# LM2904W

## Low power dual operational amplifier

## Features

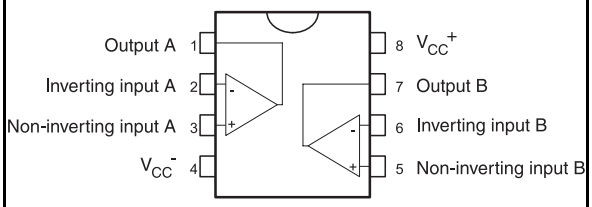
- Internally frequency compensated
- Large DC voltage gain: 100dB
- Wide bandwidth (unity gain): 1.1MHz (temperature compensated)
- Very low supply current/op (500µA)
- Low input bias current: 20nA (temperature compensated)
- Low input offset current: 2nA
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage
- Large output voltage swing 0V to ($V_{CC}$ - 1.5V)
- ESD internal protection: 2kV

**N**
**DIP8**
(Plastic package)

**D**
**SO-8**
(Plastic micropackage)

**P**
**TSSOP8**
(Thin shrink small outline package)

Pin connections (top view)




## Description

This circuit consists of two independent, high gain, internally frequency compensated operational-amplifiers, designed specifically for automotive and industrial control system. It operates from a single power supply over a wide range of voltages. The low power supply drain is independent of the magnitude of the power supply voltage.

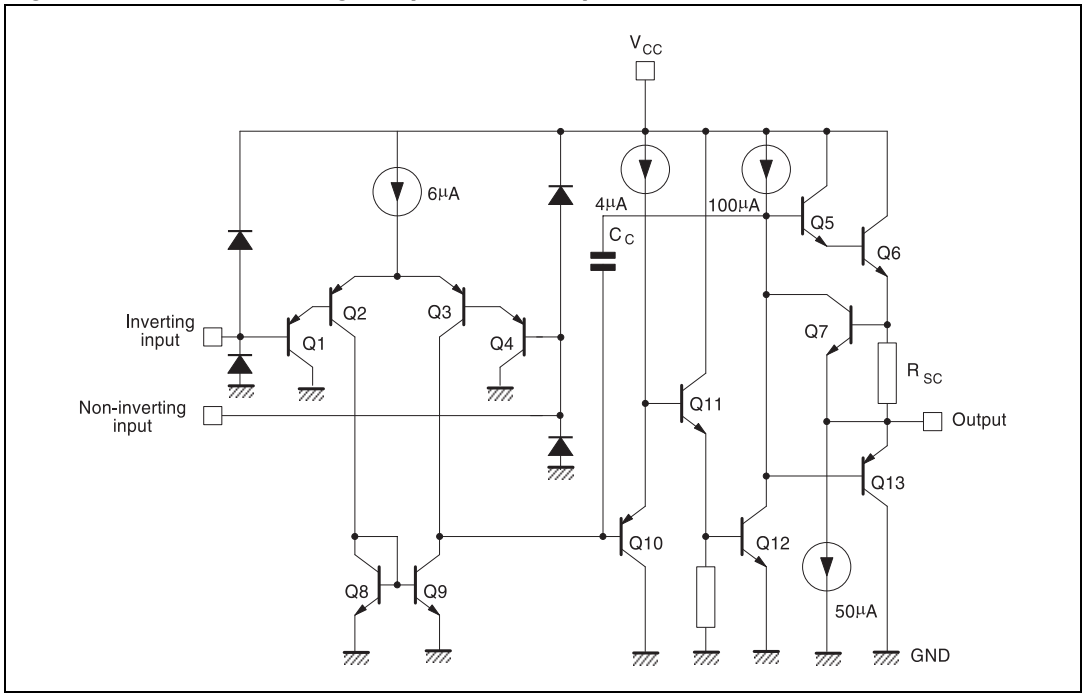
Application areas include transducer amplifiers, DC gain blocks and all the conventional op-amp circuits which now can be more easily implemented in single power supply systems. For example, these circuits can be directly supplied with off the standard +5V which is used in logic systems and will easily provide the required interface electronics without requiring any additional power supply.

In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage.

# Contents

# 1 Schematic diagram

**Figure 1. Schematic diagram (1/2 LM2904W)**



# 2 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CC}$ | Supply voltage | +32 | V |
| $V_{id}$ | Differential input voltage | -0.3V to $V_{CC}$ + 0.3 | V |
| $V_I$ | Input voltage | -0.3V to $V_{CC}$ + 0.3 | V |
| | Output short-circuit duration(1) | Infinite | s |
| $p_{tot}$ | Power dissipation | 500 | mW |
| $I_{in}$ | Input current (2) | 50 | mA |
| $T_{oper}$ | Operating free-air temperature range | -40 to +125 | °C |
| $T_{stg}$ | Storage temperature range | -65 to +150 | °C |
| $R_{thja}$ | Thermal resistance junction to ambient(3) (4)<br>SO-8<br>TSSOP8<br>DIP-8 | <br>125<br>120<br>85 | °C/W |
| $R_{thjc}$ | Thermal resistance junction to case<br>SO-8<br>TSSOP8<br>DIP-8 | <br>40<br>37<br>41 | °C/W |
| $T_{stg}$ | Storage temperature range | -65 to +150 | °C |
| ESD | HBM: human body model(5) | 2 | kV |
| | MM: machine model(6) | 200 | V |
| | CDM: charged device model(7) | 1.5 | kV |

1. Short-circuits from the output to $V_{CC}$ can cause excessive heating if $V_{CC}^+ > 15V$. The maximum output current is approximately 40mA, independent of the magnitude of $V_{CC}$. Destructive dissipation can result from simultaneous short-circuits on all amplifiers.
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 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 above -0.3V.
3. Short-circuits can cause excessive heating and destructive dissipation.
4. $R_{th}$ are typical values.
5. Human body model: 100pF discharged through a 1.5kΩ resistor between two pins of the device, done for all couples of pin combinations with other pins floating.
6. Machine model: a 200pF cap is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5Ω), done for all couples of pin combinations with other pins floating.
7. Charged device model: all pins plus package are charged together to the specified voltage and then discharged directly to the ground.

