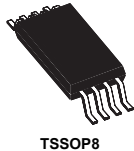


Low-power, dual operational amplifier



TSSOP8

Features

- Frequency compensation implemented internally
- Large DC voltage gain: 100 dB
- Wide bandwidth (unity gain): 1.1 MHz (temperature compensated)
- Very low supply current/amplifier, essentially independent of supply voltage
- Low input bias current: 20 nA (temperature compensated)
- Low input offset current: 2 nA
- Input common-mode voltage range includes negative rail
- Differential input voltage range equal to the power supply voltage
- Large output voltage swing 0 V to $(V_{CC+} - 1.5 \text{ V})$

Description

This circuit consists of two independent, high gain operational amplifiers (op amps) that have frequency compensation implemented internally. They are designed specifically for automotive and industrial control systems. The circuit 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 can now be more easily implemented in single power supply systems. For example, these circuits can be directly supplied from the standard 5 V which is used in logic systems and easily provides 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 a single power supply.

Maturity status link

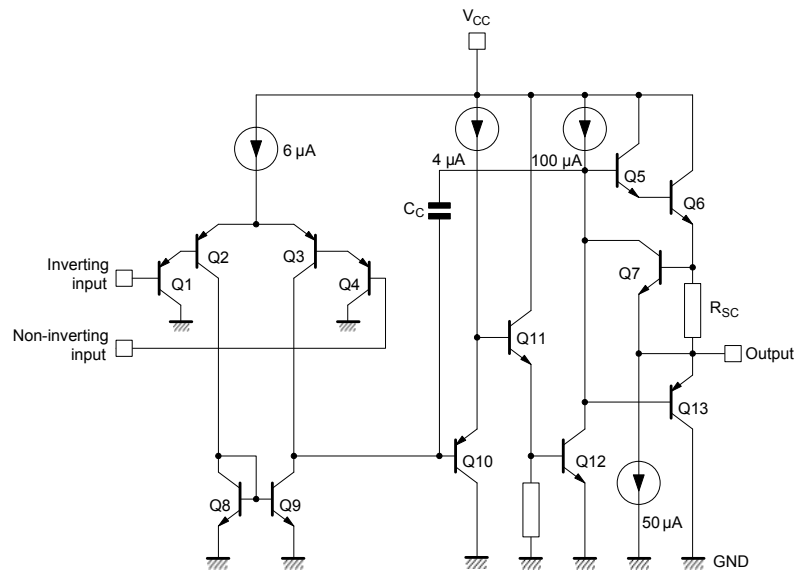
[LM2904H](#)
[LM2904AH](#)

Related products

[LM2904WH](#)

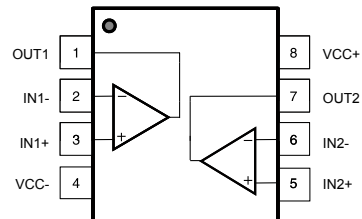
For enhanced ESD performances

1 Schematic diagram

Figure 1. Schematic diagram (1/2 LM2904AH)


2 Package pin connections

Figure 2. TSSOP8 package pin connections (top view)



3 Absolute maximum ratings and operating conditions

Table 1. Absolute maximum ratings

| Symbol | Parameter | Value | Unit |
|------------|--|---|------|
| V_{CC} | Supply voltage ⁽¹⁾ | ±16 or 32 | V |
| V_{id} | Differential input voltage ⁽²⁾ | ±32 | |
| V_{in} | Input voltage | -0.3 to 32 | |
| | Output short-circuit duration ⁽³⁾ | Infinite | s |
| I_{in} | Input current: V_{in} driven negative ⁽⁴⁾ | 5 mA in DC or 50 mA in AC (duty cycle = 10 %, T = 1 s) | mA |
| | Input current: V_{in} driven positive above AMR value ⁽⁵⁾ | 0.4 | |
| T_{stg} | Storage temperature range | -65 to 150 | °C |
| T_j | Maximum junction temperature | 160 | |
| R_{thja} | Thermal resistance junction to ambient ⁽⁶⁾ | 120 | °C/W |
| R_{thjc} | Thermal resistance junction to case ⁽⁶⁾ | 37 | |
| ESD | HBM: human body model ⁽⁷⁾ | 300 | V |
| | MM: machine model ⁽⁸⁾ | 200 | |
| | CDM: charged device model ⁽⁹⁾ | 1.5 | kV |

