------------|--|------|------|------|------------------------------|
| $e_n$           | Equivalent input noise voltage    | $f = 1 \text{ kHz}$ , $R_S = 100 \ \Omega$ , $V_{CC^+} = 30 \text{ V}$ |      | 40   |      | $\text{nV}/\sqrt{\text{Hz}}$ |
| $V_{O1}/V_{O2}$ | Channel separation <sup>(3)</sup> | $1 \text{ kHz} \leq f \leq 20 \text{ kHz}$                             |      | 120  |      | dB                           |

### Notes:

<sup>(1)</sup> $V_O = 1.4 \text{ V}$ ,  $R_S = 0 \ \Omega$ ,  $5 \text{ V} < V_{CC^+} < 30 \text{ V}$ ,  $0 \text{ V} < V_{ic} < (V_{CC^+}) - 1.5 \text{ V}$ .

<sup>(2)</sup>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.

<sup>(3)</sup>Due to the proximity of external components, ensure that stray capacitance does not cause coupling between these external parts. Typically, this can be detected as this type of capacitance increases at higher frequencies.



## 5 Electrical characteristic curves



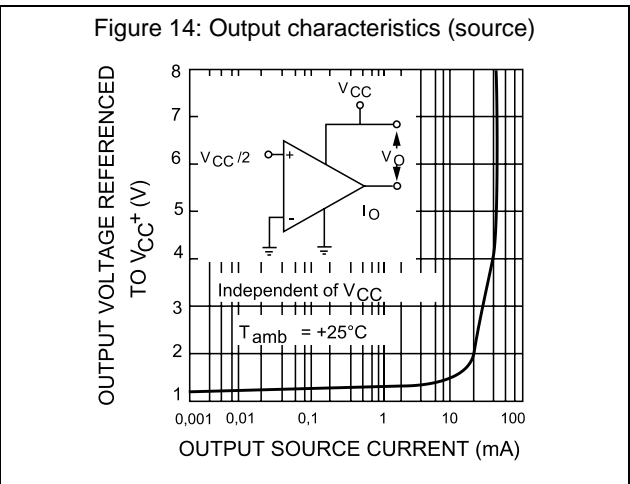
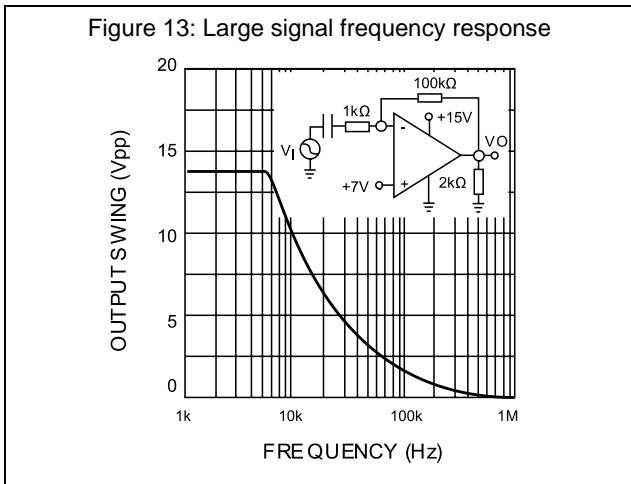
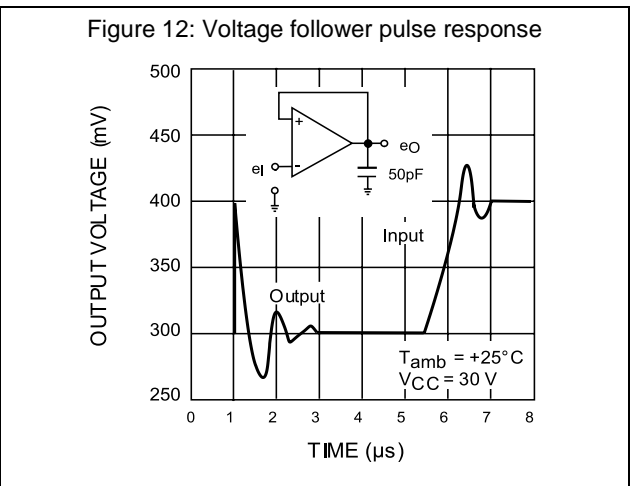
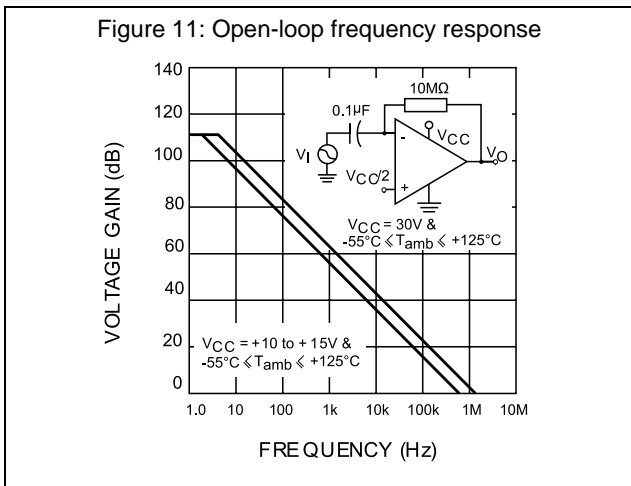
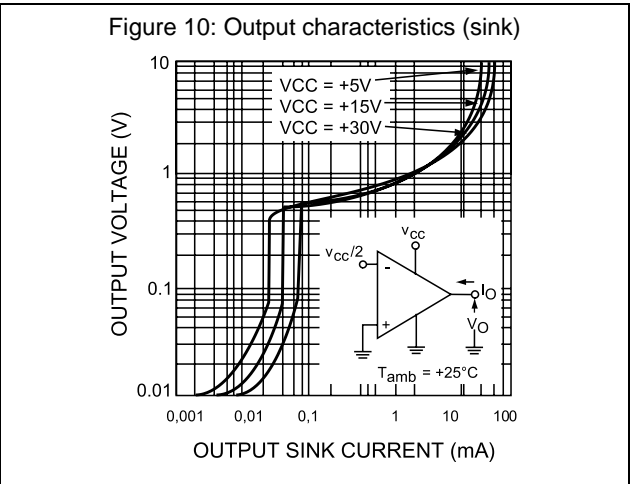
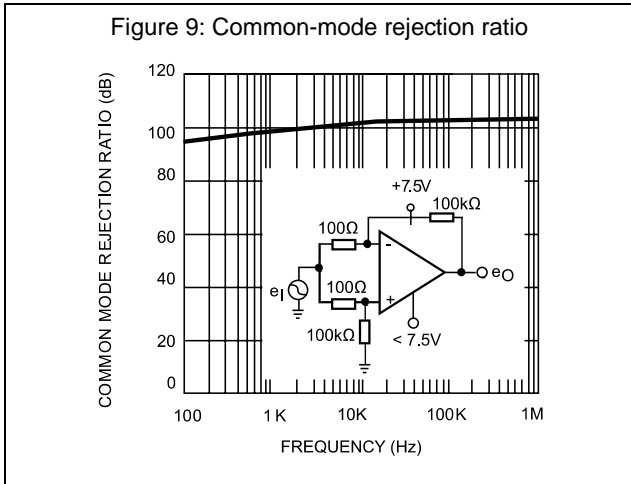