**Table 2. Operating conditions**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CC}$ | Supply voltage | 3 to 30 | V |
| $V_{icm}$ | Common mode input voltage range | $V_{CC}^{+}$ - 1.5 | V |

# 3 Electrical characteristics

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

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{io}$ | Input offset voltage (1) | $T_{amb}$ = 25°C<br>$T_{min} \le T_{amb} \le T_{max}$ | | 2 | 7<br>9 | mV |
| $I_{io}$ | Input offset current | $T_{amb}$ = 25°C<br>$T_{min} \le T_{amb} \le T_{max}$ | | 2 | 30<br>40 | nA |
| $I_{ib}$ | Input bias current (2) | $T_{amb}$ = 25°C<br>$T_{min} \le T_{amb} \le T_{max}$ | | 20 | 150<br>200 | nA |
| $A_{vd}$ | Large signal voltage gain | **$V_{CC}^+$ = +15V, $R_L$=2kΩ, $V_o$ = 1.4V to 11.4V**<br>$T_{amb}$ = 25°C<br>$T_{min} \le T_{amb} \le T_{max}$ | 50<br>25 | 100 | | V/mV |
| SVR | Supply voltage rejection ratio | **$R_S$ ≤10kΩ**<br>$T_{amb}$ = 25°C<br>$T_{min} \le T_{amb} \le T_{max}$ | 65<br>65 | 100 | | dB |
| $I_{cc}$ | Supply current, all Amp, no load | $T_{amb}$ = 25°C, $V_{CC}$ = +5V<br>$T_{min} \le T_{amb} \le T_{max}$, $V_{CC}$ = +30V | | 0.7 | 1.2<br>2 | mA |
| $V_{icm}$ | Input common mode voltage range | **$V_{CC}$= +30V** (3)<br>$T_{amb}$ = 25°C<br>$T_{min} \le T_{amb} \le T_{max}$ | 0<br>0 | | $V_{CC}^+$ -1.5<br>$V_{CC}^+$ -2 | V |
| CMR | Common-mode rejection ratio | **$R_S$ = 10kΩ**<br>$T_{amb}$ = 25°C<br>$T_{min} \le T_{amb} \le T_{max}$ | 70<br>60 | 85 | | dB |
| $I_{source}$ | Output short-circuit current | $V_{CC}$ = +15V, $V_o$ = +2V, $V_{id}$ = +1V | 20 | 40 | 60 | mA |
| $I_{sink}$ | Output sink current | $V_O$ = 2V, $V_{CC}$ = +5V<br>$V_O$ = +0.2V, $V_{CC}$ = +15V | 10<br>12 | 20<br>50 | | mA<br>µA |
| $V_{OPP}$ | Output voltage swing | **$R_L$ = 2kΩ**<br>$T_{amb}$ = 25°C<br>$T_{min} \le T_{amb} \le T_{max}$ | 0<br>0 | | $V_{CC}^+$ -1.5<br>$V_{CC}^+$ -2 | V |
| $V_{OH}$ | High level output voltage | **$V_{CC}$ + 30V**<br>$T_{amb}$ = +25°C, $R_L$ = 2kΩ<br>$T_{min} \le T_{amb} \le T_{max}$<br>$T_{amb}$ = +25°C, $R_L$ = 10kΩ<br>$T_{min} \le T_{amb} \le T_{max}$ | 26<br>26<br>27<br>27 | 27<br><br>28 | | V |
| $V_{OL}$ | Low level output voltage | **$R_L$ = 10kΩ**<br>$T_{amb}$ = +25°C<br>$T_{min} \le T_{amb} \le T_{max}$ | | 5 | 20<br>20 | mV |
| SR | Slew rate | $V_{CC}$ = 15V, Vi = 0.5 to 3V, $R_L$ = 2kΩ,<br>$C_L$ = 100pF, unity gain<br>$T_{min} \le T_{amb} \le T_{max}$ | 0.3<br>0.2 | 0.6 | | V/µs |
| GBP | Gain bandwidth product | f = 100kHz, $V_{CC}$ = 30V,$V_{in}$ = 10mV,<br>$R_L$ = 2kΩ, $C_L$ = 100pF | 0.7 | 1.1 | | MHz |

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

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| THD | Total harmonic distortion | f = 1kHz, $A_V$ = 20dB, $R_L$ = 2kΩ, $V_o$ = 2Vpp, $C_L$ = 100pF, $V_{cc}$ = 30V | | 0.02 | | % |
| $DV_{io}$ | Input offset voltage drift | | | 7 | 30 | µV/°C |
| $DI_{io}$ | Input offset current drift | | | 10 | 300 | pA/°C |
| $V_{O1}/V_{O2}$ | Channel separation (4) | 1kHz ≤ f ≤ 20kHz | | 120 | | dB |

1. $V_O$ = 1.4V, $R_S$ = 0Ω, 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 loading charge on the input lines.
3. The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is $V_{CC}^+$ –1.5V, but either or both inputs can go to +32V without damage.
4. Due to the proximity of external components, ensure that stray capacitance between these external parts does not cause coupling. Typically, this can be detected because this type of capacitance increases at higher frequencies.

