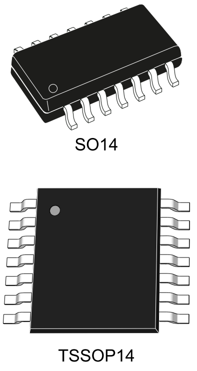
# Low-power quad operational amplifier

Datasheet - production data




## Features

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

## Description

This circuit consists of four independent, high-gain operational amplifiers which have frequency compensation implemented internally and are designed especially for automotive and industrial control systems.

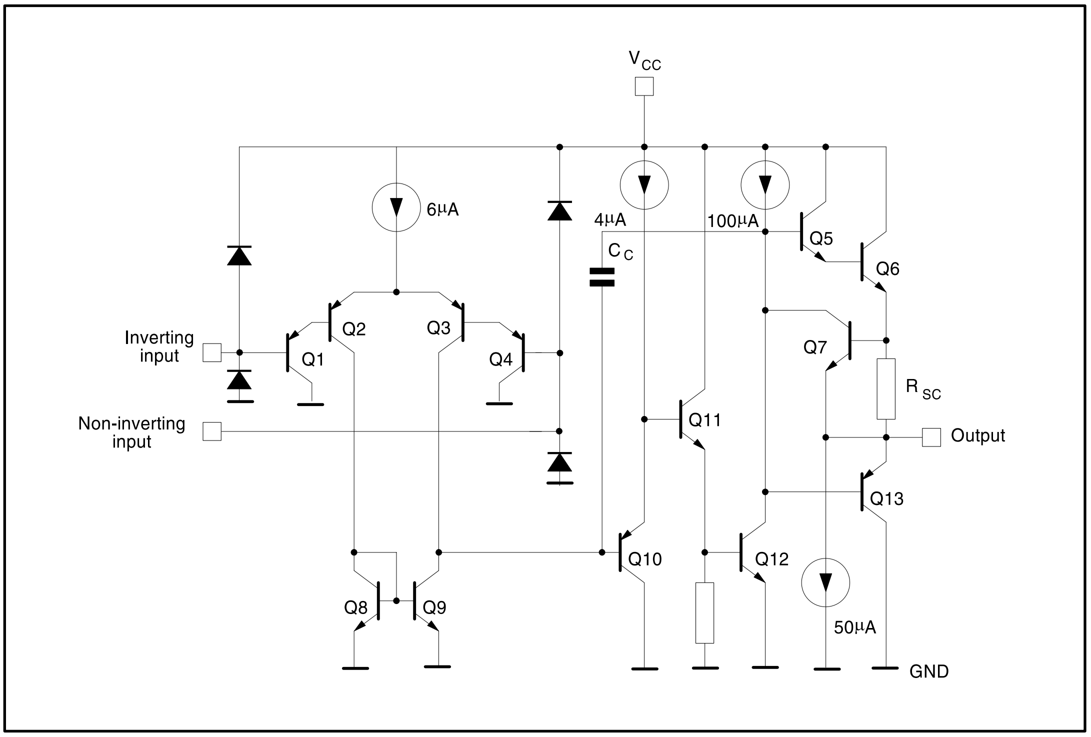
The device operates from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

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

# Contents

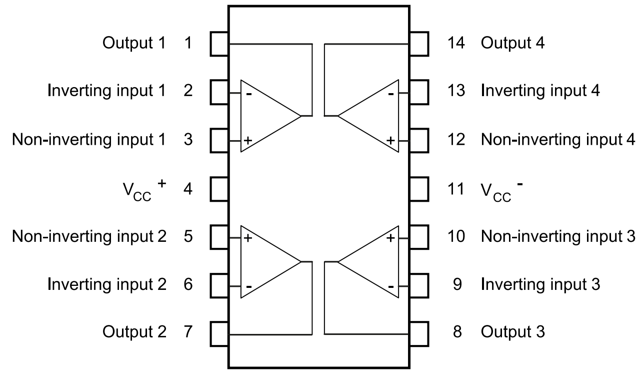
# 1 Schematic diagram

Figure 1: Schematic diagram (1/4 LM2902W)



# 2 Package pin connections

**Figure 2: SO14 and TSSOP14 pin connections (top view)**



# 3 Absolute maximum ratings and operating conditions

**Table 1: Absolute maximum ratings**

| Symbol | Parameter | | Value | Unit |
| --- | --- | --- | --- | --- |
| $V_{CC}$ | Supply voltage | | ±16 to 32 | V |
| $V_{id}$ | Differential input voltage | | 32 | |
| $V_i$ | Input voltage | | -0.3 to ($V_{CC}^+$) + 0.3 | |
| | Output short-circuit to ground [(1)] | | Infinite | |
| $I_{in}$ | Input current [(2)] | | 50 | mA |
| $T_{stg}$ | Storage temperature range | | -65 to 150 | °C |
| $R_{thja}$ | Thermal resistance junction to ambient [(3)] | SO14 | 105 | °C/W |
| | | TSSOP14 | 100 | |
| $R_{thjc}$ | Thermal resistance junction to case [(3)] | SO14 | 31 | |
| | | TSSOP14 | 32 | |
| ESD | HBM: human body model [(4)] | | 800 | V |
| | MM: machine model [(5)] | | 100 | |
| | CDM: charged device model [(6)] | | 1500 | |