Figure 15: Input current

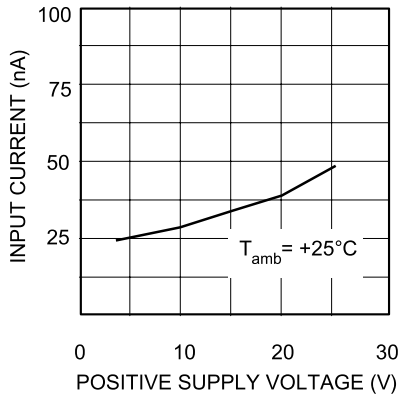


Figure 16: Voltage gain

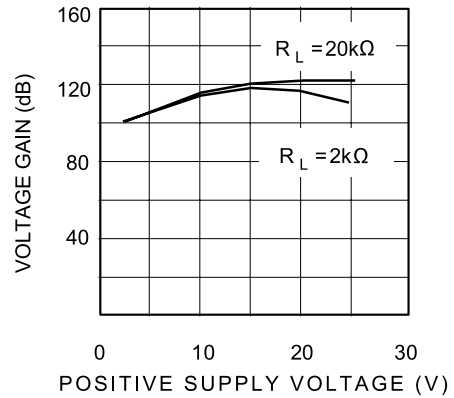


Figure 17: Power supply and common-mode rejection ratio

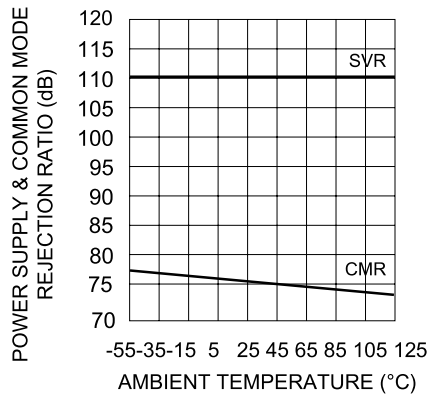
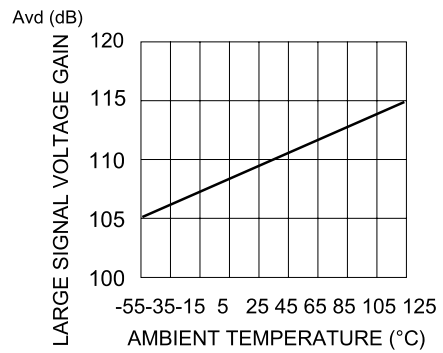


Figure 18: Large signal voltage gain



## 6 Typical single-supply applications

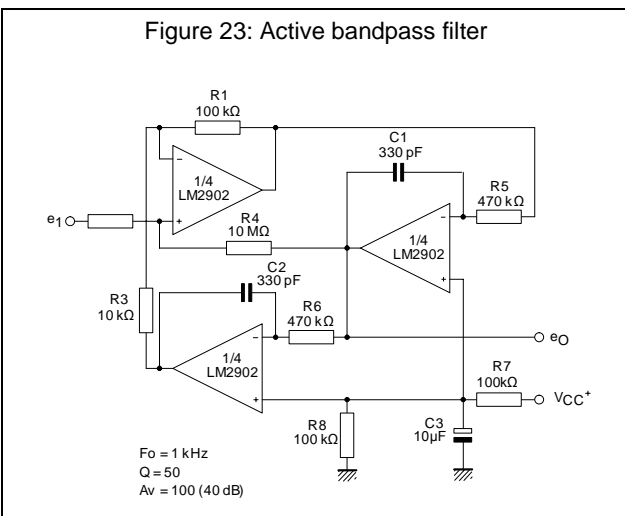
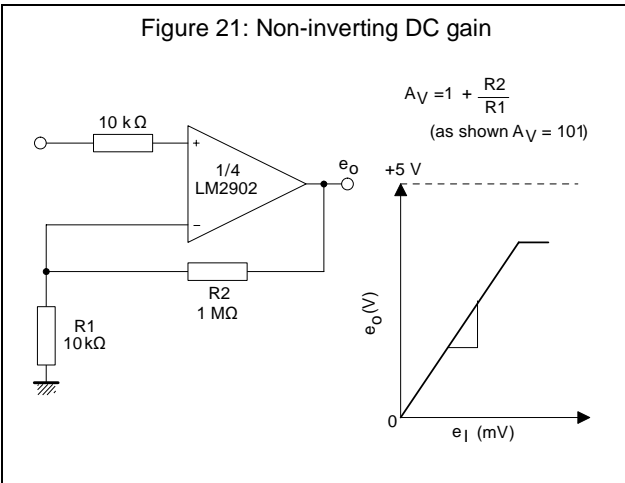
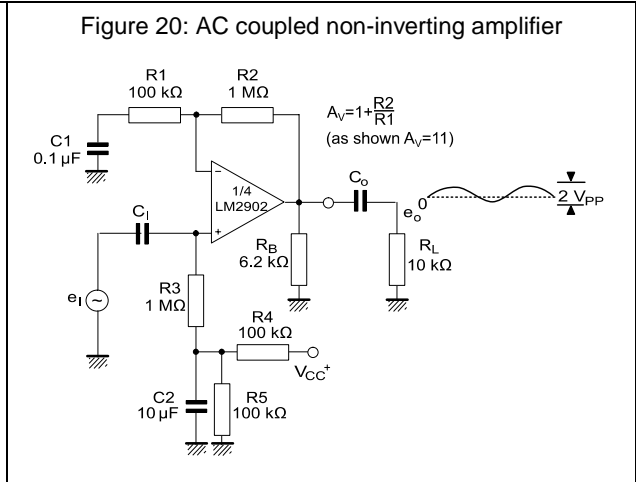
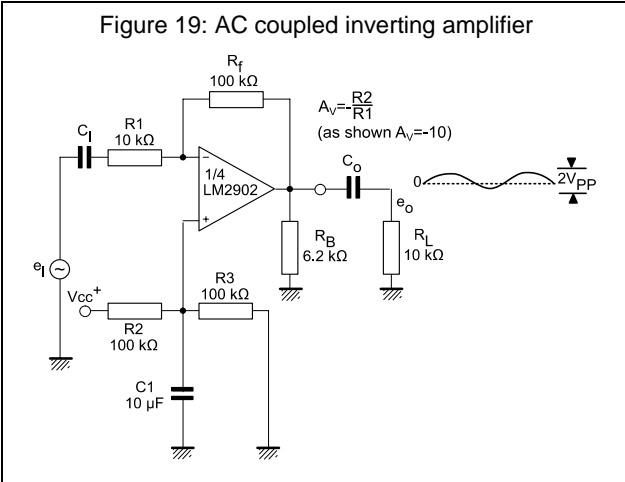