**Figure 2. Open loop frequency response**

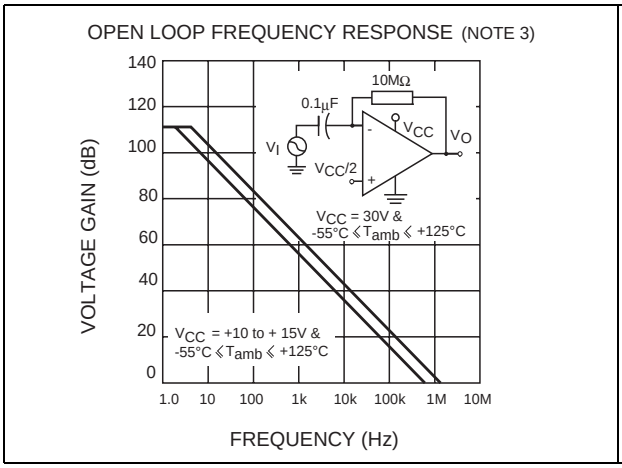



**Figure 3. Large signal frequency response**

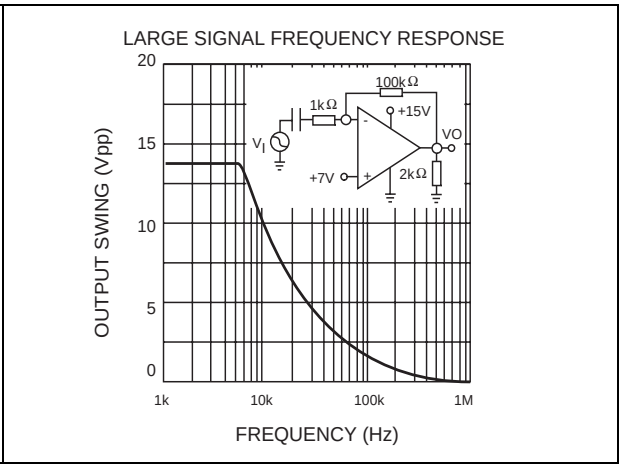



**Figure 4. Voltage follower pulse response**

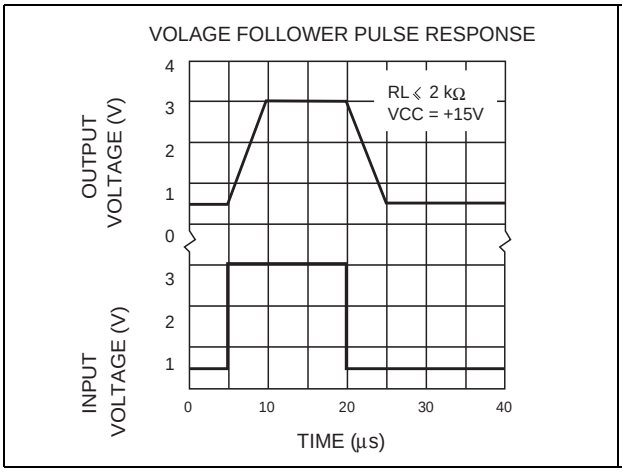



**Figure 5. Output characteristics**

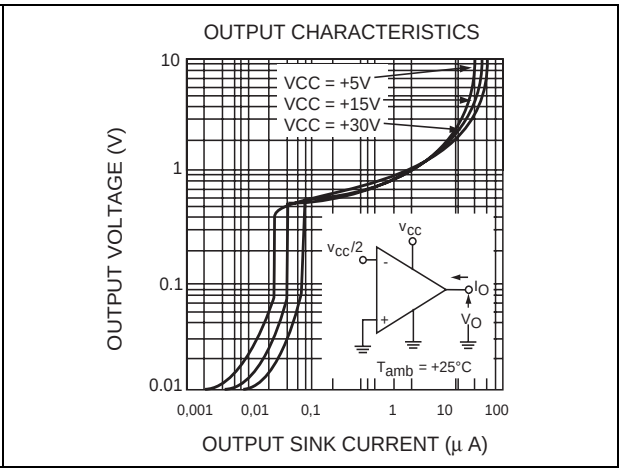



**Figure 6. Voltage follower pulse response**

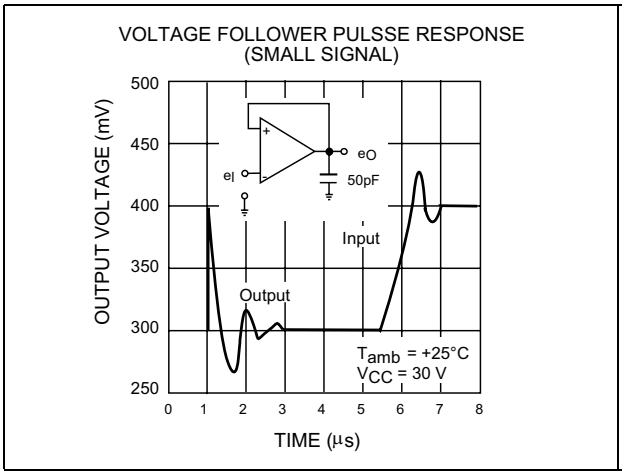