**Notes:**

(1) Short-circuits from the output to $V_{CC}^+$ can cause excessive heating and potential destruction. The maximum output current is approximately 20 mA, independent of the magnitude of $V_{CC}^+$

(2) 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 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 -0.3 V.

(3) $R_{thja/c}$ are typical values.

(4) 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.

(5) Machine model: a 200 pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω). This is done for all couples of connected pin combinations while the other pins are floating.

(6) 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 | | ($V_{CC}^-$) to ($V_{CC}^+$) - 1.5 | |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | ($V_{CC}^-$) to ($V_{CC}^+$) - 2 | |
| $T_{oper}$ | Operating free-air temperature range | | -40 to 125 | °C |

# 4 Electrical characteristics

Table 3: VCC+ = 5 V, VCC- = ground, VO = 1.4 V, Tamb = 25 °C (unless otherwise stated)

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{io}$ | Input offset voltage (1) | LM2902W | | 2 | 7 | mV |
| | | LM2902AW | | | 2 | |
| | | $T_{min} \leq T_{amb} \leq T_{max}$, LM2902W | | | 9 | |
| | | $T_{min} \leq T_{amb} \leq T_{max}$, LM2902AW | | | 4 | |
| $\Delta V_{io}/\Delta T$ | Input offset voltage drift | | | 7 | 30 | µV/°C |
| $I_{io}$ | Input offset current | $T_{amb}$ = 25 °C | | 2 | 30 | nA |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 40 | |
| $DI_{io}$ | Input offset current drift | | | 10 | 200 | pA/°C |
| $I_{ib}$ | Input bias current (2) | $T_{amb}$ = 25 °C | | 20 | 150 | nA |
| | | $T_{min} \leq T_{amb} \leq T_{max}$ | | | 300 | |
| $A_{vd}$ | Large signal voltage gain | $V_{CC}^+$ = 15 V, $R_L$ = 2 kΩ, $V_o$ = 1.4 V to 11.4 V, $T_{amb}$ = 25 °C | 50 | 100 | | V/mV |
| | | $V_{CC}^+$ = 15 V, $R_L$ = 2 kΩ, $V_o$ = 1.4 V to 11.4 V, $T_{min} \leq T_{amb} \leq T_{max}$ | 25 | | | |
| SVR | Supply voltage rejection ratio | $R_S \leq$ 10 kΩ, $T_{amb}$ = 25 °C | 65 | 110 | | dB |
| | | $R_S \leq$ 10 kΩ, $T_{min} \leq T_{amb} \leq T_{max}$ | 65 | | | |
| $I_{CC}$ | Supply current (all op amps, no load) | $T_{amb}$ = 25 °C, $V_{CC}^+$ = 5 V | | 0.7 | 1.2 | mA |
| | | $T_{amb}$ = 25 °C, $V_{CC}^+$ = 30 V | | 1.5 | 3 | |
| | | $T_{min} \leq T_{amb} \leq T_{max}$, $V_{CC}^+$ = 5 V | | 0.9 | 1.2 | |
| | | $T_{min} \leq T_{amb} \leq T_{max}$, $V_{CC}^+$ = 30 V | | 1.5 | 3 | |
| CMR | Common-mode rejection ratio | $R_S \leq$ 10 kΩ, $T_{amb}$ = 25 °C | 70 | 80 | | dB |
| | | $R_S \leq$ 10 kΩ, $T_{min} \leq T_{amb} \leq T_{max}$ | 60 | | | |
| $I_o$ | Output short-circuit current | $V_{id}$ = 1 V, $V_{CC}^+$ = 15 V, $V_o$ = 2 V | 20 | 40 | 70 | mA |
| $I_{sink}$ | Output sink current | $V_{id}$ = -1 V, $V_{CC}^+$ = 15 V, $V_o$ = 2 V | 10 | 20 | | mA |
| | | $V_{id}$ = -1 V, $V_{CC}^+$ = 15 V, $V_o$ = 0.2 V | 12 | 50 | | µA |
| $V_{OH}$ | High-level output voltage | $V_{CC}^+$ = 30 V, $R_L$ = 2 kΩ, $T_{amb}$ = 25 °C | 26 | 27 | | V |
| | | $V_{CC}^+$ = 30 V, $R_L$ = 2 kΩ, $T_{min}$ = $T_{amb}$ = $T_{max}$ | 26 | | | |
| | | $V_{CC}^+$ = 30 V, $R_L$ = 10 kΩ, $T_{amb}$ = 25 °C | 27 | 28 | | |
| | | $V_{CC}^+$ = 30 V, $R_L$ = 10 kΩ, $T_{min}$ = $T_{amb}$ = $T_{max}$ | 27 | | | |
| | | $V_{CC}^+$ = 5 V, $R_L$ = 2 kΩ, $T_{amb}$ = 25 °C | 3.5 | | | |
| | | $V_{CC}^+$ = 5 V, $R_L$ = 2 kΩ, $T_{min}$ = $T_{amb}$ = $T_{max}$ | 3 | | | |
| $V_{OL}$ | Low level output voltage | $R_L$ = 10 kΩ, $T_{amb}$ = 25 °C | | 5 | 20 | mV |
| | | $R_L$ = 10 kΩ, $T_{min}$ = $T_{amb}$ = $T_{max}$ | | | 20 | |
| SR | Slew rate | $V_{CC}^+$ = 15 V, $V_{in}$ = 0.5 to 3 V, $R_L$ = 2 kΩ, $C_L$ = 100 pF, unity gain | 0.24 | 0.4 | | V/µs |