Figure 25: High input Z, DC differential amplifier

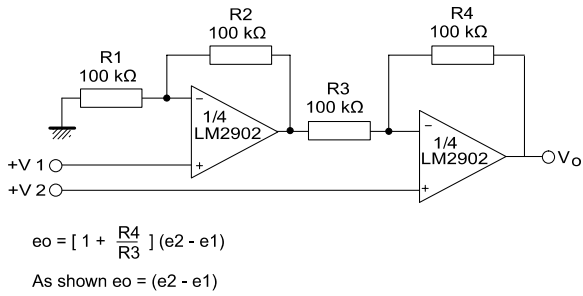


Figure 26: Low drift peak detector

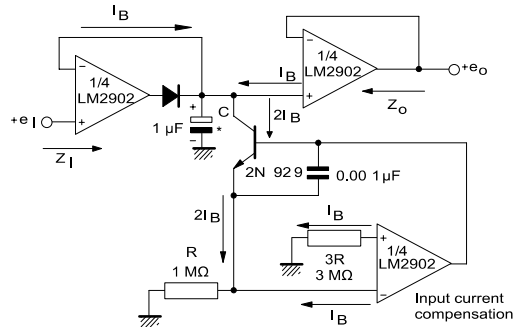
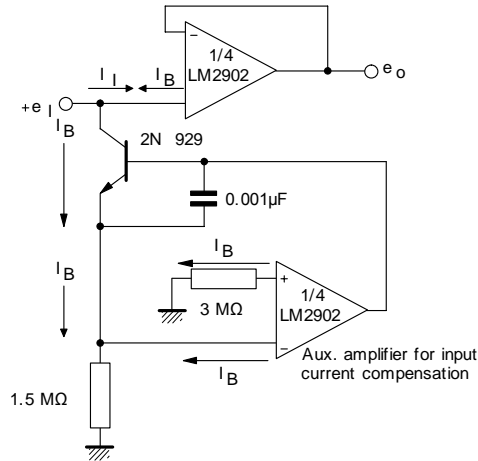


Figure 27: Using symmetrical amplifiers to reduce input current (general concept)