- All voltage values, except differential voltage are with respect to network ground terminal.
- Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
- Short-circuits from the output to V_{CC} can cause excessive heating if $(V_{CC+}) > 15$ V. The maximum output current is approximately 40 mA, independent of the magnitude of V_{CC} . Destructive dissipation can result from simultaneous short-circuits on all amplifiers.
- 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 clamp. In addition to this diode action, there is 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 -0.3 V.
- 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 ($R = (V_{in}-32 \text{ V})/400 \mu\text{A}$).
- Short-circuits can cause excessive heating and destructive dissipation. Values are typical.
- Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 k Ω 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 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.
- 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 | 0 to $(V_{CC+}) - 1.5$ | |
| T_{oper} | Operating free-air temperature range | -40 to 150 | °C |

4 Electrical characteristics

Table 3. $V_{CC+} = 5\text{ V}$, $V_{CC-} = \text{ground}$, $V_O = 1.4\text{ V}$, $T_{\text{amb}} = 25\text{ °C}$ (unless otherwise specified), $T_{\text{min}} = -40\text{ °C}$, and $T_{\text{max}} = 150\text{ °C}$

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|--------------------------|---|---|------|-------------------|-------------------------|
| V_{io} | Input offset voltage, $T_{\text{amb}} = 25\text{ °C}$, LM2904AH ⁽¹⁾ | | 1 | 2 | mV |
| | Input offset voltage, $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ LM2904AH ⁽¹⁾ | | | 6 | |
| | Input offset voltage, $T_{\text{amb}} = 25\text{ °C}$, LM2904H ⁽¹⁾ | | 2 | 7 | |
| | Input offset voltage, $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ LM2904H ⁽¹⁾ | | | 9 | |
| $\Delta V_{io}/\Delta T$ | Input offset voltage drift | | 7 | 40 | $\mu\text{V}/\text{°C}$ |
| I_{io} | Input offset current, $T_{\text{amb}} = 25\text{ °C}$ | | 2 | 30 | nA |
| | Input offset current, $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | | | 40 | |
| $\Delta I_{io}/\Delta T$ | Input offset current drift | | 10 | 300 | $\text{pA}/\text{°C}$ |
| I_{ib} | Input bias current, $T_{\text{amb}} = 25\text{ °C}$ ⁽²⁾ | | 20 | 150 | nA |
| | Input bias current, $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ ⁽²⁾ | | | 200 | |
| 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 V , $T_{\text{amb}} = 25\text{ °C}$ | 50 | 100 | | V/mV |
| | Large signal voltage gain, $V_{CC+} = 15\text{ V}$, $R_L = 2\text{ k}\Omega$, $V_O = 1.4\text{ V}$ to 11.4 V , $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | 25 | | | |
| SVR | Supply voltage rejection ratio ($R_S \leq 10\text{ k}\Omega$), $T_{\text{amb}} = 25\text{ °C}$ | 65 | 100 | | dB |
| | Supply voltage rejection ratio ($R_S \leq 10\text{ k}\Omega$), $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | 65 | | | |
| I_{CC} | Supply current, all amp, no load, $T_{\text{amb}} = 25\text{ °C}$, $V_{CC+} = 5\text{ V}$ | | 0.7 | 1.2 | mA |
| | Supply current, all amp, no load, $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$, $V_{CC+} = 30\text{ V}$ | | | 2 | |