| Symbol | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| SR | Slew rate | $V_{CC}^{+}$ = 15 V, $V_{in}$ = 0.5 to 3 V, $R_L$ = 2 kΩ, $C_L$ = 100 pF, unity gain, $T_{min} \leq T_{amb} \leq T_{max}$ | 0.14 | | | V/µs |
| GBP | Gain bandwidth product | $V_{CC}^{+}$ = 30 V, $V_{in}$ = 10 mV, $R_L$ = 2 kΩ, $C_L$ = 100 pF | | 1.3 | | MHz |
| THD | Total harmonic distortion | f = 1 kHz, $A_V$ = 20 dB, $R_L$ = 2 kΩ, $V_o$ = 2 $V_{pp}$, $C_L$ = 100 pF, $V_{CC}^{+}$ = 30 V | | 0.015 | | % |
| $e_n$ | Equivalent input noise voltage | f = 1 kHz, $R_S$ = 100 Ω, $V_{CC}^{+}$ = 30 V | | 40 | | nV/√Hz |
| $V_{O1}/V_{O}2$ | Channel separation (3) | 1 kHz ≤ f ≤ 20 kHz | | 120 | | dB |

**Notes:**

(1) $V_O$ = 1.4 V, $R_S$ = 0 Ω, 5 V < $V_{CC}^{+}$ < 30 V, 0 V < $V_{ic}$ < ($V_{CC}^{+}$) - 1.5 V.

(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. Typically, this can be detected as this type of capacitance increases at higher frequencies.