## 7 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](http://www.st.com). ECOPACK® is an ST trademark.

## 7.1 SO14 package information

Figure 28: SO14 package outline

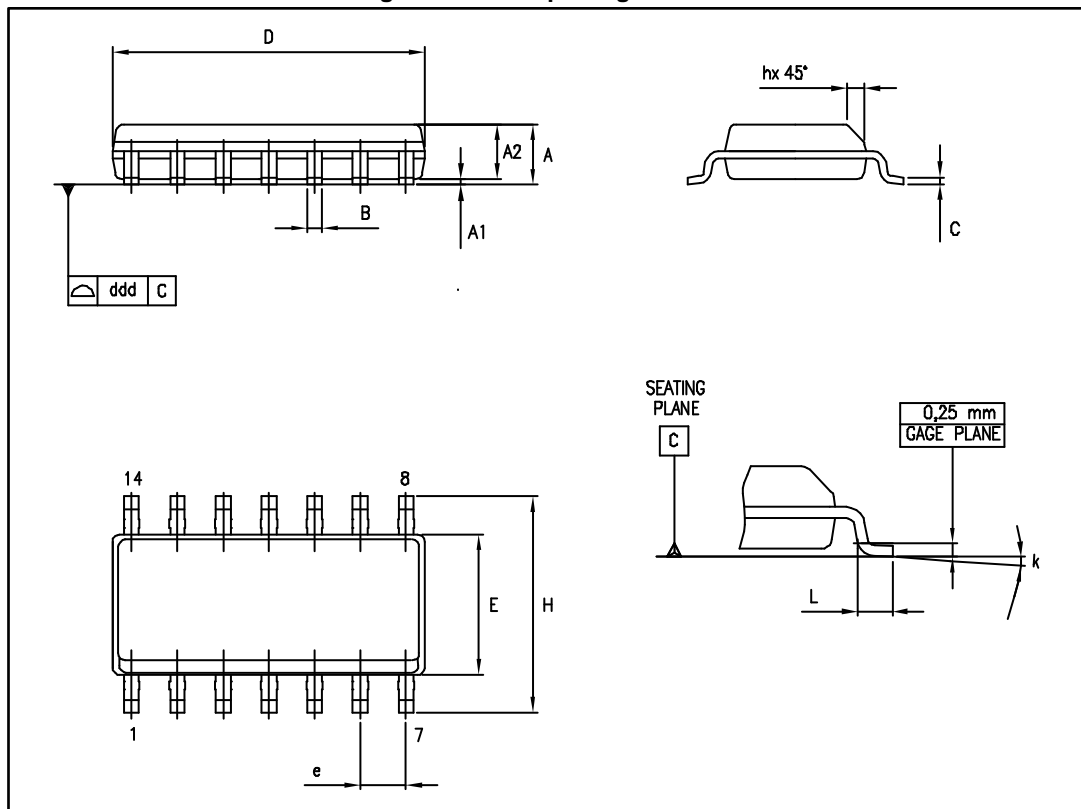


Table 4: SO14 mechanical data

| Ref. | 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 |

## 7.2 TSSOP14 package information

Figure 29: TSSOP14 package outline

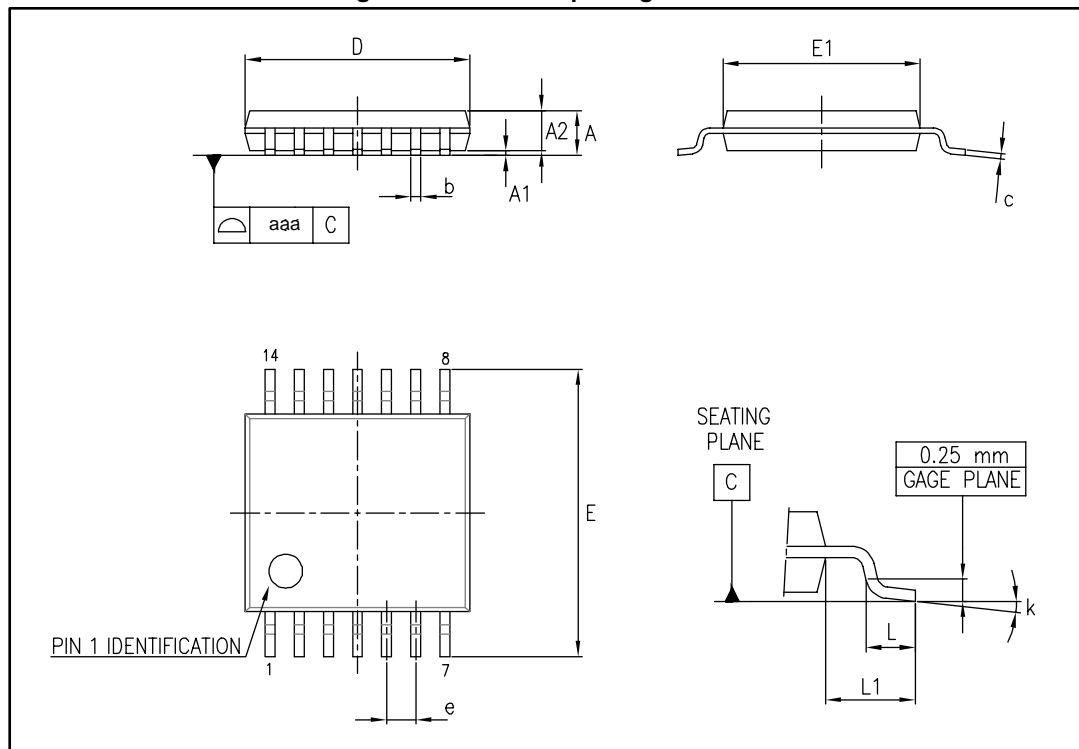


Table 5: TSSOP14 mechanical data

| Ref. | Dimensions  |      |      |        |        |        |
|------|-------------|------|------|--------|--------|--------|
|      | Millimeters |      |      | Inches |        |        |
|      | Min.        | Typ. | Max. | Min.   | Typ.   | Max.   |
| A    |             |      | 1.20 |        |        | 0.047  |
| A1   | 0.05        |      | 0.15 | 0.002  | 0.004  | 0.006  |
| A2   | 0.80        | 1.00 | 1.05 | 0.031  | 0.039  | 0.041  |
| b    | 0.19        |      | 0.30 | 0.007  |        | 0.012  |
| c    | 0.09        |      | 0.20 | 0.004  |        | 0.0089 |
| D    | 4.90        | 5.00 | 5.10 | 0.193  | 0.197  | 0.201  |
| E    | 6.20        | 6.40 | 6.60 | 0.244  | 0.252  | 0.260  |
| E1   | 4.30        | 4.40 | 4.50 | 0.169  | 0.173  | 0.176  |
| e    |             | 0.65 |      |        | 0.0256 |        |
| L    | 0.45        | 0.60 | 0.75 | 0.018  | 0.024  | 0.030  |
| L1   |             | 1.00 |      |        | 0.039  |        |
| k    | 0°          |      | 8°   | 0°     |        | 8°     |
| aaa  |             |      | 0.10 |        |        | 0.004  |