**Figure 7. Output characteristics**

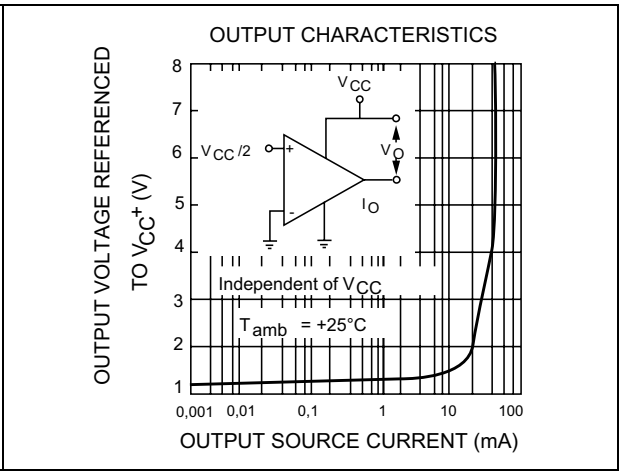


**Figure 8. Input current**

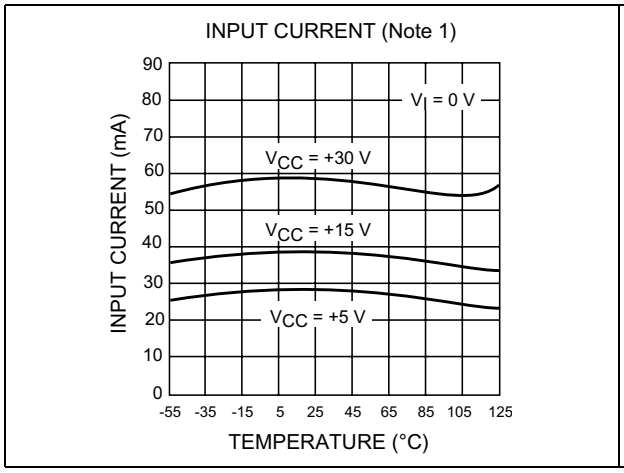



**Figure 9. Current limiting**

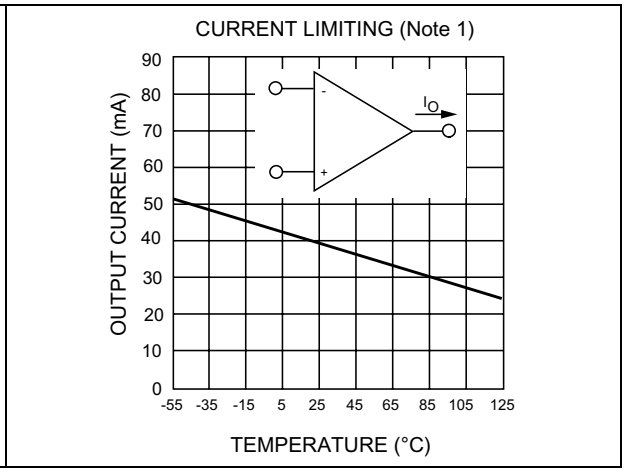



**Figure 10. Input voltage range**

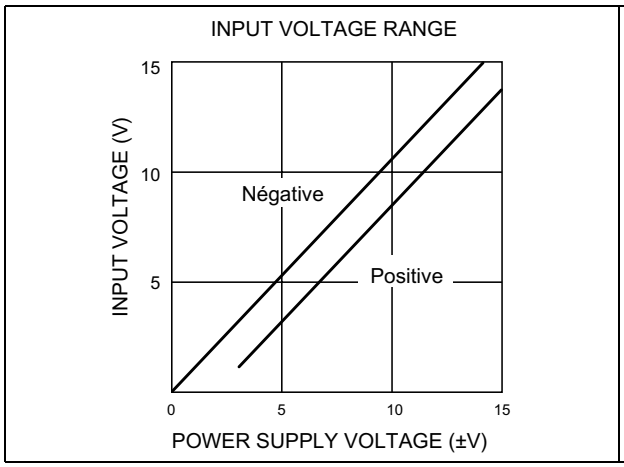



**Figure 11. Supply current**

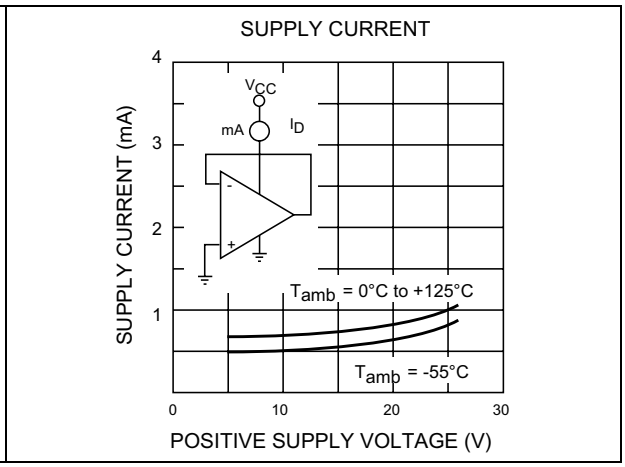



**Figure 12. Positive supply voltage**

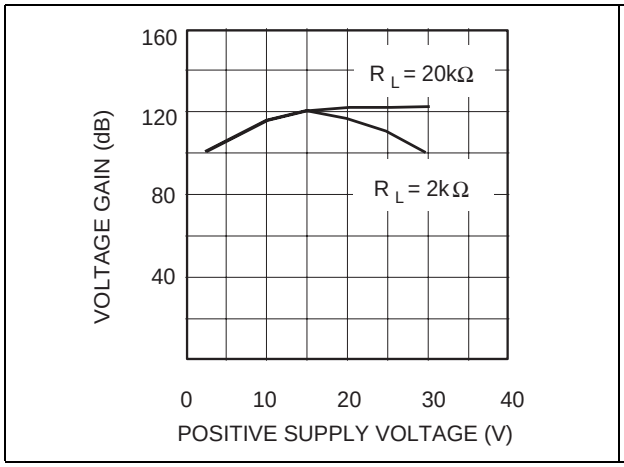