# 5 Electrical characteristic curves

Figure 3: Input bias current vs. Tamb

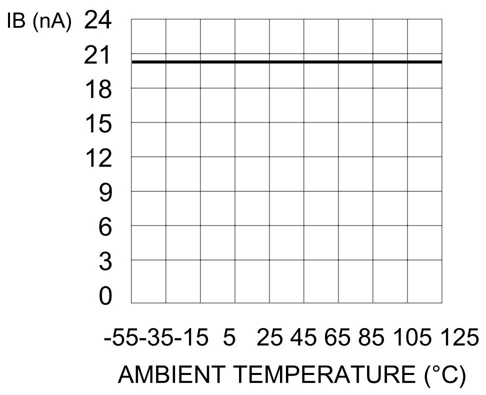



Figure 4: Input voltage range

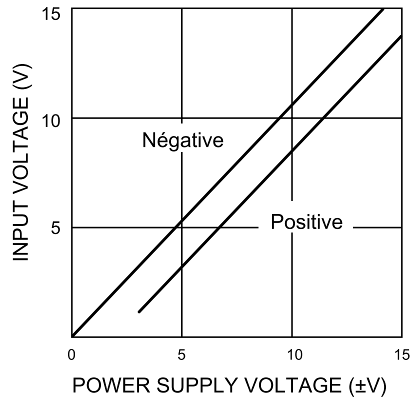



Figure 5: Current limiting

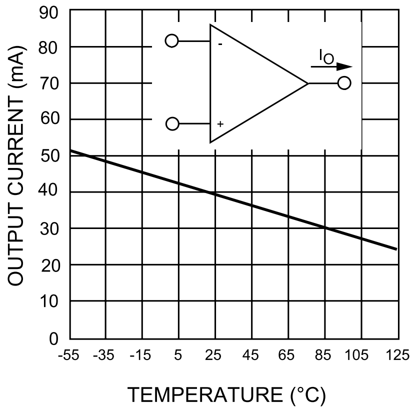



Figure 6: Supply current

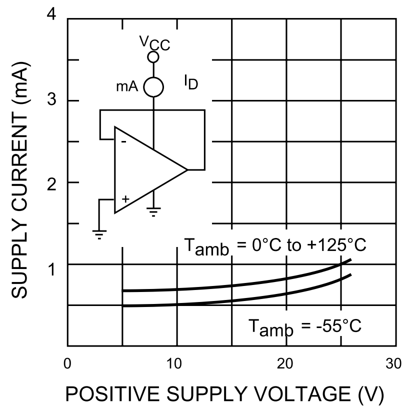



Figure 7: Gain bandwidth product

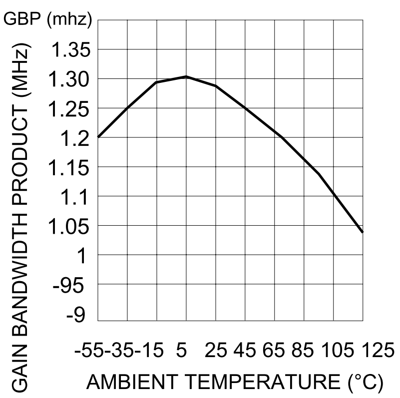



Figure 8: Voltage follower pulse response (VCC = 15 V)

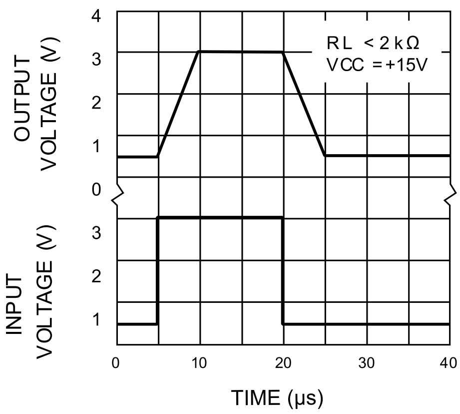


Figure 9: Common-mode rejection ratio

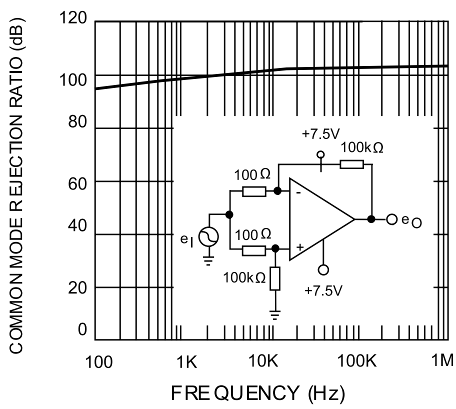



Figure 10: Output characteristics (sink)

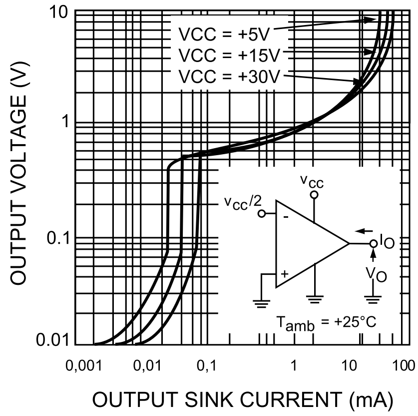



Figure 11: Open-loop frequency response

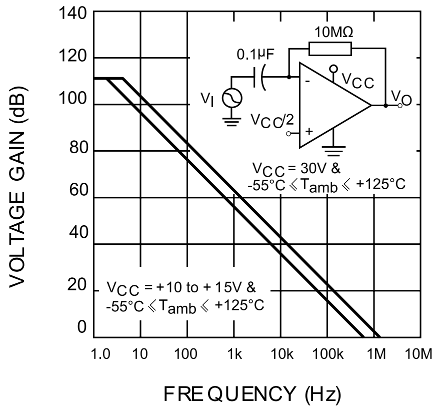



Figure 12: Voltage follower pulse response (VCC = 30 V)

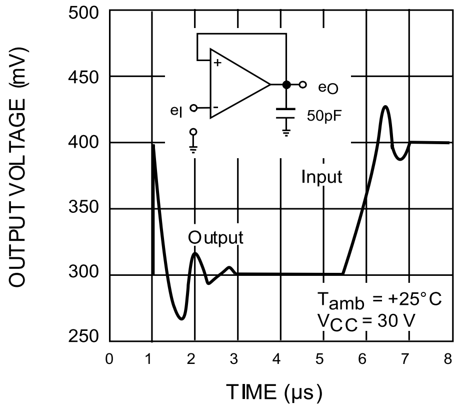



Figure 13: Large signal frequency response

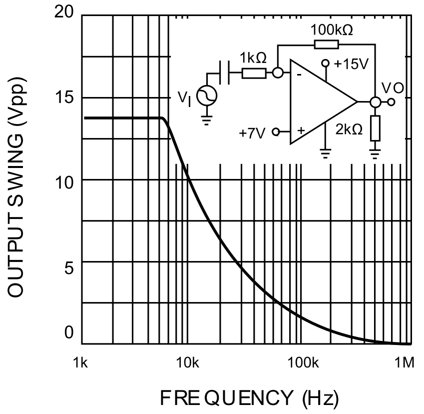



Figure 14: Output characteristics (source)