| V_{icm} | Input common mode voltage range ($V_{CC+} = 30\text{ V}$), $T_{\text{amb}} = 25\text{ °C}$ ⁽³⁾ | 0 | | $(V_{CC+}) - 1.5$ | V |
| | Input common mode voltage range ($V_{CC+} = 30\text{ V}$), $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | 0 | | $(V_{CC+}) - 2$ | |
| CMR | Common-mode rejection ratio ($R_S = 10\text{ k}\Omega$), $T_{\text{amb}} = 25\text{ °C}$ | 70 | 85 | | dB |
| | Common-mode rejection ratio ($R_S = 10\text{ k}\Omega$), $T_{\text{min}} = T_{\text{amb}} = T_{\text{max}}$ | 60 | | | |
| I_{source} | Output short-circuit current, $V_{CC+} = 15\text{ V}$, $V_O = 2\text{ V}$, $V_{id} = 1\text{ V}$ | 20 | 40 | 60 | mA |
| I_{sink} | Output sink current, $V_O = 2\text{ V}$, $V_{CC+} = 5\text{ V}$ | 10 | 20 | | |
| | | Output sink current, $V_O = 0.2\text{ V}$, $V_{CC+} = 15\text{ V}$ | 12 | 50 | μA |
| V_{OH} | High level output voltage ($V_{CC+} = 30\text{ V}$), $T_{\text{amb}} = 25\text{ °C}$, $R_L = 2\text{ k}\Omega$ | 26 | | | V |
| | High level output voltage ($V_{CC+} = 30\text{ V}$), $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | 26 | 27 | | |
| | High level output voltage ($V_{CC+} = 30\text{ V}$), $T_{\text{amb}} = 25\text{ °C}$, $R_L = 10\text{ k}\Omega$ | 27 | | | |
| | High level output voltage ($V_{CC+} = 30\text{ V}$), $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | 27 | 28 | | |
| V_{OL} | Low level output voltage ($R_L = 10\text{ k}\Omega$), $T_{\text{amb}} = 25\text{ °C}$ | | 5 | 20 | mV |
| | Low level output voltage ($R_L = 10\text{ k}\Omega$), $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | | | 20 | |
| SR | Slew rate, $V_{CC+} = 15\text{ V}$, $V_{in} = 0.5$ to 3 V , $R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$, unity gain, $T_{\text{amb}} = 25\text{ °C}$ | 0.3 | 0.6 | | V/ μs |
| | Slew rate, $V_{CC+} = 15\text{ V}$, $V_{in} = 0.5$ to 3 V , $R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$, unity gain, $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | 0.2 | | | |
| GBP | Gain bandwidth product, $f = 100\text{ kHz}$, $V_{CC+} = 30\text{ V}$, $V_{in} = 10\text{ mV}$, $R_L = 2\text{ k}\Omega$, $C_L = 100\text{ pF}$ | 0.7 | 1.1 | | MHz |
| THD | Total harmonic distortion, $f = 1\text{ kHz}$, $A_V = 20\text{ dB}$, $R_L = 2\text{ k}\Omega$, $V_O = 2\text{ V}_{pp}$, $C_L = 100\text{ pF}$, $V_{CC+} = 30\text{ V}$ | | 0.02 | | % |

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|-----------------|---|------|------|------|------------------------------|
| e_n | Equivalent input noise voltage, $f = 1 \text{ kHz}$, $R_S = 100 \ \Omega$, $V_{CC+} = 30 \text{ V}$ | | 55 | | $\text{nV}/\sqrt{\text{Hz}}$ |
| V_{O1}/V_{O2} | Channel separation, $1 \text{ kHz} \leq f \leq 20 \text{ kHz}$ ⁽⁴⁾ | | 120 | | dB |

- $V_O = 1.4 \text{ V}$, $R_S = 0 \ \Omega$, $5 \text{ V} < V_{CC+} < 30 \text{ V}$, $0 \text{ V} < V_{ic} < (V_{CC+}) - 1.5 \text{ V}$.
- 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.
- The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common-mode voltage range is $(V_{CC+}) - 1.5 \text{ V}$, but either or both inputs can go to 32 V without damage.
- Due to the proximity of external components, ensure that the stray capacitance does not cause coupling between these external parts. This can typically be detected at higher frequencies because this type of capacitance increases.