**Figure 13. Positive supply voltage**

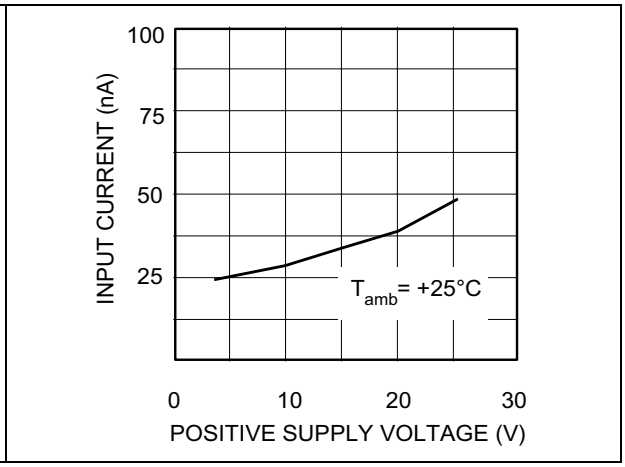


**Figure 14. Positive supply voltage**

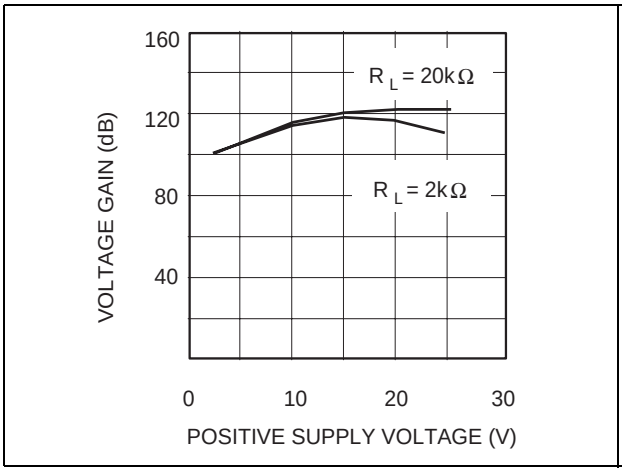



**Figure 15. Gain bandwidth product**

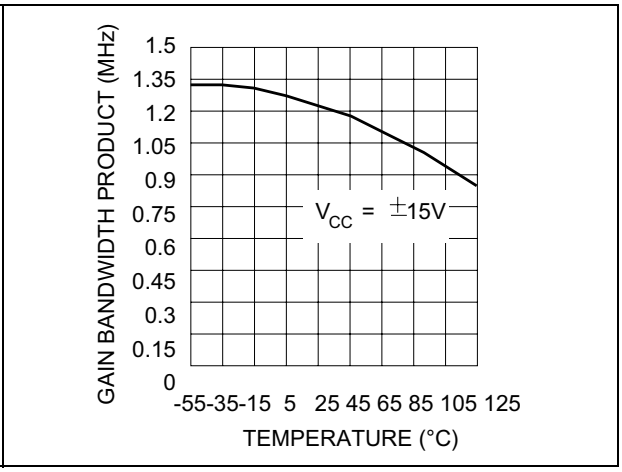



**Figure 16. Power supply rejection ratio**

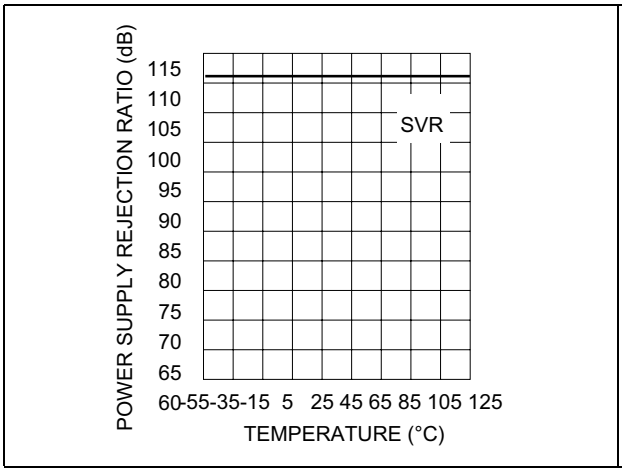



**Figure 17. Common mode rejection ratio**

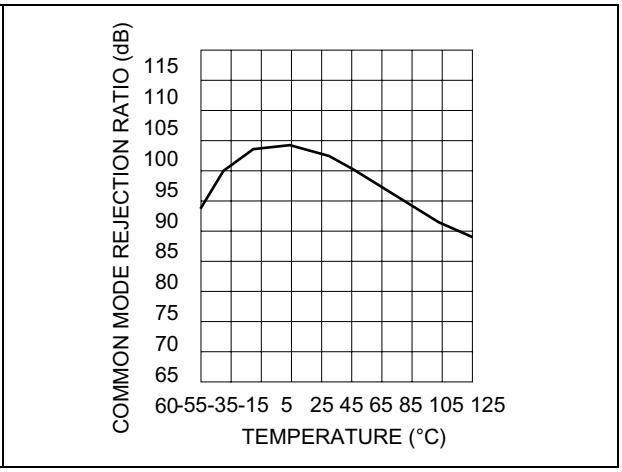
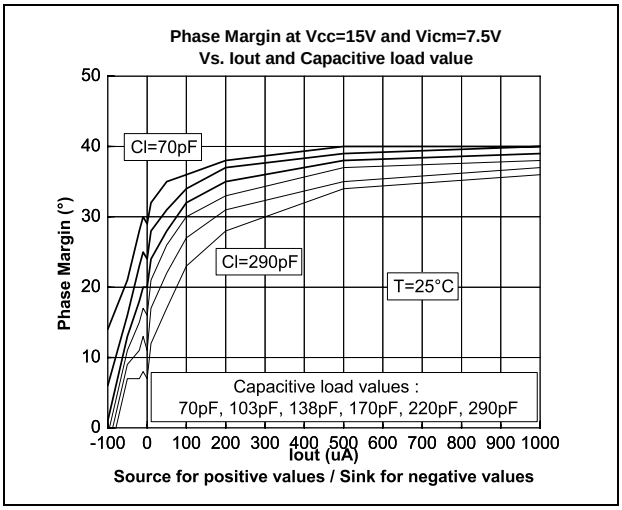