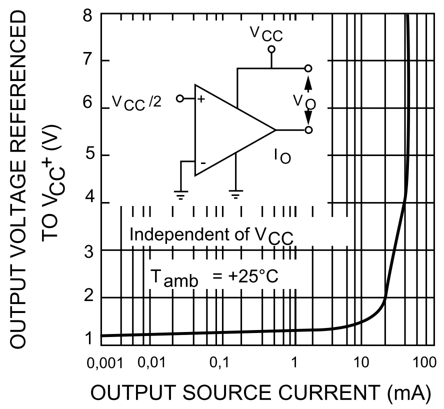


Figure 15: Input current

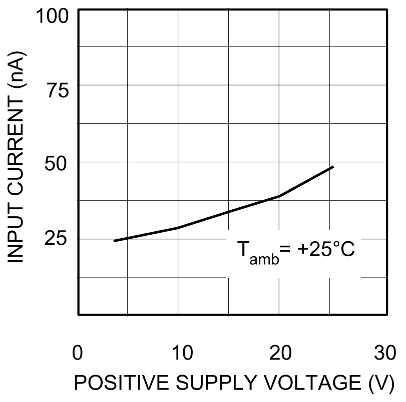



Figure 16: Voltage gain

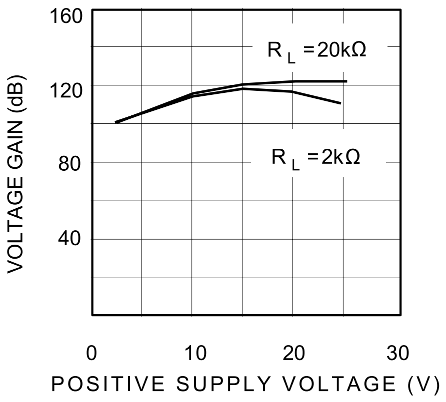



Figure 17: Power supply and common-mode rejection ratio

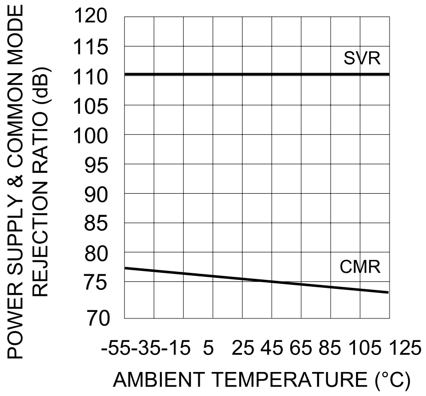
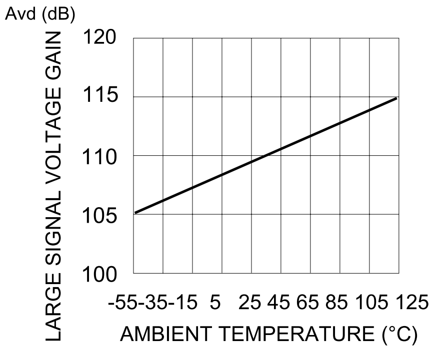