5 Electrical characteristic curves

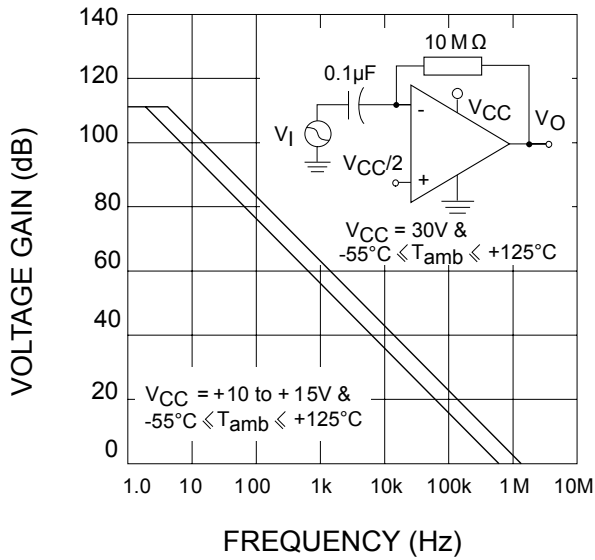
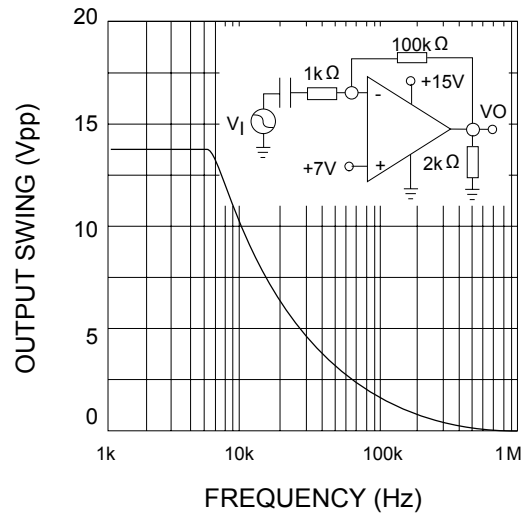
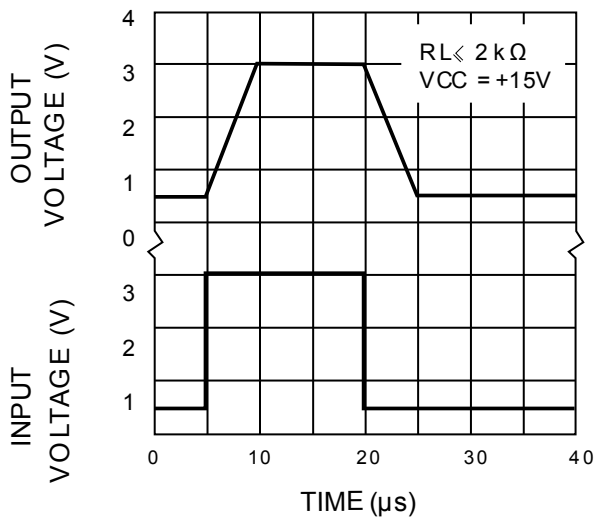
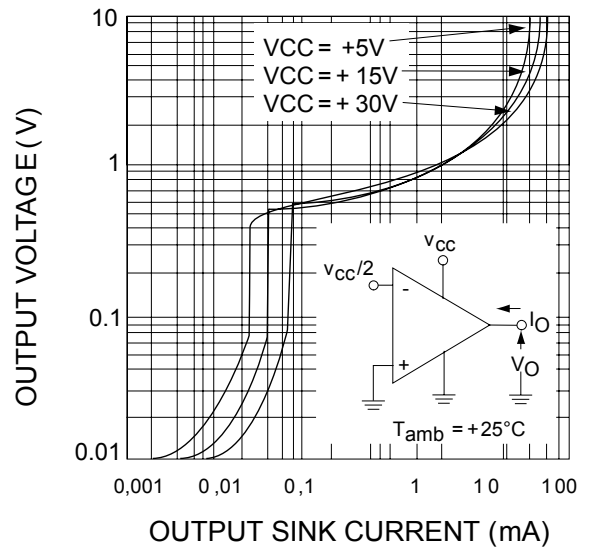
Figure 3. Open-loop frequency response