### 7.3 QFN16 3x3 package information

Figure 30: QFN16 3x3 package outline

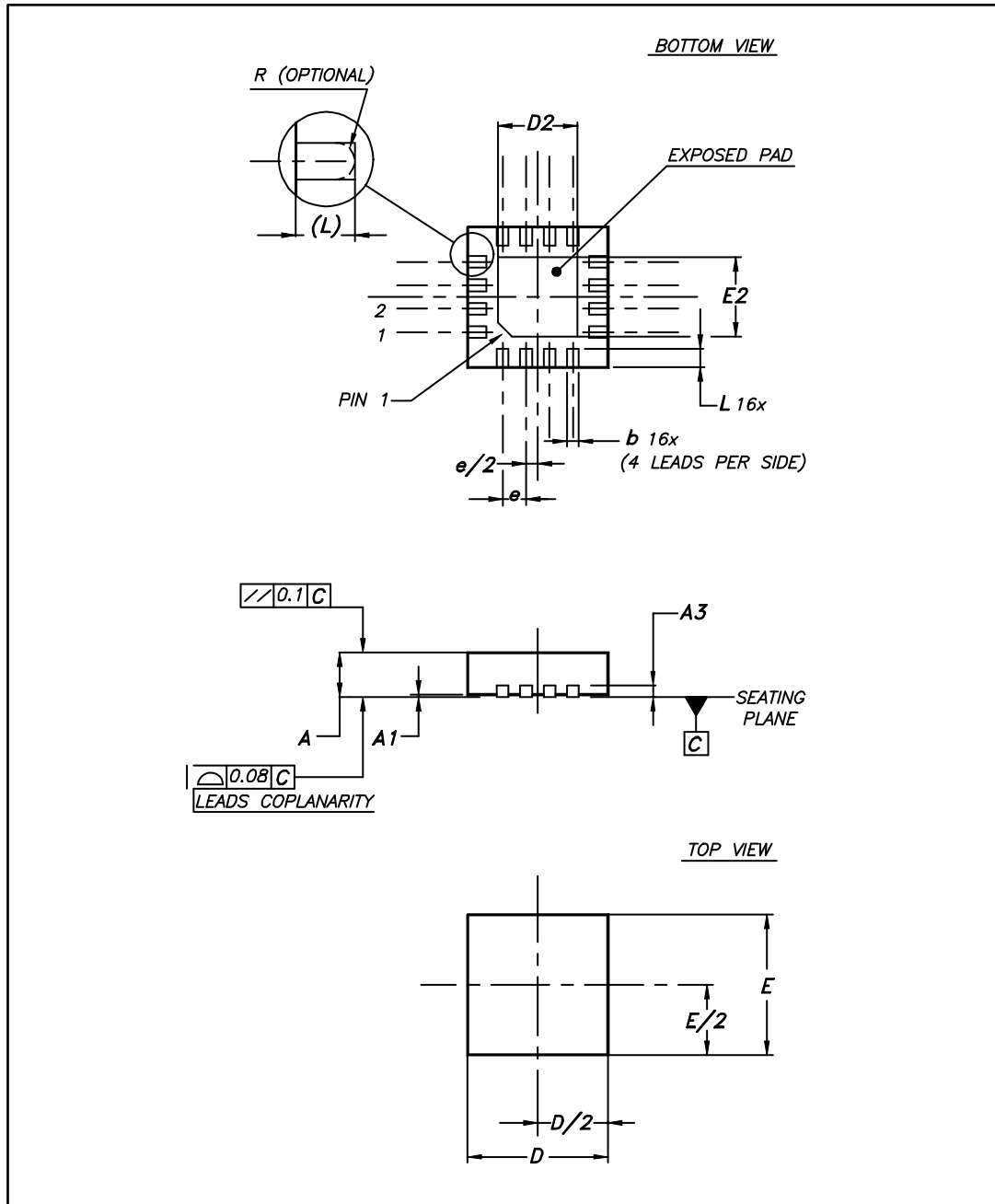
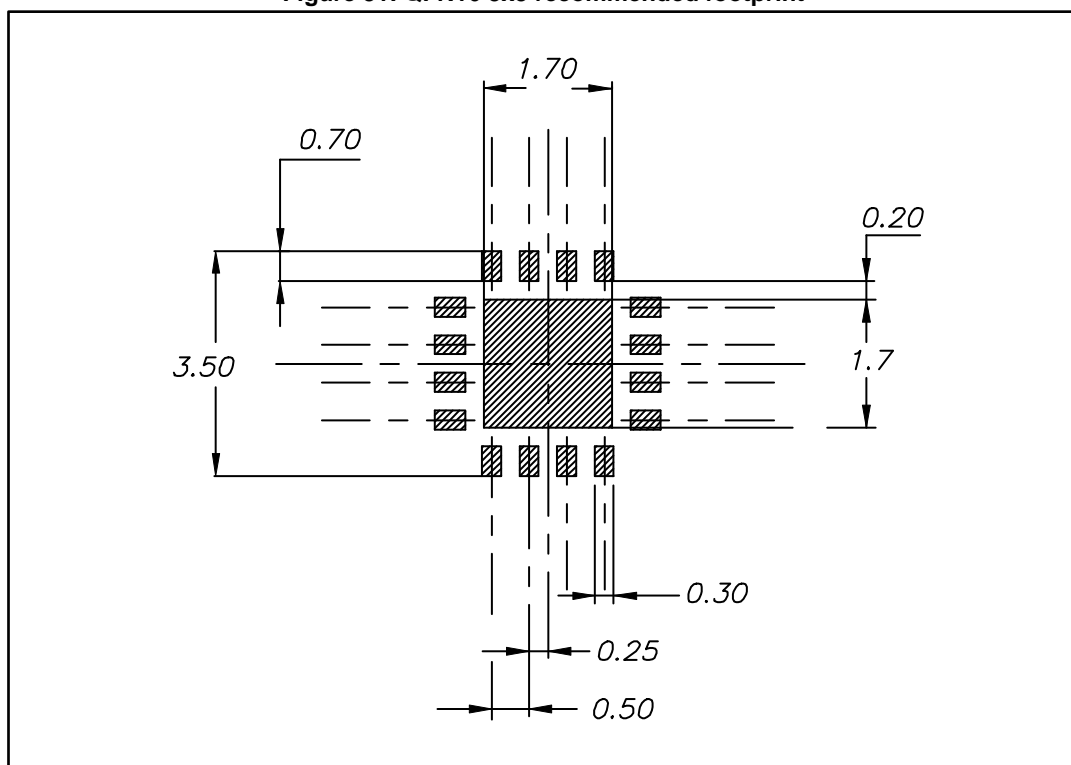