Figure 18: Large signal voltage gain



# 6 Typical single-supply applications

Figure 19: AC coupled inverting amplifier

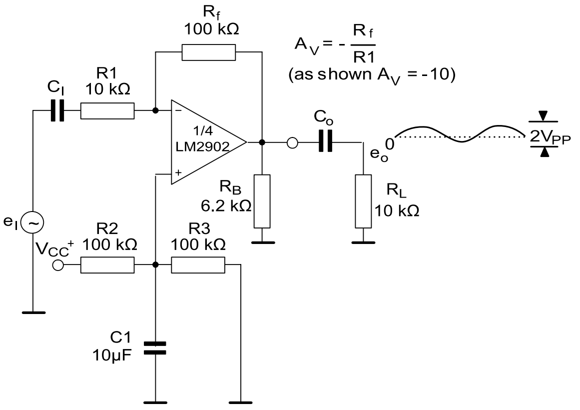



Figure 20: AC coupled non-inverting amplifier

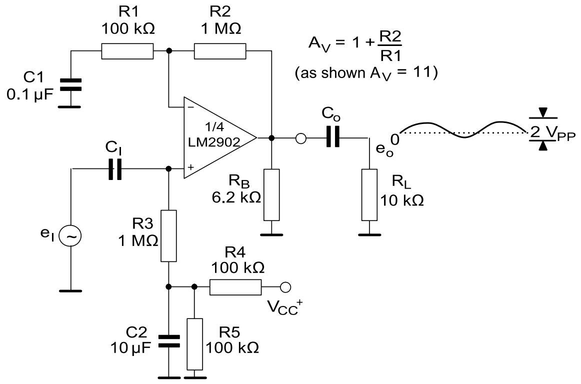



Figure 21: Non-inverting DC gain

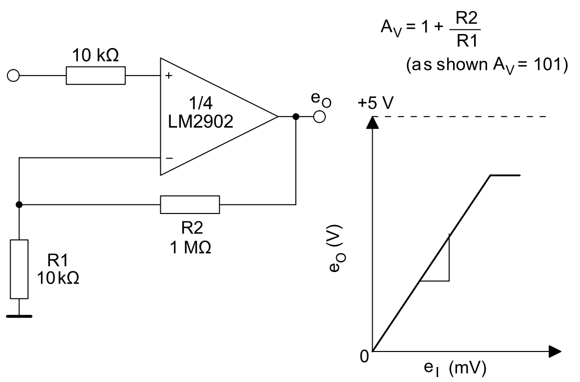



Figure 22: DC summing amplifier

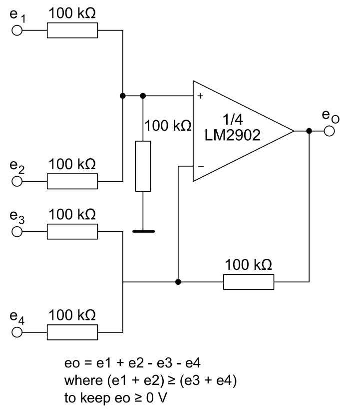



Figure 23: Active bandpass filter

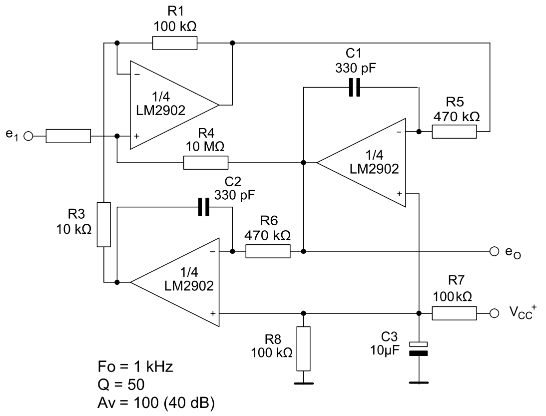



Figure 24: High input Z adjustable gain DC instrumentation amplifier

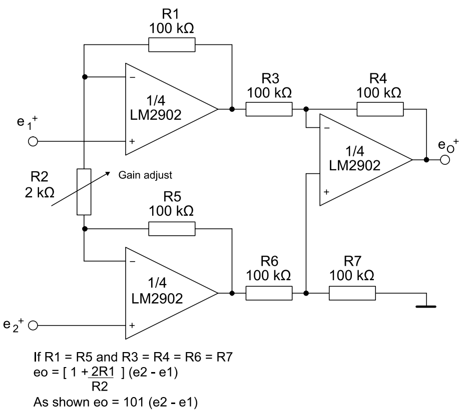
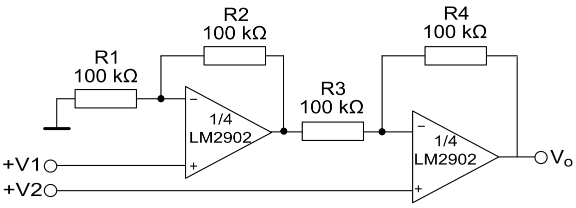


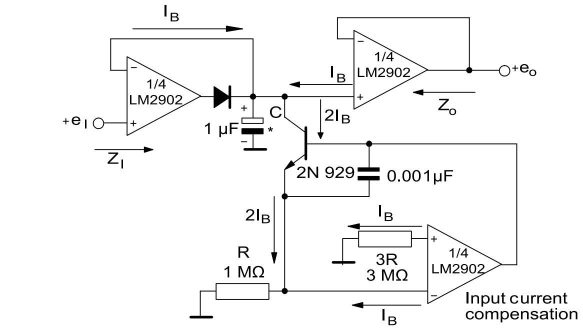
Figure 25: High input Z, DC differential amplifier




$eo = [1 + \frac{R4}{R3}] (e2 - e1)$

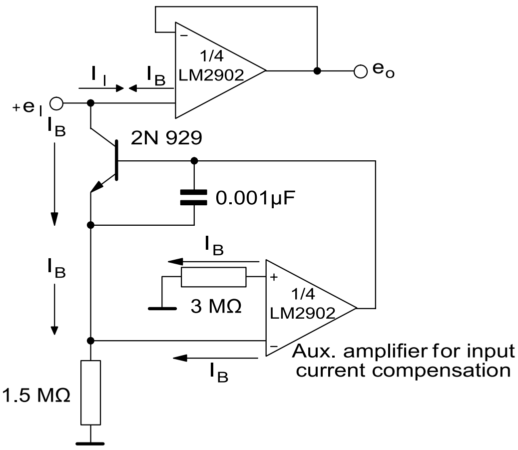
As shown eo = (e2 - e1)