Figure 4. Large signal frequency response

Figure 5. Voltage follower large signal response

Figure 6. Current sinking output characteristics


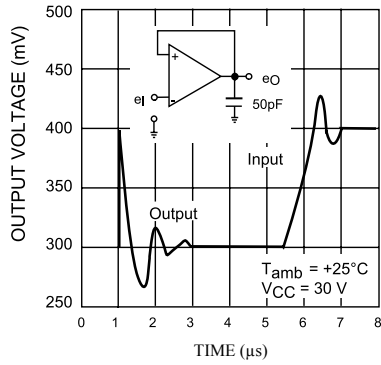
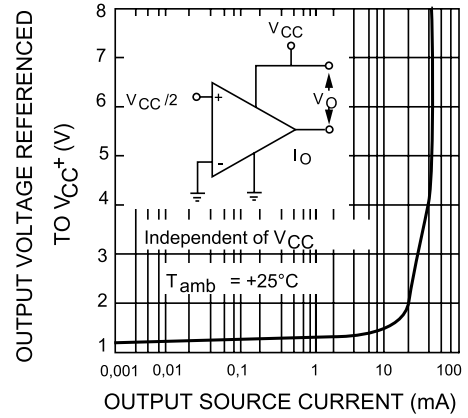
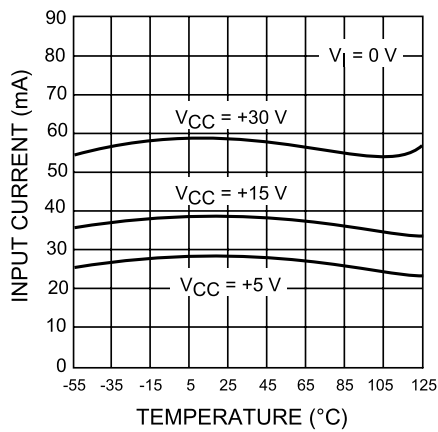
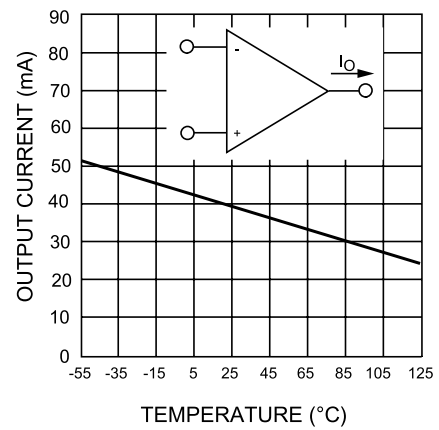
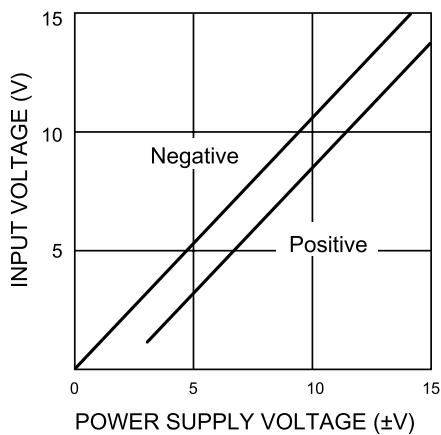