**Figure 18. Phase margin vs capacitive load**



# Typical single-supply applications

**Figure 19. AC coupled inverting amplifier**

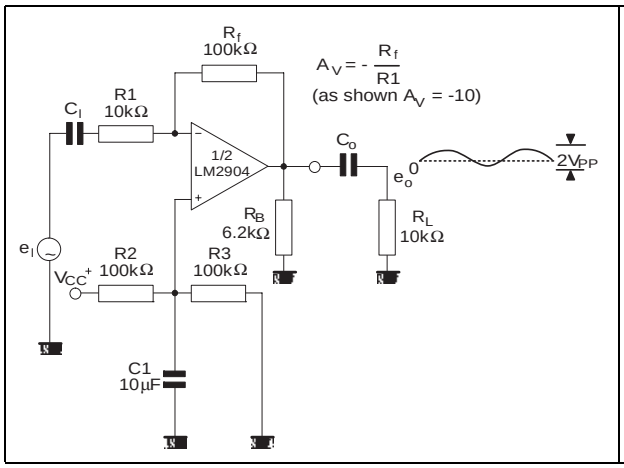



**Figure 20. AC coupled non-inverting amplifier**

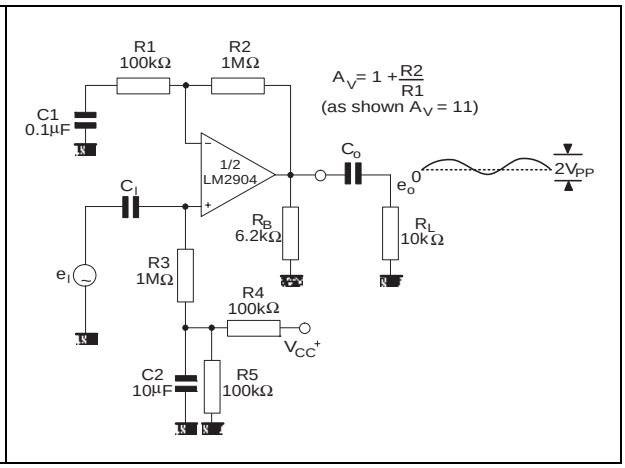



**Figure 21. Non-inverting DC gain**

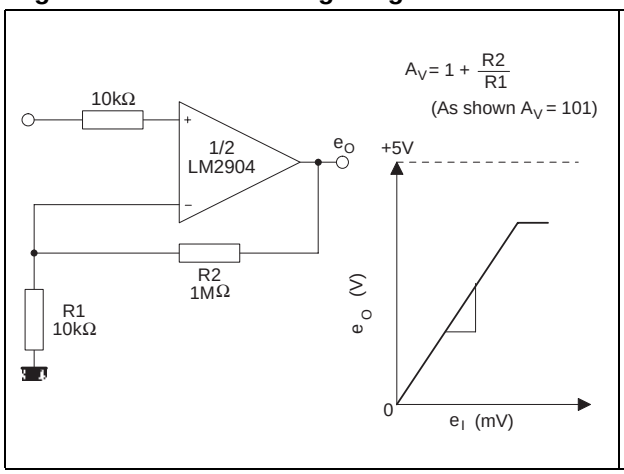



**Figure 22. DC summing amplifier**

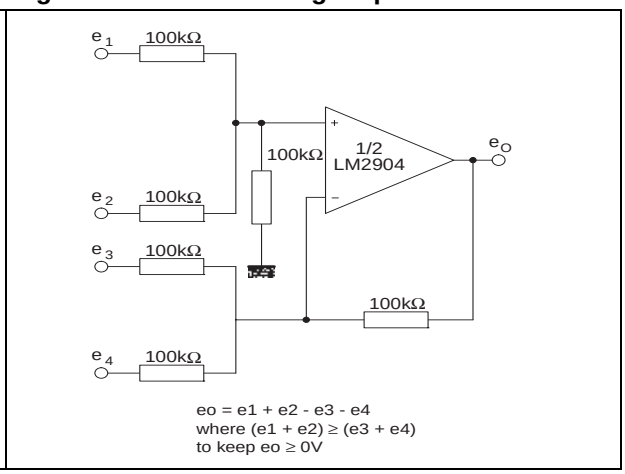



**Figure 23. High input Z, DC differential amplifier**

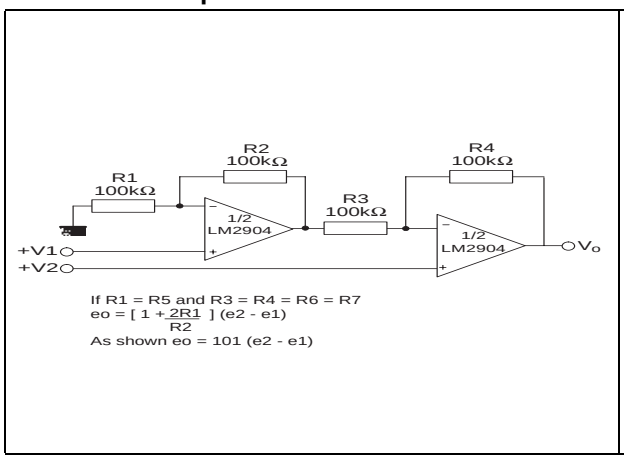