Figure 26: Low drift peak detector




* Polycarbonate or polyethylene

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



# 7 Macromodel

An accurate macromodel of the LM2902W is available on STMicroelectronics' web site at ***www.st.com***. This model is a trade-off between accuracy and complexity (that is, time simulation) of the LM2902W operational amplifiers. It emulates the nominal performances of a typical device within the specified operating conditions mentioned in the datasheet. It also helps to validate a design approach and to select the right operational amplifier, *but it does* not replace on-board measurements.

# 8 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.

## 8.1 SO14 package information

Figure 28: SO14 package outline

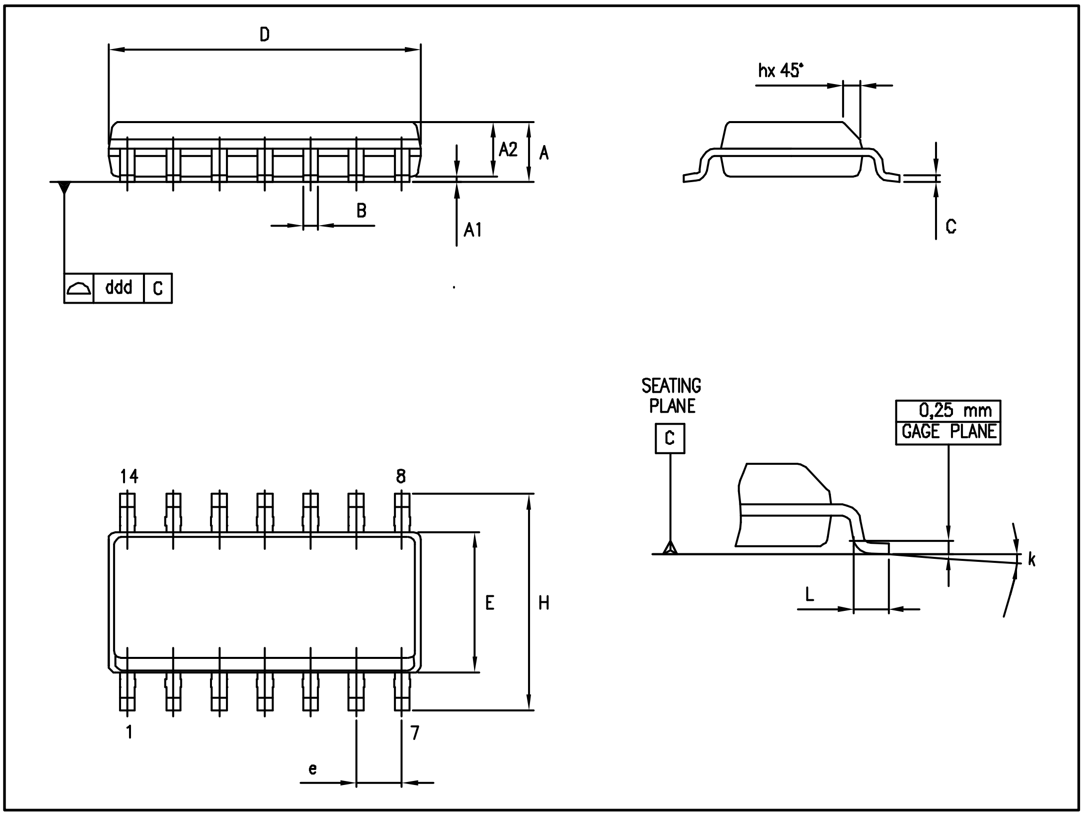



Table 4: SO14 mechanical data

| 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 |

## 8.2 TSSOP14 package information

Figure 29: TSSOP14 package outline

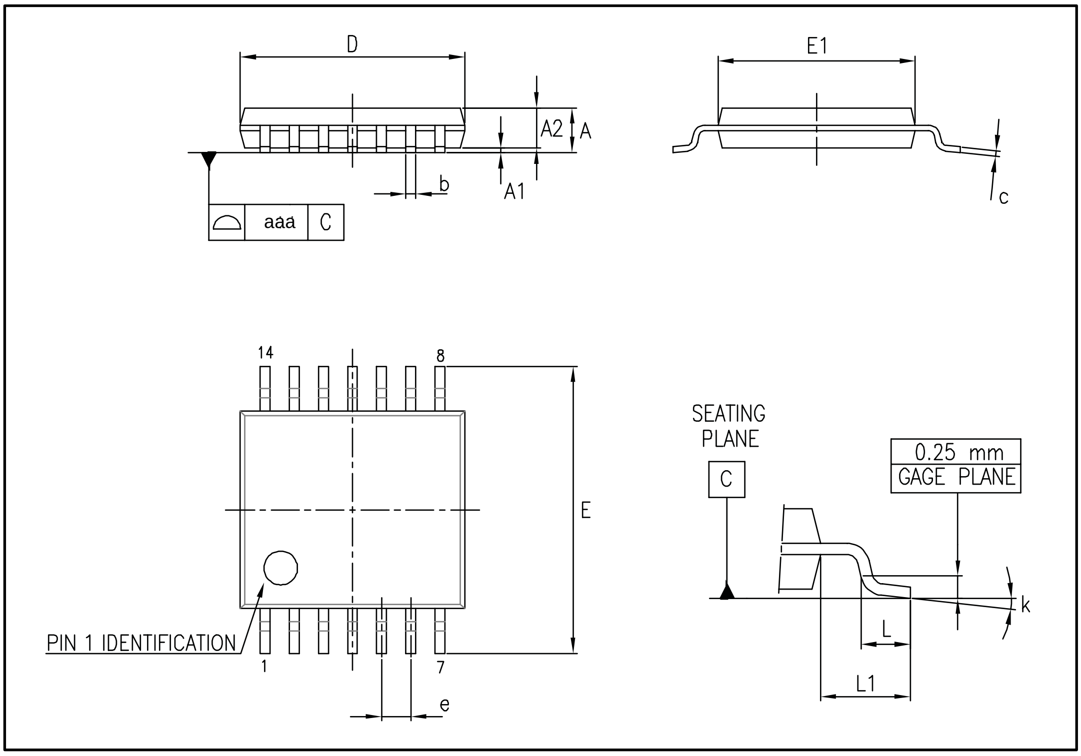



Table 5: TSSOP14 mechanical data

| 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 |

# 9 Ordering information

**Table 6: Order codes**

| Order code | Temperature range | Package | Packing | Marking |
|---|---|---|---|---|
| LM2902WDT | -40 °C to 125 °C | SO14 | Tape and reel | 2902W |
| LM2902WYDT [(1)] | | SO14 (automotive grade level) | | 2902WY |
| LM2902AWYDT [(1)] | | | | 2902AWY |
| LM2902WPT | | TSSOP14 | | 2902W |
| LM2902WYPT [(1)] | | TSSOP14 (automotive grade level) | | 2902WY |
| LM2902AWYPT [(1)] | | | | 2902AWY |

**Notes:**

[(1)]Qualification and characterization according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent.

# 10 Revision history

Table 7: Document revision history

| Date | Revision | Changes |