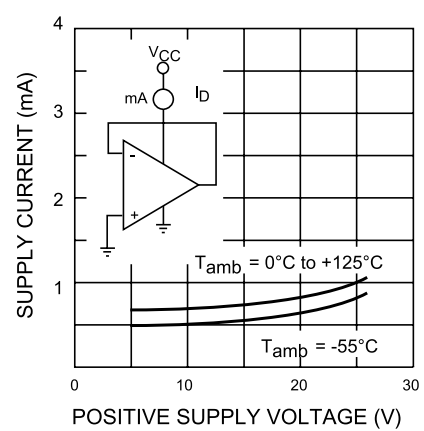
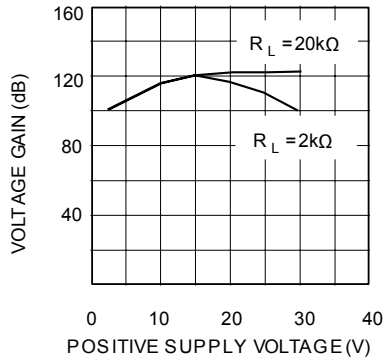
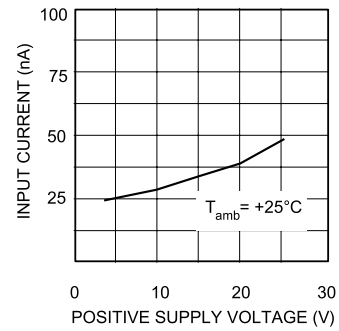
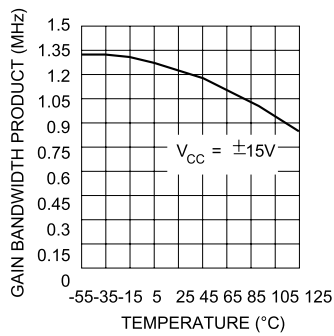
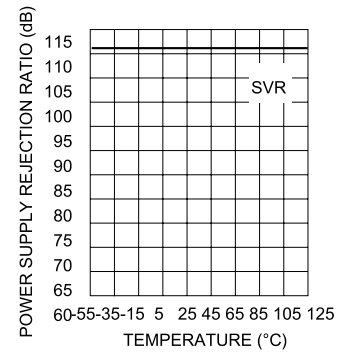
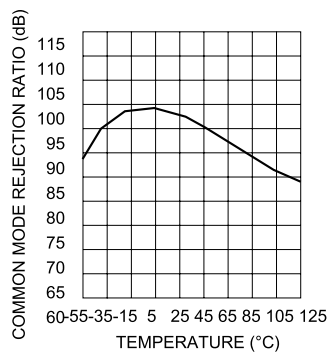
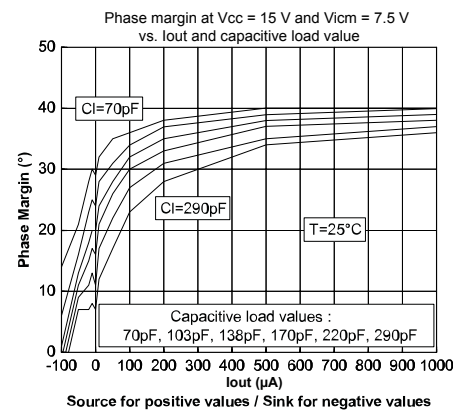
Figure 7. Voltage follower small signal response