Table 6: QFN16 3x3 mechanical data

| Ref. | Dimensions  |      |      |        |       |       |
|------|-------------|------|------|--------|-------|-------|
|      | Millimeters |      |      | Inches |       |       |
|      | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A    | 0.80        | 0.90 | 1.00 | 0.031  | 0.035 | 0.039 |
| A1   | 0           |      | 0.05 | 0      |       | 0.002 |
| A3   |             | 0.20 |      |        | 0.008 |       |
| b    | 0.18        |      | 0.30 | 0.007  |       | 0.012 |
| D    | 2.90        | 3.00 | 3.10 | 0.114  | 0.118 | 0.122 |
| D2   | 1.50        |      | 1.80 | 0.059  |       | 0.071 |
| E    | 2.90        | 3.00 | 3.10 | 0.114  | 0.118 | 0.122 |
| E2   | 1.50        |      | 1.80 | 0.059  |       | 0.071 |
| e    |             | 0.50 |      |        | 0.020 |       |
| L    | 0.30        |      | 0.50 | 0.012  |       | 0.020 |

Figure 31: QFN16 3x3 recommended footprint



## 8 Ordering information

Table 7: Order codes

| Order code               | Temperature range  | Package                         | Packing               | Marking |
|--------------------------|--------------------|---------------------------------|-----------------------|---------|
| LM2902D                  | -40 ° C to 125 ° C | SO14                            | Tube or tape and reel | 2902    |
| LM2902DT                 |                    | TSSOP14                         | Tape and reel         |         |
| LM2902PT                 |                    | QFN16 3x3                       |                       | K5H     |
| LM2902Q4T                |                    | SO14, automotive grade level    |                       | 2902Y   |
| LM2902YDT <sup>(1)</sup> |                    | TSSOP14, automotive grade level |                       |         |
| LM2902YPT <sup>(1)</sup> |                    |                                 |                       |         |

**Notes:**

<sup>(1)</sup>Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q002 or equivalent.

## 9 Revision history

**Table 8: Document revision history**

| Date        | Revision | Changes   |
|-------------|----------|---|
| 30-Nov-2001 | 1        | Initial release.  |
| 01-Jul-2005 | 2        | PPAP references inserted in the datasheet, see Table 3: Order codes.<br>ESD protection inserted in Table 1 on page 4.   |
| 31-Oct-2005 | 3        | An error in the device description was corrected on page 1.<br>PPAP reference inserted in the datasheet see Table 3: Order codes.<br>Minor grammatical and formatting changes throughout.   |
| 18-Jun-2007 | 4        | Values for thermal resistance junction to ambient and ESD HBM corrected in Table 1: Absolute maximum ratings (AMR).<br>Values for thermal resistance junction to case added in Table 1: Absolute maximum ratings (AMR).<br>Table 2: Operating conditions added.<br>Electrical characteristics figure captions updated.<br>Section 6: Package information updated.<br>Table 3: Order codes moved to end of document. |
| 18-Dec-2007 | 5        | Removed power dissipation parameter from AMR table and added maximum junction temperature.<br>Updated footnotes for automotive grade order codes.<br>Updated format of package information.   |
| 16-Feb-2012 | 6        | Added AMR values for input current in Table 1 on page 4.<br>Added QFN16 3 x 3 mm package information in Chapter 7: Ordering information.<br>Removed LM2902YD order code from Table 3 and changed status of LM2902YPT order code.  |
| 29-Jan-2013 | 7        | Small text/layout changes in Features and Description.<br>Updated Figure 2: Pin connections (top view).<br>Table 3: VCC+ = 5V, VCC- = Ground, V <sub>o</sub> = 1.4V, T <sub>amb</sub> = 25° C (unless otherwise specified): DV <sub>io</sub> replaced by DV <sub>io</sub> /DT.<br>Replaced SO-14 package silhouette, package mechanical drawing (Figure 29) and package mechanical data (Table 5).                  |
| 11-Jan-2017 | 8        | Removed DIP package<br><i>Figure 1: "Schematic diagram (1/4 LM2902)"</i> : removed two diodes<br><i>Table 1: "Absolute maximum ratings (AMR)"</i> : updated value of V <sub>CC</sub><br>Updated TSSOP14 package for L and aaa parameters  |

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