|---|---|---|
| 01-Sep-2003 | 1 | Initial release. |
| 01-Nov-2005 | 2 | Table data reformatted for easier use in Electrical characteristics on page 4.<br>Minor grammatical and formatting changes throughout. |
| 01-Jan-2006 | 3 | LM2902WYPT PPAP reference inserted in order codes table, see Section 7 on page 16. |
| 01-May-2006 | 4 | Minimum value of slew rate at 25°C and on full temperature range added in Table 3 on page 5. |
| 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 Table 1: Absolute maximum ratings.<br>Updated electrical characteristics curves.<br>Added Section 5: Macromodel.<br>Added automotive grade order codes in Section 7 on page 16. |
| 15-Jan-2008 | 6 | Corrected footnotes for automotive grade order codes. |
| 17-Oct-2008 | 7 | Added enhanced Vio version: LM2902AW.<br>Corrected $V_{OH}$ min parameter at $V_{cc}$=5V in Table 3 on page 5. |
| 16-Feb-2012 | 8 | Modified Chapter 5: Macromodel.<br>Deleted LM2902WYD and LM2902AWYD order codes from Table 7 and modified status of LM2902WYPT and LM2902AWYPT order codes. |
| 22-Jul-2013 | 9 | Table 3: $DV_{io}$ replaced with $\Delta V_{io}/\Delta T$<br>Table 7: Removed the order codes LM2902WN and LM2902WD; replaced the order codes LM2902WDT and LM2902AWDT with LM2902WYDT and LM2902AWYDT respectively. |
| 19-Feb-2016 | 10 | Updated layout<br>Removed DIP14 package and all information pertaining to it<br>Removed “D, plastic micropackage” and “P, thin shrink small outline package” respectively from the SO14 and TSSOP14 silhouettes.<br>*Section 8.1: "SO14 package information"*: replaced SO14 package outline and mechanical data<br>*Section 8.2: "TSSOP14 package information"*: updated E1 max mm value, L1 value, and added "aaa" information.<br>*Table 6: "Order codes"*: added order code LM2902WDT |