Figure 8. Current sourcing output characteristics

Figure 9. Input current versus temperature

Figure 10. Current limiting

Figure 11. Input voltage range

Figure 12. Supply current


Figure 13. Voltage gain

Figure 14. Input current versus 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


6 Typical single-supply applications

Figure 19. AC coupled inverting amplifier

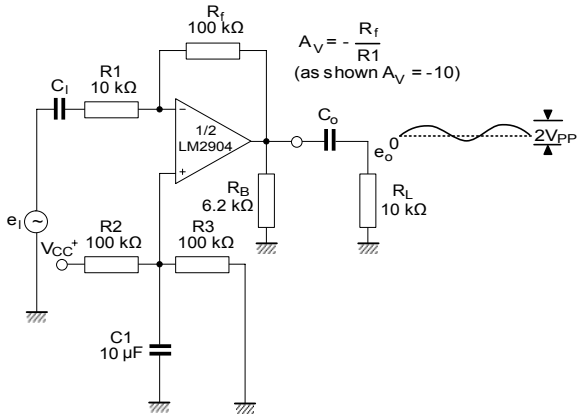


Figure 20. AC coupled non-inverting amplifier

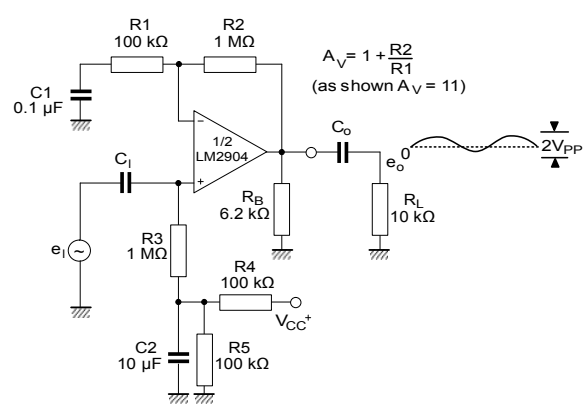


Figure 21. Non-inverting DC gain

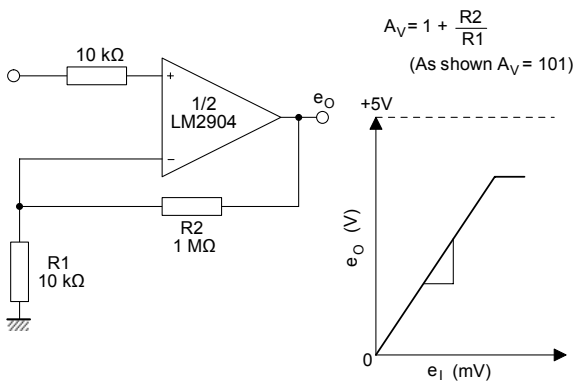


Figure 22. DC summing amplifier

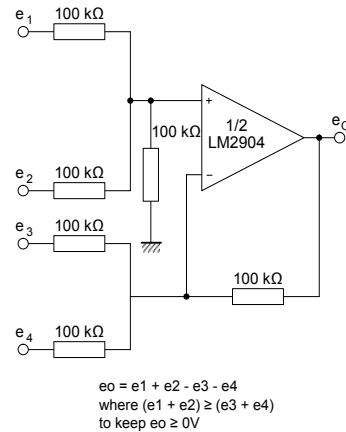


Figure 23. High input Z, DC differential amplifier

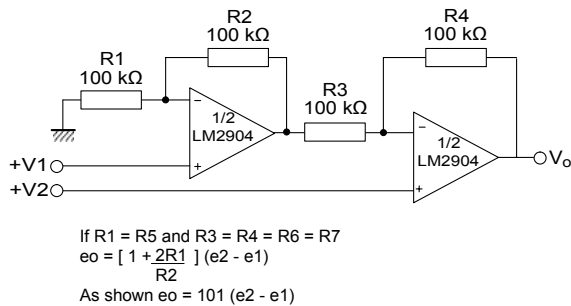
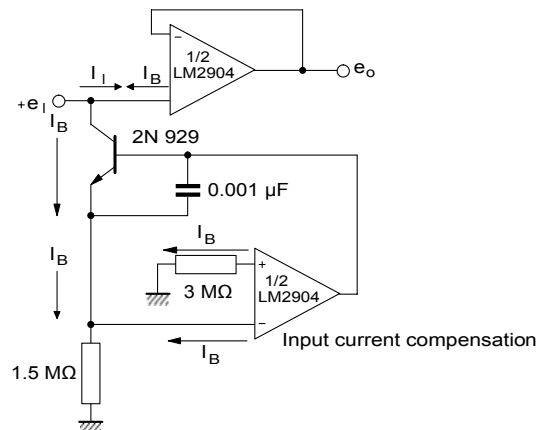