**Figure 24. Using symmetrical amplifiers to reduce input current**

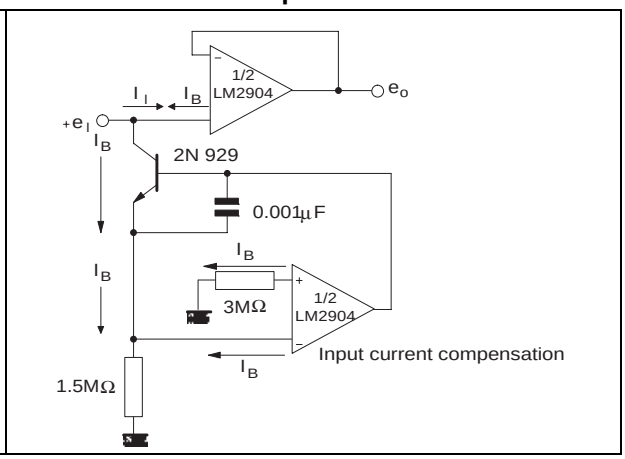


**Figure 25. Low drift peak detector**

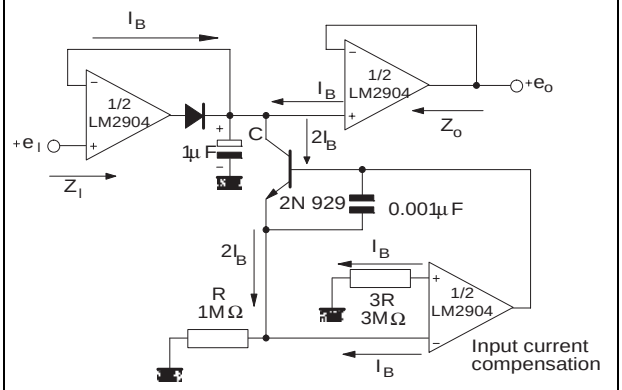
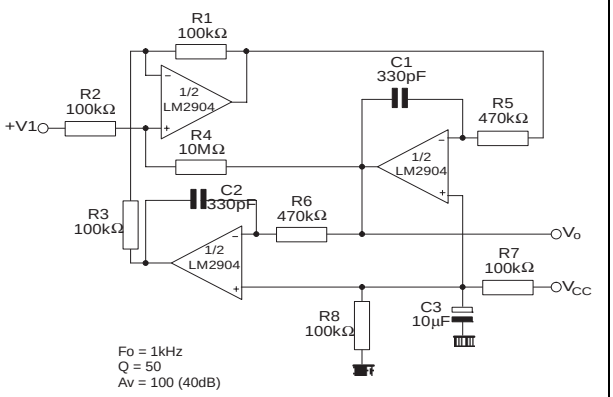



**Figure 26. Active bandpass filter**

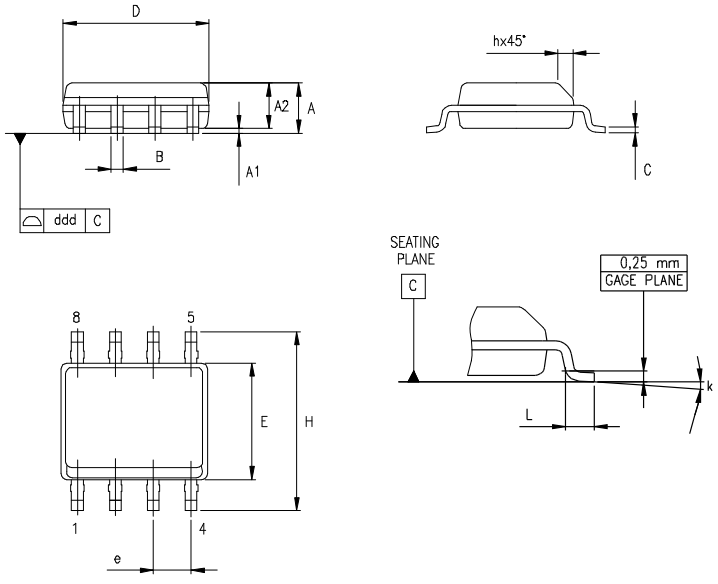


# 4 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® 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 ST trademark. ECOPACK specifications are available at: www.st.com.

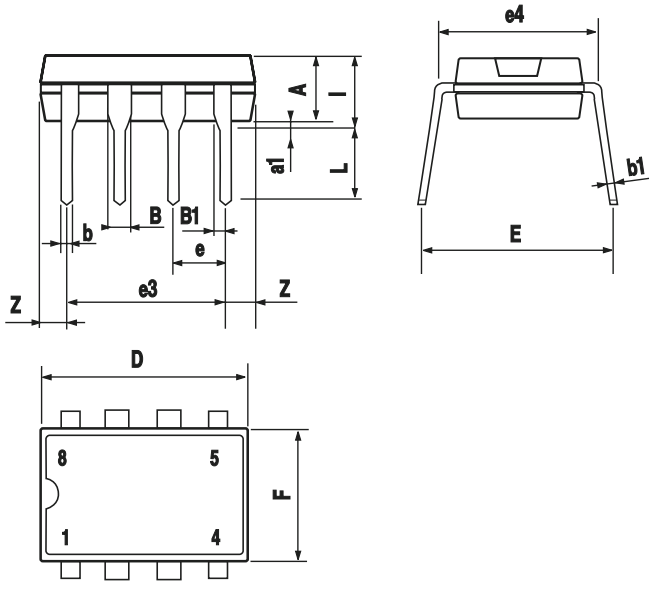
## 4.1 SO-8 package

| Ref. | Dimensions | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | 1.35 | | 1.75 | 0.053 | | 0.069 |
| A1 | 0.10 | | 0.25 | 0.04 | | 0.010 |
| A2 | 1.10 | | 1.65 | 0.043 | | 0.065 |
| B | 0.33 | | 0.51 | 0.013 | | 0.020 |
| C | 0.19 | | 0.25 | 0.007 | | 0.010 |
| D | 4.80 | | 5.00 | 0.189 | | 0.197 |
| E | 3.80 | | 4.00 | 0.150 | | 0.157 |
| e | | 1.27 | | | 0.050 | |
| H | 5.80 | | 6.20 | 0.228 | | 0.244 |
| h | 0.25 | | 0.50 | 0.010 | | 0.020 |
| L | 0.40 | | 1.27 | 0.016 | | 0.050 |
| k | 8° (max.) | | | | | |
| ddd | | | 0.1 | | | 0.04 |



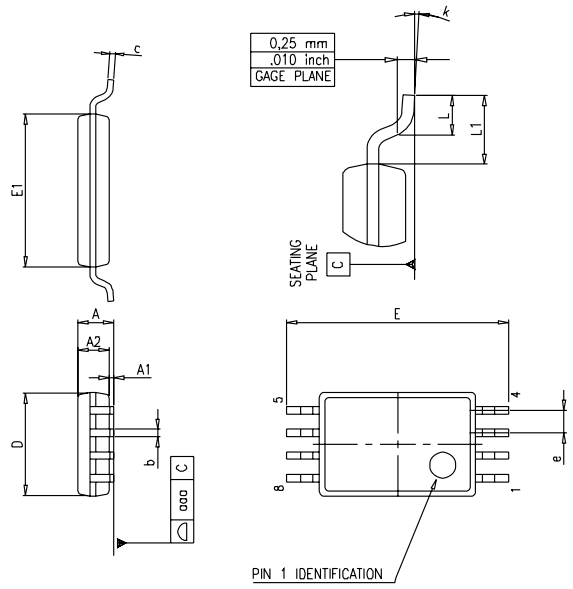
## 4.2 DIP8 package

| Ref. | Dimensions | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | 3.3 | | | 0.130 | |
| a1 | 0.7 | | | 0.28 | | |
| B | 1.39 | | 1.65 | 0.055 | | 0.065 |
| B1 | 0.91 | | 1.04 | 0.036 | | 0.041 |
| b | | 0.5 | | | 0.020 | |
| b1 | 0.38 | | 0.5 | 0.015 | | 0.20 |
| D | | | 9.8 | | | 0.386 |
| E | | 8.8 | | | 0.346 | |
| e | | 2.54 | | | 0.100 | |
| e3 | | 7.62 | | | 0.300 | |
| e4 | | 7.62 | | | 0.300 | |
| F | | | 7.1 | | | 0.280 |
| I | | | 4.8 | | | 0.189 |
| L | | 3.3 | | | 0.130 | |
| Z | 0.44 | | 1.6 | 0.017 | | 0.063 |



## 4.3 TSSOP8 package

| Ref. | Dimensions | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.2 | | | 0.047 |
| A1 | 0.05 | | 0.15 | 0.002 | | 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 | | 0.008 |
| D | 2.90 | 3.00 | 3.10 | 0.114 | 0.118 | 0.122 |
| E | 6.20 | 6.40 | 6.60 | 0.244 | 0.252 | 0.260 |
| E1 | 4.30 | 4.40 | 4.50 | 0.169 | 0.173 | 0.177 |
| e | | 0.65 | | | 0.0256 | |
| K | 0° | | 8° | 0° | | 8° |
| L | 0.45 | 0.60 | 0.75 | 0.018 | 0.024 | 0.030 |
| L1 | | 1 | | | 0.039 | |



# 5 Ordering information

| Part number | Temperature range | Package | Packing | Marking |
|---|---|---|---|---|
| LM2904WN | -40°C, +125°C | DIP8 | Tube | LM2904W |
| LM2904WD/WDT | | SO-8 | Tube or tape & reel | 2904W |
| LM2904WPT | | TSSOP8 (Thin shrink outline package) | Tape & reel | 2904W |
| LM2904WYD/WYDT | | SO-8 (automotive grade level) | Tube or tape & reel | 2904WY |
| LM2904WYPT | | TSSOP8 (automotive grade level) | Tape & reel | K04WY |

# 6 Revision history

**Table 4. Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 1-Sep-2003 | 1 | Initial release. |
| 1-Jul-2005 | 2 | PPAP references inserted in the datasheet see *Section 5: Ordering information on page 17*.<br>ESD protection inserted in *Table 1: Absolute maximum ratings on page 4*. |
| 1-Oct-2005 | 3 | Correction of error in AVD min. value see: *Table 3. on page 6* |
| 1-Dec-2005 | 4 | LM2904WYPT PPAP reference added in *Section 5: Ordering information on page 17*.<br>Information added in *Table 1: Absolute maximum ratings on page 4*. |
| 2-May-2006 | 5 | Minimum value of Slew Rate at 25°C and in temperature added in *Table 3. on page 6*. |
| 29-Sep-2006 | 6 | ESD tolerance for HBM model improved to 2kV in *Table 3. on page 6*.<br>Added *Figure 18: Phase margin vs capacitive load on page 10*. |

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