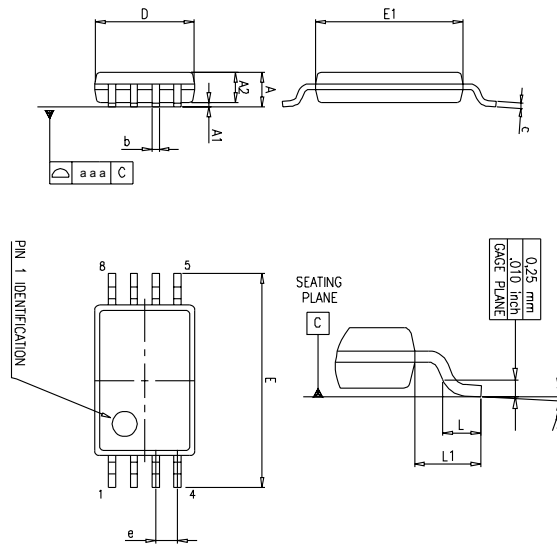
Figure 24. Using symmetrical amplifiers to reduce input current



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. ECOPACK® is an ST trademark.

7.1 TSSOP8 package information

Figure 27. TSSOP8 package outline

Table 4. TSSOP8 mechanical data

| Ref. | Dimensions | | | | | |
|------|-------------|------|------|--------|--------|-------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 1.2 | | | 0.047 |
| A1 | 0.05 | | 0.15 | 0.002 | | 0.006 |
| 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 | |
| aaa | | 0.1 | | | 0.004 | |

8 Ordering information

Table 5. Order codes

| Order code | Temperature range | Package | Packing | Marking |
|----------------------------|-------------------|---------------------------------|---------------|---------|
| LM2904AHYPT ⁽¹⁾ | -40 °C to 150 °C | TSSOP8 (automotive grade level) | Tape and reel | LM4AH |
| LM2904HYPT ⁽¹⁾ | | | | 2904H |

1. Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 and Q002 or equivalent.

Revision history

Table 6. Document revision history

| Date | Revision | Changes |
|-------------|----------|---|
| 19-Oct-2015 | 1 | Initial release |
| 05-Nov-2015 | 2 | Updated datasheet layout Table 1: removed T_{oper} parameter Table 3: updated table title |
| 16-Feb-2016 | 3 | Datasheet status changed to "production data" Table 3: unit of V_{OL} parameter changed from "V" to "mV" |
| 29-Feb-2016 | 4 | Updated product status footnote Table 5: replaced footnote 1 |
| 15-Oct-2018 | 5 | Added new order code LM2904H in Table 5. Order codes and V_{IO} parameter in Section 4 Electrical characteristics |

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[NCV33072ADR2G](#) [LM358SNG](#) [430227FB](#) [UPC824G2-A](#) [LT1678IS8](#) [042225DB](#) [058184EB](#) [UPC822G2-A](#) [UPC259G2-A](#) [UPC258G2-A](#)
[NCV33202DMR2G](#) [NTE925](#) [AZV358MTR-G1](#) [AP4310AUMTR-AG1](#) [HA1630D02MMEL-E](#) [HA1630S01LPEL-E](#) [SCY33178DR2G](#)
[NJU77806F3-TE1](#) [NCV5652MUTWG](#) [NCV20034DR2G](#) [LM324EDR2G](#) [LM2902EDR2G](#) [NTE7155](#) [NTE778S](#) [NTE871](#) [NTE924](#) [NTE937](#)
[MCP6V17T-E/MNY](#) [MCP6V19-E/ST](#) [MXD8011HF](#) [MCP6V17T-E/MS](#) [SCY6358ADR2G](#) [ADA4523-1BCPZ](#) [LTC2065HUD#PBF](#)
[ADA4523-1BCPZ-RL7](#) [NJM2904CRB1-TE1](#) [2SD965T-R](#) [RS6332PXK](#) [BDM8551](#) [BDM321](#) [MD1324](#) [COS8052SR](#) [COS8552SR](#)
[COS8554SR](#) [COS2177SR](#) [COS2353SR](#) [COS724TR](#) [ASOPD4580S-R](#) [RS321BKXF](#) [ADA4097-1HUIZ-RL7](#)